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Comparative analysis of rural communities' tradeoffs in large-scale and small-scale renewable energy projects in Kenya

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Abstract
In Kenya's dynamic renewable energy landscape, characterized by complex policy frameworks, complex land tenure regimes, and diverse community dynamics, this qualitative research investigates the mechanisms and motivations guiding community decision-making when trading land for electricity access within the context of renewable energy projects. Through the lens of the Institutional Analysis and Development (IAD) framework, particularly the rules in use, this study unravels the complexities of rural communities' trade-offs inherent in both large-scale and small-scale renewable energy projects. Data was collected through in-depth interviews, focus group discussions, and participant observations in rural communities engaged in these projects. The findings offer new insights into communities' decision-making processes and institutional dynamics in shaping outcomes, with a focus on land rights and land use implications. The analysis highlights the relational nature of the trade-offs, influenced by factors such as land tenure systems, project scale, electricity access, traditional knowledge, and local context, supporting the importance of understanding communities' diverse roles and positions, power dynamics, and governance structures. Overall, this study contributes to a deeper understanding of the complexities surrounding land-electricity trade-offs in renewable energy projects in rural areas, emphasizing the need for adaptable strategies to address evolving community needs and challenges.

Article highlights

- Large and small renewable energy projects present unique trade-offs in rural areas, influencing land use decisions and community dynamics.
- Land tenure systems shape rural communities' decision-making and benefit distribution, influencing their trust, support and involvement in renewable energy development.
- Strategic planning is essential to balance immediate energy needs with long-term rural communities' development and sustainability.

Keywords Renewable energy · Land management · Rural communities · Institutional Analysis and Development (IAD) · Rules in use · Kenya

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1 Introduction

Renewable energy has gained prominence on the international agenda and is seen as a solution for over seven hundred million people without any energy access [1, 2], the majority of whom live in rural areas of sub-Saharan Africa as it is considered the least electrified region in the world [3]. As reflected in the Sustainable Development Goals (SDGs), electricity provision plays a crucial role in fostering development and mitigating poverty [4]. According to the International Energy Agency (IEA), renewable energy sources accounted for 29% of global electricity generation in 2021 [5]. And in sub-Saharan Africa, renewable energy has been rapidly expanding to provide electricity access to remote communities and accounts for almost one-fifth (20%) of its primary energy mix [6]. However, whether achieved by grid connection through the implementation of large-scale renewable energy projects or through independent small-scale renewable energy microgrids, the specific methods for implementing these solutions and the associated trade-offs with other developmental goals remain a challenge. The first option provides affordable electricity to consumers but involves higher costs to extend national grids to scattered and sparsely populated rural areas. The second option is easily implemented in hard-to-reach areas, but difficult because of its excessive costs and the limited financial capacity of customers to pay [7, 8]. Among the main trade-offs to consider are issues related to land management and community development, particularly the spatial requirements of energy facilities [9, 10]. In many cases, the land needed for these facilities conflicts with alternative land uses such as agriculture and grazing, in addition to biodiversity conservation and land protection concerns [11]. Furthermore, the risk of unequal energy access linked to weak land tenure and property rights raises questions regarding the emergence of disparities and inequalities within communities [12, 13]. Kenya is one such example, in which these trade-offs are high on the political agenda. There is a growing need for energy in Kenya driven by rapid population growth, increasing housing demand, and expanding industrial activities to support the country's economic development, alog with a growing preference for clean energy in line with sustainable development goals [14]. These factors create a complex scenario that underscores the complexity of decision making, emphasizing the need to navigate competing priorities in land management and community empowerment in a rural context [15, 16].

Kenya has been at the forefront of renewable energy development in East Africa, with a comprehensive policy framework that encourages both decentralized small- and large-scale projects. The country's renewable energy policy is characterized by its commitment to diversify its energy mix, reduce greenhouse gas emissions, and increase access to clean energy sources, such as solar and wind energy [16, 17]. Kenya has implemented supportive policies and incentives for small-scale renewable energy development [7, 15], including feed-in tariffs, to encourage private investment in projects, such as rooftop solar installations, microgrids, and community-based initiatives, such as the SEED Living Lab, a small-scale solar PV project managed by the local Maasai community in the rural region of Narok. These policies have facilitated local empowerment, increased access to electricity, and economic development in rural areas. However, for large-scale projects such as the Kipeto Wind Energy Project, the government has created a regulatory environment that provides investment security, a transparent procurement process, and a clear grid connection framework [17]. By promoting both small- and large-scale projects, Kenya's renewable energy policy meets the energy needs of its diverse population, from rural communities to urban centers, ensuring more equitable access across different regions and socio-economic groups. This contributes to the nation's ambitious renewable energy targets and sustainable development goals. This balanced approach has made Kenya a model for the region's renewable energy policy, supporting local community-based initiatives, and grid-scale projects [18, 19].

From a land perspective, Kenya has a long history of land tenure problems owing to a multitude of overlapping and conflicting cross-sectoral laws and policies related to land and natural resources. Poor land governance has significantly contributed to increasing tenure insecurity, specifically in rural areas, which contributes to unsustainable land and resource use [20]. In addition to rising large-scale conflicts, particularly on Maasai land. In 2009, the government implemented a National Land Policy aimed at converting customary land tenure systems to private, individualized ownership. Special efforts were made to secure group tenure for Maasai pastoralist communities [21]. In the evolving Maasai landscape, the deployment of renewable energy solutions has emerged as a critical research problem. This perplexity goes beyond energy production and extends into the complex choices between large-scale and small-scale projects, especially when navigating the associated trade-offs, which involves understanding the complex dynamics of communities, land rights, and land use. As nations such as Kenya actively pursues renewable energy implementation to address the pressing issue of energy poverty, this research aims to illuminate the nuanced consequences of such choices.

Large-scale projects, although more effective for meeting growing energy demands, can carry risks to agriculture and community development by consuming significant land resources [22, 23]. Conversely, small-scale projects may

offer localized benefits, but struggle to meet the scale required for widespread energy access [24]. This research problem is multifaceted, encompassing several critical challenges that highlight the complex nature of land management choices in the context of renewable energy projects. First, the inadequacy of current spatial models poses a significant obstacle, as they prevent a comprehensive assessment of the trade-offs involved in land-use allocations [25]. These models fall short in framing the nuanced interplay between the benefits and bottlenecks arising from favoring renewable energy over competing land uses, particularly agriculture. Second, the discourse surrounding land rights, particularly those referring to communal and customary rights, lacks a thorough evaluation of how, where, and why such rights undergo changes when land is allocated to renewable energy initiatives [26–28]. This gap in understanding occurs at both small and large scales, and addressing it is crucial for ensuring equitable and sustainable land-use practices. Finally, the current discourse on land management fails to adequately predict the impacts of policy choices, interventions, and various land instruments when faced with the challenges and opportunities presented by renewable energy projects [29, 30]. A more nuanced understanding of these implications is imperative for effective decision making. Additionally, from the community's perspective, there is still a notable lack of awareness among traditional leaders regarding the available land management instruments, and their lack of knowledge regarding the potential advantages and trade-offs associated with opting for renewable energy facilities on communal lands, which obstructs their ability to identify, navigate, and derive benefits from renewable energy opportunities [31–33]. Bridging this knowledge gap is essential for empowering communities to play a proactive role in steering their communities towards sustainable energy solutions by developing practical guidelines and frameworks that empower community leaders to make informed decisions, considering the broader implications for their communities in terms of land use, development, and social dynamics, and allowing them to efficiently handle the complex trade-offs involved in land management choices for renewable energy projects.

In view of the above-described research problems, the key research questions of this study are: What are the mechanisms and motivations underlying the decision-making processes within communities when trading land for access to electricity in the context of renewable energy projects? What are the diverse roles that communities assume in these trade-offs? This research specifically compares the land-electricity trade-offs, roles, and rules in use by communities in either large-scale or small-scale projects within the Kenyan context. To address these questions, we conducted qualitative research using two case studies: the large scale Kipeto Wind farm project and the small-scale SEED solar PV project in Kenya. Through semi-structured interviews, focus group discussions, and literature reviews, our data collection focuses on two aspects: first, there needs to be data supporting a better understanding of the implications for communities in terms of their changing land rights, land use, and land access; and second, data on how, when, and why communities and individuals make their choices in trading in land for electricity access. The benefit of the insights generated from this research is that they contribute to the development of a more balanced and sustainable approach to land management in the context of renewable energy initiatives and community development. By delving into the mechanisms and motivations guiding decision-making processes surrounding land-electricity trade-offs, this study sheds light on the complexities inherent in such projects. Furthermore, this highlights the need for flexible and adaptive strategies that can address evolving community needs alongside shifting socio-economic and environmental landscapes, and mitigate the potential challenges associated with renewable energy development in rural areas.

This paper is organized as follows: In Sect. 2, we introduce and explain the theoretical framework used. Section 3 provides an overview of the data and methods used in the empirical research. Section 4 outlines the results, including the narratives and rationales uncovered, leading to the observed trade-off between land and electricity. Section 5 presents the findings from this analysis through the lens of the Institutional Analysis and Development (IAD) framework by interpreting the different roles and positions of the involved communities, offering new insights into decision-making processes and institutional dynamics. Finally, Sect. 6 draws conclusions and highlights implications for further research in this dynamic field.

2 Theoretical framework

To understand how and why communities make trade-offs, the roles they play, and why, it is necessary to opt for an institutional theoretical perspective. In the context of rural electrification, the choice between connecting to the national grid through large-scale renewable energy projects and adopting isolated small-scale initiatives is influenced by multiple institutional factors, such as regulations, social norms, and economic considerations [34–36]. Communities may conform to national or international regulations promoting renewable energy, showing a form of institutional influence [37,

38]. Likewise, communities tend to copy successful models considering their geographical, demographic, and energy independence aspirations, reflecting an institutional tendency to mimic practices that have proven effective. Societal expectations of environmentally friendly and sustainable practices further contribute to the decision-making process as a form of normative influence. Additionally, the trade-offs between small-scale and large-scale projects illustrate the complexities of institutional logic, with small-scale efforts emphasizing community engagement and adaptability, while large-scale projects contribute to infrastructure development and grid stability. Amidst these considerations, we argue that the often-overlooked factor of land management emerges as a critical trade-off as decisions related to land use and land rights become central issues, requiring a careful balance amongst institutional pressures.

We consider these land management and community action trade-offs rooted within neo-institutional theories, as they encapsulate the interplay between formal and informal institutional structures, stakeholder engagement, and power dynamics and emphasize the role of rules, norms, and practices in shaping human behavior and collective action outcomes within organizations and communities [39]. These structures include regulatory frameworks, property rights, and customary practices that govern land use and access. Stakeholder engagement is influenced by these institutional arrangements, as they define roles and responsibilities among community members, government agencies, and private entities. And power dynamics further shape how these stakeholders interact, often determining who benefits from renewable energy projects and who influences decision-making processes. Specifically, the Institutional Analysis and Development (IAD) framework [40, 41] has proven to be a valuable tool for modeling these dynamics. The IAD framework is a diagnostic tool used to analyze, explain, and improve commons resource management, where individuals repetitively interact within rules and norms that shape their choice of strategies and behaviors [42]. As suggested by Elinor Ostrom and her research on common pool resources, this framework is very flexible and adaptable [40], as it can be used to analyze static situations regulated by established rules within a stable physical environment and relevant community, as well as dynamic situations where individuals develop new norms, rules, and physical technologies [43]. Thus, we justify the use of the IAD framework to analyze common resources, such as land, where new technologies are developing at an extremely rapid pace, such as renewable energy projects [44, 45].

Specifically tailored to our research questions, the IAD framework proves invaluable, as it adeptly models the complex mechanisms through which land-related trade-offs are deliberated and decided upon. This conceptualization emphasizes that decisions are not isolated events determined by independent individuals, but rather outcomes of a consultative and externally influenced process, involving community consultation, brokering, and power dynamics. Furthermore, the IAD framework facilitates the modeling of decision outcomes [41, 42], indicating that the choice between large-scale and small-scale projects is not merely a decision but an institutional outcome with profound implications for behavioral changes, compliance, and stimulated community actions. Overall, this framework provides a robust foundation for unraveling the dynamics of decision making within communities and the consequential impact on land use, property rights, and rural development.

This framework clusters variables into three main categories (see Fig. 1): on the left are the underlying factors such as the physical/material characteristics, the attributes of the relevant community, and the rules-in-use; in the middle, the action arena can be understood as spaces where actors make decisions and take actions; and on the right, the outcomes,

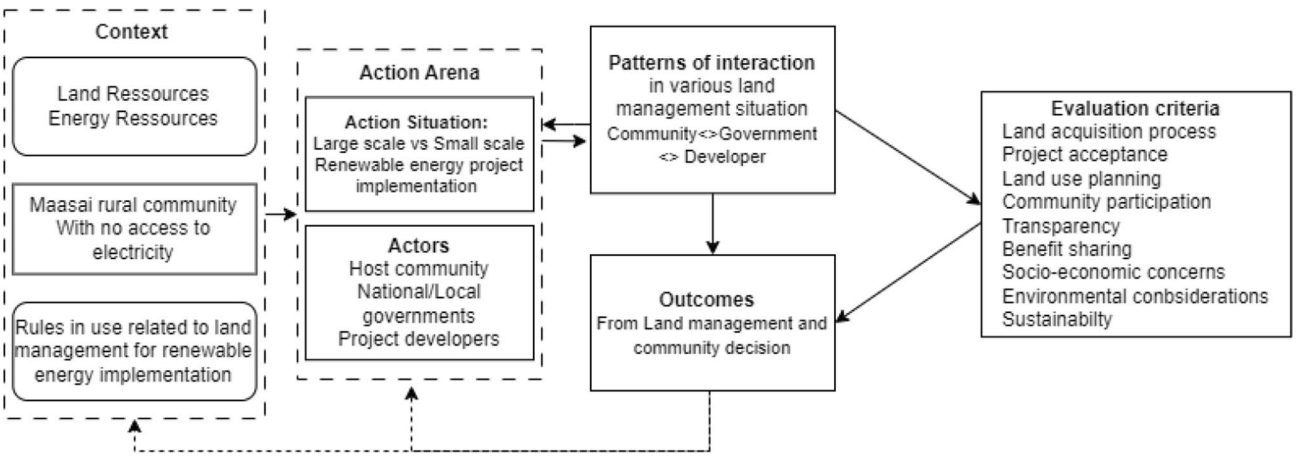

Fig. 1 Adapted IAD framework

which are the payoffs of the actions of others and the results, which encompass economic benefits, environmental impacts, changes in community well-being, and alterations to land use and property rights [40]. For our study, we focus on rules-in-use as the formal and informal rules governing land use and management, including governmental regulations, community norms, and any existing property rights structures. They are used to explain the human interaction situations of stakeholders in renewable energy projects by looking at their positions and the information they have to act on to achieve outcomes. We also consider the benefits and costs they perceive in these outcomes [46, 47].

In her framework, Ostrom identifies seven types of rules that shape an action: (1) position rules define actors' roles and positions, (2) boundary rules define which actors and positions are included and which are not; (3) choice rules relate to the actions that participants in a position, (4) aggregation rules relate to actors collectively influencing control over action outcome, (5) information rules involve sending or receiving information, (6) scope rules define the finality of the outcomes, and (7) payoff rules relate to paying or receiving costs or benefits. These operational rules define the action arena within the IAD framework and are used to analyze unfolding outcomes. For our analysis, we will mainly focus on the following rules in use (see Table 1) for implementing renewable energy projects within rural communities and will not consider biophysical/material conditions and the attributes of the community. Our research compares two rural renewable energy projects in Kenya: The Kipeto Wind energy project, a large-scale wind farm in Kajiado County, operated by an independent power producer and supporting community development through its community trust. And the SEED Living Lab, a small-scale, community owned, solar PV project in Narok County, that provides energy access and fosters local entrepreneurship. Both projects illustrate different models of renewable energy development, land management, and community engagement in different regions.

By applying this adapted IAD framework, we can systematically evaluate the differences in land ownership models (private vs. communal) and their implications for decision making, resource management, and sustainability in both large-scale and small-scale renewable energy projects. This framework provides a solid foundation for elaborating how collective outcomes vary based on the local arrangements in each project, which may explain why one project type has better acceptance and resilience than others.

3 Methodology

3.1 Selection of case studies

Our research compared two existing renewable energy rural electrification projects in Kenya (see Table 2). The first case study was the Kipeto Wind project, which is a large-scale project located in the foothills of Ngong Hills, Kajiado County, 80 km south of Nairobi. The second case study is the SEED living lab, which is a small-scale solar PV project located in Narok County, near the Tanzanian border, and border Kaijado County from the East (see Fig. 2).

Kaijado county lies between rural and peri-urban areas and serves as a buffer zone for Nairobi, the center of economic growth. Meanwhile, Narok county is situated in a rural setting along the Great Rift Valley, next to the Maasai Mara National Reserve, making it area of significant importance for wildlife conservation. Kaijado and Narok regions are predominantly semi-arid, with an average annual temperature ranging from 20 °C to 30 °C. They both experience a bimodal rainfall pattern, with the long rains occurring from March to May and the short rains from October to December. However, these areas have become highly vulnerable to climate change, with prolonged droughts and unpredictable rainfall. Livestock husbandry and crop farming are the main economic activities. And both counties are known for their Maasai communities and heritage.

The Kipeto Wind Energy project is Kenya's second largest renewable energy project. It was developed by Kipeto Energy PLC (KEP), an Independent Power Producer (IPP) with a 20-year power purchase agreement with Kenya Power and Lighting Company (KPLC), Kenya's national utility. Although not owned by the community, Kipeto has committed to creating Community Trust, which aims to execute community projects in the areas of education, health, water and sanitation, and sustainable livelihood [48]. The Kipeto Wind Power Project emerged as a potential good practice case study for land management and stakeholder engagement, following an informal assessment of the renewable energy sector in Kenya. The assessment involved desktop reviews of available information on land practices, stakeholder engagement, and informal consultations with Indigenous rights activists in their respective energy project areas. Similar to the SEED Living Lab, we established a collaborative partnership with the SEED Living Lab during the project's development phase, which allowed us access to relevant data and information, key project documents, and direct insights from project stakeholders, including the local community, which is crucial for a detailed and holistic analysis of the project's land management

Table 1 Analytical approach for studying the types of rules-in-use within the IAD framework

Rules in use	Definition	Case Study 1: Kipeto Wind Energy Project	Case Study 2: SEED Living Lab
Position rules	Positions and roles that participants assume	Understanding how private landownership is affecting the positions of individual landowners in land management and large-scale project decisions	Understanding how communal land ownership system is impacting the positions of community members in land management and small-scale project decisions
Boundary rules	Which participants enter or leave a position, and how they do	Assessing how Private landownership facilitates the active involvement of both individuals and households	Assessing how communal land ownership restricts participation to community elders and men exclusively
Choice rules	Actions that participants in a position do	Analyzing the choices made for land acquisition, considering long-term land leasing and its implications on the individuals and the community	Analyzing the choices made in land acquisition through donation-based model and its impacts on the community, considering the absence of a compensation scheme
Aggregation rules	How decisions are made in an action situation	Understanding how private landownership has implemented a dual-level approach to decision-making, encompassing both individual and community perspectives	Understanding how communal landownership still relies on a single-level approach to decision-making, based on traditional knowledge
Scope rules	Jurisdiction and finality of outcomes	Evaluating the impact of outcomes on land use planning, practices, and environmental considerations, both at the individual and community levels Focusing on outcomes within a broader land area	Evaluating the impact of outcomes on land use planning, practices, and environmental considerations specifically at the community level Focusing on outcomes within a more localized area
Information rules	Amount and type of information available to participants	Analyzing the individuals and the community's involvement in information access and decision-making processes	Analyzing the community's involvement in information access and decision-making processes
Payoff rules	Costs and benefit distribution	Reviewing the costs and benefits associated with the land lease agreements and their impact on the individuals and the community Analysis of the benefits-sharing schemes through a community trust fund	Reviewing the costs and benefits associated with the donation-based land acquisition model on the community, especially in the absence of a compensation scheme, and their impact on the community Analysis of the benefits-sharing schemes through a community cooperative

Table 2 Main characteristics of the case studies

Component	Kipeto Wind Energy	SEED Living Lab
Size	Large-scale	Small-scale
Technology	Wind	Solar
Power capacity (KWp)	100	12
Area (Ha)	7000	< 1
Year commissioned	2021	2022
Ethnic group	Maasai	Maasai
Community	Kipeto	Olderkesi
Land use	Grazing/Agriculture	Grazing/Agriculture
Access to electricity	No	No
Property Rights	Private land ownership	Communal land ownership (Transitioning to Private land ownership since 2020)

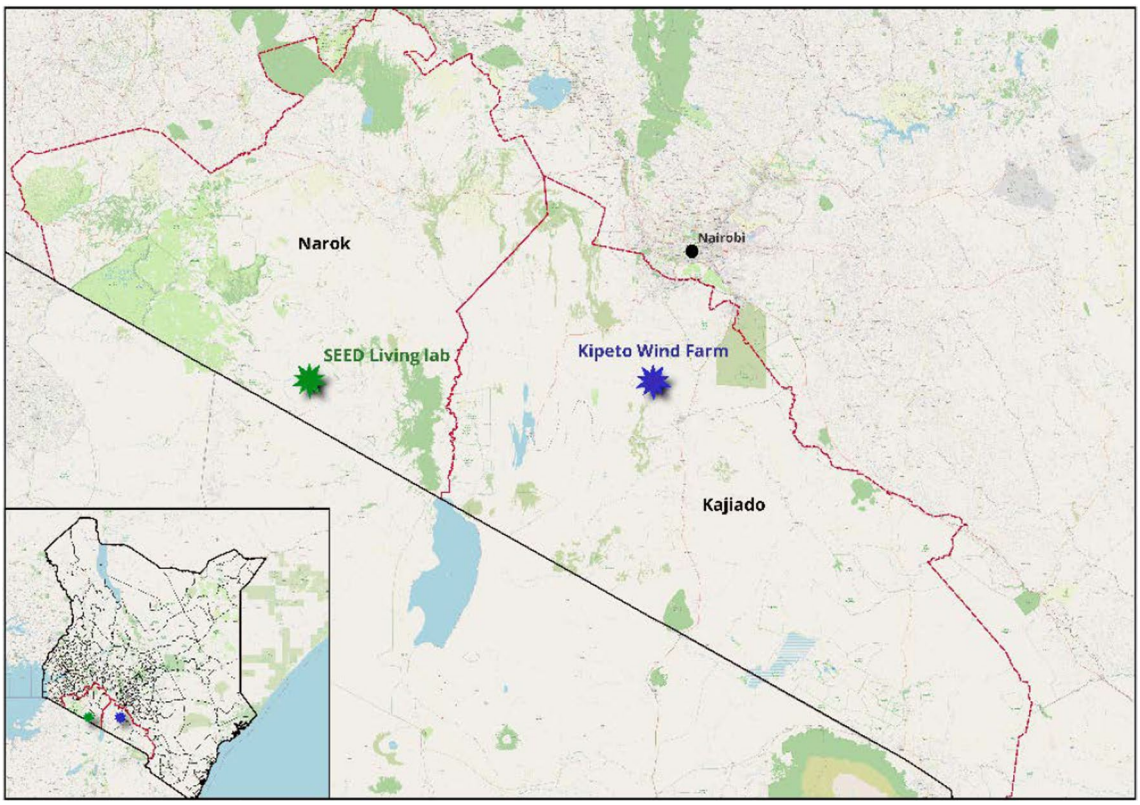

Fig. 2 Location of the case studies

practices and community involvement. The SEED Living Lab was also developed in cooperation with members of selected rural communities to create a direct impact by ensuring energy access and improving living conditions through local entrepreneurship opportunities. The microgrid is owned by Community Interest Companies (CIC). This business model emphasizes commitment to both sustainable energy provision and a business approach that prioritizes social impact within the community.

3.2 Data collection

The data collection was designed to comprehensively finding and exploring artifacts and evidence related to the trade-offs inherent in the behavior, rationales, decision-making processes, and governance structures of the

communities involved in large-scale and small-scale renewable energy projects. To achieve this, we adopted a threefold approach (see Table 3). Semi-structured interviews were conducted with key stakeholders, including community members, local leaders, government officials, and project developers. These interviews aimed to gather in-depth insights into the motivations, considerations, and decision-making processes guiding the trade-offs made by communities concerning land use and electricity access. Additionally, these interviews explored the roles assumed by different actors within the community and their perspectives on the governance structures leading to these trade-offs. Focus group discussions were conducted to facilitate interactive dialogue among community members, allowing for the exploration of individual and collective decision-making processes, social and cultural norms, and power dynamics influencing land-electricity trade-offs. This participatory approach allowed participants to share their perspectives, experiences, and concerns regarding the implications of such trade-offs on their livelihoods, land rights, and overall community well-being. To initiate engagement, community leaders were approached first to seek their support for our research. Once their approval was obtained, community meetings were organized to introduce the research team and explain the purpose and objectives of the study. Community members were then actively engaged throughout the research process, and efforts were made to ensure the inclusion of diverse voices and perspectives, by seeking input from various stakeholders, including men, women, youth, and elders. This participatory approach helped to foster trust and rapport with the community, facilitating open and honest communication. Moreover, the use of local assistants and translators, who were familiar with the cultural nuances and local dialects, ensured effective communication and minimized language barriers. Finally, a comprehensive review of grey literature, referring to materials and research produced outside of traditional peer reviewed publishing, was conducted involving environmental and social impact assessment reports, policy documents, and community engagement records, to supplement the collected primary data and provide contextual background and insights into the historical, social, and policy dimensions shaping land-electricity trade-offs in Kenya.

The interviews and focus group discussions were conducted in the Nairobi, Kajiado, and Narok areas, where the renewable energy projects were located. They were held in a relaxed and informal setting, often taking place in the village center or local gathering spots, to ensure participants felt comfortable and at ease. Field observations were conducted during site visits to the communities involved in the projects, which took place between February and March 2023. Additionally, complementary online meetings were held before and after each visit to maintain communication and ensure ongoing engagement with the participants. The ethical approval for this research was granted by the Jomo Kenyatta University of Agriculture and Technology (JKUAT), which supported and collaborated with us throughout the research process, ensuring alignment with international ethics standards. For ethical reasons, informed consent was obtained verbally from all participants prior to their involvement in the study. They were provided with information about the study's purpose, and interviews procedures, and they voluntarily agreed to participate. Furthermore, to safeguard participants' confidentiality, all personal information was excluded from the study.

3.3 Data analysis/interpretation

Data analysis/interpretation focuses on relating and integrating our empirical findings on trade-off practices, choices, and justifications to our theoretical framework. We followed a thematic approach focusing on identifying recurring themes, patterns, and nuances within the interview transcripts, focus group discussions, and grey literature [49, 50]. Thematic analysis enables the exploration of the sequence of decision-making processes, alignment of decisions with established rules and norms, and behavioral responses of communities under varying contextual circumstances. This involves several steps. First, we familiarize the participants with the data to gain a comprehensive understanding of the content. Subsequently, an initial coding phase was undertaken to systematically categorize and structure meaningful data segments. Following this, we attributed the potential thematic based on similarities and connections. These themes were reviewed and refined to ensure coherence and relevance to the research questions. Finally, themes were cross-referenced with the entire dataset to verify their consistency and comprehensiveness. Moreover, the analysis seeks to uncover the role of institutional logic in shaping and guiding the dynamics of these trade-offs in energy projects. By drawing upon the IAD framework, the interpretation aims to discern the interplay between communities' actions and their roles, positions, and rules, shedding light on the factors that contribute to cooperation or conflict in decision-making processes related to land use and electricity access. This analysis provides a comprehensive understanding of the complexities surrounding land-electricity trade-offs and community governance structure.

Table 3 Collected data

Data collection method	Case study	Interview	Participants
Primary data: Semi-structured interviews Focus group	Kipeto Wind project	Interview 1	1 Local project coordinator – Technical team 1 Assistant project coordinator – Technical team
		Interview 2	1 Local project coordinator – Biodiversity team 1 Assistant project coordinator– Biodiversity team
		Interview 3	1 Local representative of Kaijado county government
		Interview 4/ Focus group	4 Households/Community members
	SEED Living lab	Interview 5	1 local project coordinator 1 Assistant project coordinator
		Interview 6	1 Local representative of Narok county government
		Interview 7	1 Local representative of Ministry of Land, Nairobi
		Interview 8/ Focus group	Maasai Land committee (6 elders of the Olderkesi community)
		Interview 9/ Focus group	6 Community members
	General	Interview 10	1 Land Tenure professional, Nairobi
		Interview 11	1 representative of the Ministry of Land, Nairobi
		Interview 12	1 representative of THE Rural Electrification and Renewable Energy Corporation (REREC)
Secondary data Gray literature	Field observations		-Direct observations made during site visits to both projects
	Review of formal documents		Government reports or policies related to land management and renewable energy projects in Kenya Reports from international organizations such as the United Nations or World Bank Impact assessment reports
	Review of informal documents		Transcripts of discussions with community members Online sources such as websites, publications, and reports

4 Findings: uncovering narratives, rationales, and land-electricity trade-offs

4.1 Small versus large-scale approaches to electrification—different narratives and trade-offs?

Our data revealed diverse narratives and significant trade-offs related to land and energy when exploring the contrast between small- and large-scale approaches to electrification. Smaller projects demonstrate distinct reasons and decision-making processes compared with larger projects when considering the exchange of land for electricity. In our case studies, both rural communities lacked access to electricity, presenting an opportunity to explore different electrification approaches. The distinction between small-scale and large-scale projects lies in their fundamental philosophies: customer-centric versus grid-centric [51]. Our interviews showed that the small-scale project adopted a customer-centric approach, as it prioritized the needs and preferences of end-users, who are members of the community. The planning phase relies on the active participation and engagement of the local community, which provides inputs for understanding their energy needs, lifestyles, and expectations. From a technical perspective, the project involves deploying a modular solar PV solution tailored to current energy needs. The modular design allows for scalability, facilitating the addition of modules as the community grows or its energy demands change without necessitating a complete overhaul. This adaptability not only keeps the energy infrastructure aligned with evolving needs, but also allows communities to adopt and integrate this modern technology over time. Another important aspect is the affordability and accessibility of the project; small-scale project developers must ensure that the community can afford and access the electricity solution. The SEED living lab involved the establishment of a community cooperative. This model places community empowerment as a central goal, achieved through involvement in decision-making processes and fostering a sense of ownership and responsibility for the energy system. In contrast, our interviews revealed the focus of the grid-centric large-scale project on developing a centralized infrastructure that prioritizes regional efficiency over community-specific needs. Our data showed that this approach involves creating a comprehensive centralized electricity grid, requiring larger land areas and substantial investments in transmission lines and substations. By prioritizing economies of scale, the project aims to achieve cost efficiency by serving a larger population but not community members. Additionally, the decision-making and planning for grid-centric projects are typically top-down, with less direct involvement of the local community in the planning, construction, and maintenance phases, which led the Kipeto Wind farm project to face several conflicts. Thus, we conclude that while the customer-centric approach of a small-scale project fosters a deeper involvement of the community, it may face challenges in terms of scalability and upfront costs. However, the grid-centric approach may encounter resistance from local communities and lack flexibility in addressing local needs.

4.2 Powering communities: to connect or disconnect to electricity?

Providing direct access to electricity to communities has emerged as a critical factor in the complex negotiation of land allocation for renewable energy projects. In our case studies, two distinct approaches were adopted. While the SEED Living Lab prioritized providing electricity directly to community members, the Kipeto Wind Farm did not consider the community as one of its primary beneficiaries. This dichotomy is again justified by the customer-centric approach of the SEED Living Lab, which emphasizes meeting the specific needs of the local community, versus the grid-centric approach of the Kipeto Wind Farm, which prioritizes regional efficiency over community-specific considerations. This highlight contrasting philosophies regarding community engagement and benefit distribution in electrification projects. Despite these variations, both communities in both cases need to keep the project operating on their land, and their involvement when the system comes into operation will significantly influence the long-term continuity of the projects. As the SEED living lab primarily benefited the community, our interviews showed that community members played an active role in deciding which and how roles and benefits were allocated within the project. This active involvement helps foster a sense of ownership and responsibility, contributing to conflict avoidance and the project's long-term sustainability. The interviews also highlighted the influence of communal land tenure and Maasai culture, as these decisions were mostly guided by community traditions and made by the elders, who served as chiefs within the community. However, the SEED living lab also faced a challenge in defining who receives electricity and benefits from the project within the local community. In its first phase, the project gave priority to business owners in the area, as they were considered customers with enough financial capacity to afford

electricity services. While this approach reflects a strategy aimed at ensuring the project's financial sustainability, it raises questions regarding whether it effectively and adequately meets the energy requirements of every community member. To address this concern, the second phase of the project is promised to the community, with plans to connect the rest of the households once sufficient funding is secured, aiming for a more comprehensive and equitable distribution of electricity benefits. This non-inclusive distribution mechanism not only risks creating disparities but also leaves certain members of the community underserved or excluded from the project's guaranteed positive impacts. Such inequalities can worsen the existing socioeconomic divide and threaten the communities' trust in the project's overall effectiveness. The interviews showed that there is a pressing need to reassess distribution strategies while balancing electricity access and ensuring project inclusivity.

Meanwhile, the choice of not directly connecting community members to the electrical grid has led to a major conflict when developing the Kipeto Wind farm, despite the use of their individual lands for energy production. This discrepancy in the distribution of benefits created tensions and grievances among the community members. The company proactively addressed this issue by gifting solar home systems. This strategic action aimed to mitigate the conflict arising from the disconnect between land use and direct benefits, as well as to secure ongoing support for the wind farm project. However, although the provision of home solar systems alleviated some immediate concerns, it did not fully address the underlying issue of equitable benefit distribution. Our interviews also indicated that community members expressed concerns regarding the reliance on solar home systems as a substitute for direct grid connection due to their limited capacity and reliability. They felt that this approach may not be sustainable in the long term, especially considering the visible presence of wind farms in their vicinity. They also felt excluded from the economic opportunities and energy access provided by the wind farm, which highlights the limitations of partial solutions in addressing the complex socio-economic challenges inherent in large-scale energy projects, particularly in rural areas. The Kipeto Wind Farm case demonstrates the importance of reconciling land use benefits with direct energy provision for sustainable project outcomes.

4.3 Empowering communities: individual versus communal approaches to electrification

Communities with private land ownership, relying on individuals and individual assessments, make various kinds of trade-offs related to land and electricity than communities with communal land tenure, who still function using community rules and making decisions as a group. In both cases, the observations demonstrate that the land tenure system distinctively influenced the boundary and aggregation rules within the community. Communal land tenure within the SEED living lab community played a significant role in the decision-making process. Following Maasai traditions and norms, siting the project was predominantly determined by the community's elders, as they held authority and influence over communal land decisions. The elderly, acting as land custodians, hold significant control in shaping the landscape, both in its physical form and social dynamics. This influence extended to not only choosing the project location but also evaluating land use plans for activities such as grazing and housing, as well as the distribution of benefits. Decision-making and resource allocation are often guided by a collective mindset that prioritizes the community's overall lifestyle and welfare. Most community engagement occurs among the community's elders. The project developer would convene meetings with them, following which the elders would consult with the wider community before deciding. This traditional decision-making method ensures that the broader community's voices are acknowledged and considered. However, this communal approach, which is rooted in tradition, presents challenges to ensuring the inclusion of specific groups, particularly women and youth. Due to the patriarchal aspect of Maasai culture, where land ownership is often dominated by men, women and youth find themselves marginalized from decision-making and have more difficulties in advocating for benefits that directly address their needs. Hindered by limited access to clearly defined land, they struggle to envision future development opportunities from the project. This can lead to challenges in clearly defining individual rights and entitlements and balancing access and inclusion within the community, as seen in the ambiguity surrounding who receives electricity and benefits.

For the Kipeto Wind Farm, individual land ownership dynamics within the community add complexity to the project's decision-making process. Balancing the communal approach with the recognition of individual rights proved to be a source of conflict and requires careful consideration. For the Kipeto wind power project, consultations were complicated, time-consuming, and required heavy financial investment, as the company had to negotiate with each landowner individually, and then collectively as a community, which complicates project development if one of the landowners opts out of the project at any stage. Moreover, community consultation needs to be conducted regarding the different elements of the project, for turbine installation, transmission lines, and other infrastructures. Then, decisions regarding land acquisition are made at various levels, including the household level, the family level in the case of multi-household families, village elders,

and a community implementation committee consisting of landowners, elders, women, youth, provincial administration, and representatives of the company. Beyond meetings with community members, consultations also involved the Kajiado County government, Environmental and Indigenous Rights Non-Governmental Organizations, and other stakeholders. In summary, the impact of land tenure systems on the boundary and aggregation rules is evident in both cases. The communal land tenure system in the SEED living lab community, rooted in Maasai traditions, shapes decision making but poses challenges in inclusive participation. The Kipeto Wind Farm navigates complexities arising from individual land ownership, requiring extensive consultation and multilevel decision-making processes, highlighting the complex relationship between land tenure and community engagement in renewable energy projects. In sum, land tenure regimes influence trade-offs.

4.4 Lease versus donation for renewable energy implementation

In both cases, communities have made different trade-offs regarding land acquisition for the implementation of each of these projects. For the SEED Living Lab, the decision to donate communal land to the project developer for free, despite its relatively small area, reflects an unconventional, yet strategic choice, as typically giving out land for free without receiving compensation is uncommon. From our interviews, we understood that the rationale behind this decision was to initiate a trade system, trading (access to) land for (access to) electricity, without any monetary compensation for the loss of access to land. This choice stemmed from a pragmatic understanding that the government might not connect the community to the grid given the geographical challenges and associated high costs, so it is deemed better to use at least some electricity rather than no electricity, even if this means that they lose some of their land tenure claims. The project initiators promised to hand over full ownership of the community at the end of the project, which provided an incentive for the community to accept the trade-off of land without any compensation; however, as of now, administrative ownership of the project remains with the developers. Handing-over depends on the community's capacity to manage electricity independently. The skills and knowledge acquired would empower the community, allow for the effective management and maintenance of the project, and secure its long-term impacts. This long-term perspective aims to empower the community economically and socially, as it emphasizes long-term control and ownership alongside immediate electricity access. However, challenges such as delays in providing access to electricity to the rest of the members, postponements in ownership transfer, and capacity-building issues may affect the community's decision-making process and willingness to provide more land for the second phase of the project. These challenges could undermine community trust in the project and hinder their willingness to make future concessions, thus impacting the project's success and community's overall development.

For the Kipeto Wind Farm, after consulting with the community, the decision was made to establish inclusive benefit-sharing structures by opting for land leasing instead of purchasing or compulsory acquisition. Although these options were easier and less costly, community pressure persuaded the project developer to opt for leasing land. They agreed on an annual lease rate that varied with the acreage. Furthermore, the company chose to allocate a five percent share to the landowners through community trust, aiming to extend benefits beyond those directly affected by the project and contribute to the broader community's and county's development. These two compensation models offer opportunities for individual and community development, but each comes with its own set of challenges and considerations. While paying individuals or households through lease contracts may seem simpler, it also carries risks as they may lack the financial literacy needed to make informed decisions about investing and spending, potentially hindering their socio-economic development. However, the community trust model is more complex, requiring unanimous agreement from the entire community for fund utilization to ensure benefits are directed towards community-wide interests rather than individual interests. In conclusion, the SEED Living Lab's unconventional donation of communal land reflects a strategic trade system that emphasizes immediate electricity access and long-term community empowerment. Meanwhile, Kipeto Wind Farm's decision to lease land, driven by community pressure, demonstrates a commitment to inclusive benefit-sharing and broader community and county development. These varied choices highlight the adaptability and strategic alignment with local needs and sustainability.

5 Discussion

The findings from this analysis through the lens of the (IAD) framework provide new insights into decision-making processes and institutional dynamics related to the different roles and positions of the involved communities. Within both the SEED Living Lab and the Kipeto Wind Farm renewable energy projects, communities assume diverse roles and

operate under distinct rules while managing trade-offs between land interventions, clean energy development, and community engagement strategies.

5.1 Position and boundary rules: empowerment through participation

Position and Boundary rules play a critical role in shaping participation and decision-making in renewable energy projects. In both cases, the project brought new positions into the community, and we observed varying degrees of community participation and representation, influenced by factors such as communal land ownership and traditional governance structures. For the SEED Living Lab, the community assumed various roles, such as producers, consumers, operators, and owners of the project, which promote inclusive decision-making. However, communal land ownership limited participation to community elders and men, maintaining their dominance as decision-makers and beneficiaries, thereby potentially compromising representation, and inclusivity. In contrast to the Kipeto wind farm project, some members were considered producers because of the use of their land energy production and with no designated consumers, suggesting limited involvement in decision-making and potential conflicts arising from rigid boundary rules. Nevertheless, private land ownership has facilitated active engagement from individuals and households, enabling diverse perspectives and interests to shape project outcomes.

Overall, our findings reveal nuanced dynamics influenced by the projects' approaches to land acquisition and community engagement. It is essential to recognize that power dynamics within communities are complex and multifaceted, influenced by factors such as gender, age, and socio-economic status. Further exploration of the role of community leaders and power dynamics within decision-making processes is necessary to better understand how these factors shape project governance and community representation. Moreover, land acquisition, whether by lease or donation, significantly shapes the decision-making process and eventual project outcomes. A different approach leading to dispossession or displacement could have resulted in divergent project trajectories. And both projects face challenges in reconciling modern energy infrastructure with traditional land uses and rights, which may conflict with grazing areas, wildlife migration routes or cultural sites, raising questions about land use prioritization and its future potential impacts on community livelihoods.

5.2 Choice and aggregation rules: navigating decision-making dynamics

The analysis of land acquisition choices in both cases further highlights disparities and emphasizes the critical role of choice and aggregation rules in shaping decision making and resource allocation within renewable energy projects. In the SEED Living Lab, choice rules prioritize local community participation and engagement, enabling flexible decision making aligned with local needs and preferences. Simultaneously, the aggregation rules facilitate community-led decision-making processes, fostering a sense of ownership and responsibility. In the Kipeto Wind Farm project, choice and aggregation rules may lean towards centralization and individualization, shifting project objectives from community needs to regional needs and community benefits to individual benefits. Choice and Aggregation Rules have also led to the installation of a dual-level approach to decision-making for the Kipeto wind farm, encompassing both individual and community perspectives, versus a one-level approach to decision-making for the SEED living lab rooted in traditional knowledge and communal consensus. Additionally, long-term leasing coupled with individual land tenure offers stability and community engagement opportunities by providing more structured land use planning and facilitating more robust negotiations for compensation or benefits schemes. This model not only ensures that community members retain a degree of control over their land but also enables them to actively participate in the project's development and share its benefits. The donation-based model, coupled with communal land tenure, lacks a structured compensation system, leaving affected community members without tangible benefits in exchange for their land, especially among marginalized groups already facing socio-economic challenges. Furthermore, a lack of transparency in land use and land rights can eventually lead to conflicts.

5.3 Scope and information rules: defining jurisdiction and transparency

The outcome narratives within and by communities are influenced by scope and information rules. In the SEED Living Lab, scope rules helped prioritize community-specific outcomes. The customer-centric approach and the small-scale and communal land tenure system collectively contributed to outcome narratives that are likely to emphasize community empowerment and active participation. The community engaged in decision-making and ownership highlighted easier

electricity access, economic benefits, and skill development through capacity-building initiatives. The community in this case was also in charge of land use planning in a way that aligned with their cultural and environmental values, specifically for grazing activity, business activity, and other communal needs. This responsibility extends beyond energy considerations to encompass broader aspects of community well-being and sustainability. Positive outcomes may be framed in terms of improved socio-economic status, self-sufficiency, and stronger collective links. The information rules helped to set up a bottom-up approach in information communication channels, as regular meetings were held between the project developers and community leaders, followed by consultations among the leaders and the broader community throughout the project development phases, which reinforced transparency and community trust. However, the community's one-level decision-making approach can unintentionally restrict access to information for certain members of the community, particularly women and youth, which challenges inclusivity within the project narrative.

In the Kipeto Wind Farm, scope rules helped prioritize individual-specific outcomes. The grid-centric approach, large-scale, and individual land ownership have jointly facilitated outcome narratives that are likely to emphasize individual needs, regional efficiency, and economic growth. Community members benefit from job creation and infrastructure development and are included in broader county development. The centralized aspect of the project helped establish a top-down approach in information communication channels, as the main decisions were predominantly made at the project developer level, where community members could only negotiate for certain benefits, potentially limiting community access to critical information and overlooking community-specific needs. In this case, the community did not assume direct responsibility for land-use planning, as the turbine location was decided by the project's technical team. Consequently, community members had to adapt their grazing paths and activities to accommodate the presence of wind turbines. Other challenges include the complex and time-consuming nature of consultations with individual landowners and the whole community, potential conflicts, and the need for comprehensive community engagement to secure ongoing support. This centralized approach may undermine trust in project outcomes by neglecting to consider the intricacies of local contexts and preferences, thus highlighting the importance of ensuring transparency and inclusivity in the information dissemination and decision-making processes.

5.4 Payoff rules: balancing costs and benefits

In both cases, the renewable energy project was considered a catalyst for rural development, as they both brought along economic benefits, emphasizing opportunities for economic development. The scale of renewable energy projects and the land acquisition approach are determining factors for revenue distribution and, thus, rural development. As shown in our analysis, the larger the area of land used, the greater the benefits for the community [45], and local ownership is recognized as a means of retaining economic benefits in a local economy. However, our examination reveals several challenges and limitations encountered during the implementation of these projects, notably delays in electricity access, as the SEED Living Lab's gave initial priority to business owners over households, while the Kipeto wind farm project gave priority to the national grid over the community itself, underscoring issues in equitable distribution. Capacity-building issues were also particularly present in the SEED Living Lab, where community members lacked the necessary skills and knowledge to effectively manage and maintain the energy infrastructure, a challenge aggravated by delays in training programs due to resource constraints. Also, Kenya does not have a law that governs how communities benefit from investments in and on their territories. The distribution of these economic benefits for rural development can be challenging and conflictual, as it seemingly depends on the goodwill of the project developer and the landowners in the case of private ownership, or of the elders in the case of communal landownership. Additionally, payoff rules are intricately linked to the choice of project scale. Due to the pressing need for a carbon–neutral energy sector, emphasizing the economy of scale, both national and international energy policies are clearly prioritizing larger renewable energy projects [52], as they require, absorb, and generate more capital, and their revenues are strategically directed to initiate long-term economic effects. Small-scale projects, with partial or full community ownership, can be more easily sustained by communities and are meant to maximize longer-term income, with a relatively small capital requirement. All these challenges could become significant obstacles to realizing the intended benefits of the projects for the communities involved.

Overall, to improve the decision-making processes in renewable energy projects, it is crucial to empower community participation by establishing inclusive structures that recognize diverse roles, particularly for marginalized groups. Also, prioritizing local needs through flexible decision-making can foster a sense of ownership and responsibility among community members, and transparency in communication channels is crucial, ensuring that all individuals, including women and youth, have access to information and can engage meaningfully. Finally, a fair revenue distribution framework should

consider project scale and land acquisition approaches to ensure that economic benefits contribute to long-term rural development and community well-being.

6 Conclusion

Rural areas are crucial for the energy transition, providing new opportunities through renewable energy deployment. However, despite abundant resources, many rural communities are still trapped in energy marginalization and under development, as both large-scale and small-scale renewable energy projects involve various complex trade-offs that impact communities in terms of changing land rights, land use, and land access. To understand how these communities engage in land-for-electricity trade-offs and the mechanisms and motivations underlying their decision-making processes, we explored two renewable energy rural electrification projects in Kenya: the large scale Kipeto wind farm project, and the small-scale SEED living lab, both implemented in rural Maasai land.

Through the lens of the (IAD) framework, our analysis unveils the trade-offs related to decision-making processes, institutional dynamics, and varying land interventions made by each community, while including the factors of communal and individual land tenure systems that present distinct challenges and benefits. Position and boundary rules confirmed that engaging a community requires an initial comprehension of the roles and responsibilities of its members, in addition to what is included and excluded within each community. Similarly, choice and aggregation rules emphasize the necessity of providing clarity regarding available options and how decisions will be made individually, collectively, or through designated authorities. Scope and information rules highlight the need to delineate project outcomes and ensure transparent access to relevant information, particularly in terms of future land use, land rights, and environmental and social concerns. Finally, the payoff rules stress the importance of clearly defining how costs and benefits will be distributed among participants and stakeholders to facilitate effective community engagement.

The strength of the IAD framework is its structured approach, which provides a useful frame of reference for analyzing this complexity. It has proven effective in facilitating a nuanced examination of distinct challenges and opportunities within the renewable energy institutional framework. However, its weakness lies in its categorization of all these rules under the single term of rules in use, which fails to distinguish between internally generated and externally imposed rules and between how rules are meant to be understood and applied versus how they are interpreted and applied in practice, thus overlooking further distinctions in their specific impacts on actor choices and interaction patterns. Additionally, the qualitative nature of our research, based on interviews and community consultations, presents limitations related to sample size and scope. Moreover, these communities were impacted not just by the energy provision itself, but also by how it is deployed, and their narratives reflect the challenges associated with the selected electrification approach, mainly concerning individual and collective benefits as well as local and regional economic development opportunities. Many trade-offs were relational, as they were affected by the interactions between land tenure systems, scale of the project, traditional knowledge, and local context. Although some might be consistent across projects, others vary according to the different project motivations and roles of the community.

Beyond this specific case of Kenya, the IAD framework has broader applications for understanding the institutional dynamics of renewable energy development in rural areas across diverse regional and international contexts. Future research, using comparative studies across diverse cultural and geographical contexts, can explore how institutional rules shape community engagement, decision-making, and land-energy trade-offs in various settings. This is particularly relevant for regions undergoing similar rural energy transitions, where land tenure systems, community governance structures, and socio-economic conditions influence renewable energy deployment. Furthermore, conducting longitudinal studies which include in-depth data that captures not only community perceptions, but also quantifiable metrics related to land-energy tradeoffs is crucial to monitor the evolution of these trade-offs over time. This comprehensive strategy can help identify the best practices applicable across diverse settings and improve our understanding of the complex interactions between renewable energy projects development and rural community dynamics.

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Data availability This study was conducted as part of a collaborative research project between the Technical University of Munich (TUM), Germany, and Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya. The research was conducted following best practices in research ethics and adhering to principles of good scientific practice. Formal ethical approval was not strictly required, and the study complied with these practices to ensure ethical rigor. The Technical University of Munich (TUM) provided oversight for the research design, data analysis, and overall academic guidance, ensuring compliance with the principles of good scientific practice. And Jomo Kenyatta University of Agriculture and Technology (JKUAT) facilitated the data collection and participant interactions in Kenya to comply with local ethical guidelines and regulations. Due to the nature of this research and the need to protect the privacy and confidentiality of the research participants, the supporting data is not publicly available. This restriction aligns with ethical guidelines, the informed consent provided by the participants, and the principles of good scientific practice. However, the data that support the findings of this study can be made available by the corresponding author, B.E.H.L upon reasonable request.

Declarations

Competing interests The authors declare no competing interests.

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