A novel political ecology approach to low-carbon energy transition in rural Ghana

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Abstract

Title: A novel political ecology approach to low-carbon energy transition in rural Ghana

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Despite clean energy solutions being critical for sustainable development, their uptake in the Global South has been slow. This research lays down the fundamentals for rethinking energy transition by reviewing the theoretical perspectives of energy justice, socio-technical transitions, and political ecology and presents a plausible way to approach an equitable low-carbon transition using political ecology as a broad framework.

Drawing on primary data collected in the Kwahu Afram Plains North and South Districts of Ghana, the research examines the residential energy situation of off-grid rural communities, an understudied region where access is largely described as the provision of an energy source. It explores household energy decisions, perspectives on the energy-environment-livelihoods nexus and the role of key actors in the transition process, recognising their influence on clean energy adoption.

The findings highlight how political dynamics shape energy distribution, often reinforcing existing inequalities. Energy access is identified as not solely a technological challenge but a broader socio-political issue constrained by affordability, availability and limited household knowledge. Economic ties to charcoal production further hinders households' clean energy adoption, demonstrating how local livelihoods intersects with energy choices.

Despite the involvement of both the state and non-state actors, the findings indicate that the transition process lacks coordination due to competition among private clean energy providers and weak collaboration between actors. Various forms of exclusions and injustices are found to characterise transition at the household level. The findings of this research thus, offer valuable insights for charting future directions to attain transition objectives, aligned with the Sustainable Development Goals and African Union's *Agenda 2063*.

Keywords: Energy access; Low-carbon energy transitions; Off-grid communities; Rural Ghana; Clean energy

Declaration

I hereby affirm that this thesis is my own work, completed without unauthorised aid from others. All ideas and information sourced externally have been correctly cited. This thesis has not been submitted, either partially or fully, to any examination board, whether in Ireland or internationally. The work was conducted under the supervision of Dr. Julian Bloomer and Dr. John Morrissey at Mary Immaculate College, Limerick from 2021 to 2024.

Dickson Boateng,

Limerick, 2024.

Statement of Contribution

For all the chapters of the thesis, the candidate was responsible for conceptualising, gathering data, analysing and interpreting the results. The candidate was also the first author on three of the four publications from the findings of the study. The PhD supervisors contributed as co-authors on these by offering guidance throughout the process and reviewing all drafts. The Research and Graduate School also provided essential support and advise during the PhD.

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"A paddle here, a paddle there – the canoe stays still" – African proverb.

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Chapter 5	A Burning Desire: Trying to Achieve SDG 7 and Improving Access to Cleaner Cooking Fuels in Rural Ghana'	Published	*Living with Energy Poverty*, 1st ed., Routledge
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Chapter 6	Dilemmas and decision-making: Exploring households' perspectives on the energy-environment-livelihoods nexus in off-grid rural Ghana	Published	*Energy for Sustainable Development*
Chapter 7	Shifting away from unclean energy; Perspective of Ghanaian stakeholders on achieving just transition	Under review	

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List of Abbreviations

MDG ………………………………………………………… Millennium Development Goals

SDG ……………………………………………………….. Sustainable Development Goals

SSA ………………………………………………………………….. sub-Saharan Africa

GHG …………………………………………………………………… Greenhouse Gas

LPG ………………………………………………………………. Liquefied Petroleum Gas

PV ……………………………………………………………………….... Photovoltaic

SHS …………………………………………………………………. Solar Home Systems

SNM ……………………………………………………….. Strategic-Niche-Management

TIS …………………………………………………………. Technological Innovation System

STT ………………………………………………………. Socio-technical Transitions

PESET………………………. Political Ecology framework for Sustainable Energy Transition

NGO ……………………………………………………... Non-Governmental Organisation

STS ……………………………………………………….. Science and Technology Studies

IS ………………………………………………………………….... Innovation Studies

STI ………………………………………………………. Science, Technology and Innovation

OECD …………………………… Organisation for Economic Co-operation and Development

KAPN ………………………………………………………. Kwahu Afram Plains North

KAPS ………………………………………………………….. Kwahu Afram Plains South

IPP ……………………………………………………….... Independent Power Producers

GRIDCo ………………………………………………………….... Ghana Grid Company

ECG .... Electricity Company of Ghana

NEDCo .... Northern Electricity Distribution Company

LPG4D .... LPG for Development

REMP .... Renewable Energy Master Plan

NET..National Energy Transition

RLP .... Rural LPG Promotion Program

MP .... Member(s) of Parliament

DCE .... District Chief Executive

UHI .... Urban Heat Islands

IEA .... International Energy Agency

ACEP .... Africa Centre for Energy Policy

GHACCO .... Ghana Alliance for Clean Cookstoves and Fuels

1. INTRODUCTION

1.1 Energy access in the Global South

Access to energy is widely regarded as a right and hence its demand proportionately rises with population growth (Bradbrook and Gardam 2006; Löfquist 2020) Although energy was not explicitly considered in the Millennium Development Goals (MDGs), the Sustainable Development Goals (SDGs) clearly take it into account, namely SDG 7. The strategic plan of the United Nations Development Programme (UNDP) considers access to energy as a crucial enabler towards attaining sustainable development (UNDP 2021; United Nations 2023).

Despite its role in sustainable development, one in every ten people globally has no access to electricity and are therefore excluded from its benefits. This figure is projected to rise to some 652 million by 2030. More so, about 2.8 billion people (a third of the world's population) still cook without clean fuels and more efficient technologies. A substantial number of these people reside in the Global South and consequently, there is a surge in energy demand in the region (Sackeyfio 2018; IEA 2021a; UNDP 2021).

As the global population is expected to reach 9.7 billion by 2050, there will be a commensurate rise in greenhouse gas (GHG) emissions from the energy industry (United Nations 2022; U.S. Energy Information Administration 2023). With energy consumption being a major source of anthropogenic GHG emissions, coupled with an ever-increasing demand in the Global South, associated GHG emissions are estimated to increase in the region. This has brought to the fore the global need for a low-carbon energy transition to ensure that not only do people get access to energy but also, to one that is environmentally friendly (World Resources Institute 2020; IEA 2021b; UNDP 2021).

As the United Nations Secretary General, António Guterres, puts it:

"*A fair, just, equitable, and urgent transition from dirty fossil fuels to clean energy is essential to avoid the worst of climate chaos and spur sustainable development*" – (United Nations 2024).

1.2 Overview of energy access with a focus on rural Ghana

In sub-Saharan Africa (SSA), a region where many people use unclean fuels for cooking and lighting, actors are encouraged to invest and play a vital role in the clean/modern/new energy transition (UNDP 2021; Mulopo 2022). Consequently, decentralised clean energy transitions have gained traction in the region over the years (Liao *et al*. 2021). However, some actors (e.g. governments, companies and researchers), similar to those identified in other regions, are likely protect the status quo by slowing down or taking advantage of the process for their own benefits, as highlighted by Goldthau (2017), Stephens and Surprise (2020) and Si *et al*. (2023). For instance, some fossil fuel companies have obstructed climate action by advocating for the use of natural gas (Si *et al*. 2023).

A swift action on just transition in SSA is anticipated to protect the environment, people's health and provide livelihood opportunities for a lot of people and hence, is a key principle in the Paris Agreement and the SDGs, which aims to ensure universal access to affordable, reliable and low-carbon energy services (UNDESA 2021). However, this shift is likely to perpetuate energy injustices and may pose a challenge to achieving other SDGs, such as SDG 1 (end poverty), SDG 2 (achieve food security) and SDG 3 (promote good health and wellbeing).

A transition to an equitable low-carbon energy system in SSA remains a great challenge confronting many countries. This challenge is exacerbated by the existing rural-urban disparities in energy access, which Minas *et al*. (2024) recommends has to be addressed to achieve SDG 7. Ghana, an SSA country committed to reducing greenhouse emissions under the Paris Agreement, exemplifies this situation — facing unequal access to low-carbon energy systems, and having a pronounced rural-urban divide in clean energy availability. Thus, like other countries of SSA, achieving an equitable low-carbon energy transition remains a challenge in Ghana (SE4ALL 2017; Baker *et al*. 2021; MESTI 2021).

1.2.1 The state of energy in rural Ghana – Electricity

There is a divide in electricity access in Ghana despite the country having a high electricity grid access, with about 85% of its population having access. However, the access rate in rural Ghana (74%) is low compared to urban Ghana (94.7%) (Sackeyfio 2018; Energy Commission of Ghana 2019; World Bank 2022b). This is partly due to the perception that some rural communities are too remote and dispersed, making it not cost effective for the government to expand the electricity grid there (SE4ALL 2012, 2019).

Following its crucial role in most sectors of the economy, especially the manufacturing and service sectors, the absence of electricity has adversely impacted the prosperity and well-being of rural dwellers (Kanagawa and Nakata 2008; Niu *et al*. 2013). To meet their electricity demands, some rural households often resort to kerosene lamps, candles and battery-powered LEDs which are regarded as unclean because of their impacts on the environment and public health (Obeng *et al*. 2008; Bailis *et al*. 2015; GPOBA 2016; Bensch *et al*. 2017; Muyanja *et al.* 2017).

1.2.2 The state of energy in rural Ghana – Cooking fuels

Woodfuels (firewood and charcoal) are the predominant sources of cooking fuel in Ghana – accounting for about 60% of the country's total energy consumption (Asante *et al*. 2018; Energy Commission of Ghana 2019a). The raw materials, primarily trees, are readily available in rural areas because of their proximity to forested areas. However, the usage of woodfuels is both urban and rural, although a relatively higher number of rural dwellers rely on them (Karimu *et al*. 2016; Wiedinmyer *et al*. 2017).

In rural Ghana, firewood is mostly used for cooking because it requires minimal time to prepare, unlike charcoal, which involves processes such as burning and drying, and is free of cost. On the other hand, charcoal production and sale provides a source of income to some rural dwellers. The production and sale of charcoal is very lucrative because of the ready market available, particularly in urban poor communities (Anang *et al.* 2011; Brobbey *et al*. 2015, 2019).

Although serving as a source of income and cooking fuel for rural dwellers, the consumption of woodfuels is a major contributor to environmental degradation, especially as live trees are recognised for producing the best charcoal, leading to deforestation rather than using fallen trees (Bensch and Peters 2013; Omer 2017). Furthermore, the production of charcoal and use of woodfuels contribute to anthropogenic GHG emissions, while indoor air pollution associated with the use of woodfuels also causes health problems for users (Sulaiman *et al*. 2017).

1.2.3 Expanding clean energy solutions in rural Ghana

Reflecting on the threat of unclean energy to the environment and rural development, actors have supported the investment in renewable energy, specifically in rural and off-grid communities. These investments have primarily focused on solar technologies, Liquefied Petroleum Gas (LPG) and improved cookstoves (Kemausuor *et al*. 2011; Bawakyillenuo *et al*. 2021; Ojong 2021).

Clean energy technologies, when effectively deployed, can save lives, protect the environment and create opportunities for rural households. The uptake of these technologies can address the energy needs, wants, and challenges of marginalised households, particularly, people living in rural and off-grid communities (Energy Commission of Ghana 2020).

Key actors in the energy sector of Ghana have championed the production and distribution of clean energy technologies, with the aim of enhancing off-grid rural communities' access to clean energy. Yet, these energy sources do not typically reach the intended beneficiaries and if they do, they are unable meet their energy demands.

Moreover, some of these technologies are not sufficiently suitable and affordable for the intended beneficiaries. This therefore generates new forms of exclusion, for example, when it comes to the question of affordability, availability, suitability, sustainability and diversification. Additionally, a shift to clean energy technologies may likely affect rural households whose livelihoods are largely dependent on the production and sale of unclean energy sources, such as charcoal.

1.3 Rationale of the study

As a decentralised clean energy transition continues to gain ground in SSA, gathering more information, specifically at the household level, remains crucial in future research (IEA 2020; Liao *et al*. 2021). However, if not properly contextualised, transition efforts could potentially deteriorate living conditions and/or lead to a situation where clean technologies are available but not utilised by households, thereby reinforcing existing inequalities (Bharadwaj *et al*. 2021; Sovacool 2021a; Otlhogile and Shirley 2023).

For example, introducing clean energy systems in communities without considering affordability and local economic conditions could lead to limited adoption. If households cannot afford the upfront costs or maintenance expenses, the technology may remain underutilised, despite being available. Similarly, if policies phase out traditional fuels without providing viable and accessible alternatives, low-income households may struggle to meet their energy needs, ultimately worsening their living conditions.

This is particularly important as decentralised energy systems in the region can at times fail to adequately engage community members, disregarding their social, technical and cultural practices, and positioning them merely as consumers (Eaton *et al*. 2014; Bukari *et al*. 2021a). Such inadequate community engagement has been identified by Bukari *et al.* (2021a) and Minas *et al*. (2024) as a barrier to accelerating decentralised renewable energy transition. Although energy access is conceptualised as a right, it is sometimes leveraged as a political tool to exert influence over off-grid communities, which can worsen existing inequalities in energy access. This situation may result from the limited political influence and low voting numbers of these communities (Bukari *et al*. 2021a).

According to Sovacool (2021a), "low-carbon transitions… can be viewed as power struggles and processes of exacerbating vulnerability" (Sovacool 2021a, p. 13). This implies that, in transitioning to cleaner energy technologies, there will inevitably be winners and losers. Thus, whereas the uptake of clean energy technologies has many benefits, it should not occur at the expense of traditional livelihoods (Bharadwaj *et al*. 2021). This prompts the need to examine the approaches actors employ when engaging with households.

To enhance the equitable adoption of clean energy technologies, Mfune and Boon (2008), Irfan *et al.* (2021), Sovacool and Griffiths (2020) and Ibegbulam *et al*. (2023) highlight the vital role of access to information or knowledge. Therefore, it is important that efforts aimed at transitioning households to clean energy technologies do not solely focus on the mere distribution of technologies but also, strive to bridge the knowledge gap among potential users.

Examining ways to advance social justice in the transition process, Stephens (2021) argues that:

> "*whether this happens depends on how the transformation evolves, how the new material supply chains are adjusted, who is included, who is excluded, and how the costs and benefits are distributed*" (Stephens 2021, p. 1208).

From this background, the rationale of this research was to firstly, illuminate the energy situation and decision-making processes of households in off-grid rural communities;

secondly, ascertain the knowledge households have on clean energy and the environment and the influence this knowledge has on their energy decisions and; thirdly, examine the strategies actors employ in transitioning rural households to the use of clean energy technologies.

1.4 Research questions

With an overarching aim to examine low-carbon energy transition under a novel political ecology lens, the study aimed to answer these four key research questions:

a) What are the connections between the concepts of energy justice, socio-technical transitions, just energy transition and political ecology?

- How can the concepts of energy justice, inclusive innovations and political ecology be unified in achieving just energy transition*?*

b) How can energy decisions of rural households be explained?

- What energy sources are available for rural households and what criteria do households prioritise when selecting an energy source?
- Are rural households able to meet their energy needs with their primary energy sources and why do households resort to woodfuels, in particular?
- What are the gender dimensions associated with access to woodfuels and cooking practices in households?

c) What are rural households' perspectives on the energy-environment-livelihoods nexus?

- What insights do rural households have on energy-environment issues and clean energy options and how does that influence their energy choices?
- What are the barriers preventing the adoption of clean energy technologies by rural households?
- What are the potential (dis)possessions associated with a low-carbon transition and how are households' livelihoods tied to unclean energy sources?

d) Who are the key actors in the low-carbon transition, and what strategies do they employ to improve access?

- Which actors are active in off-grid rural communities, and what strategies do they deploy?

- What motivates private clean energy technology providers[1] to invest in clean energy technologies, and how do households perceive the cost of these technologies?

1.5 Analytical framework

The past decade has undergone significant transformation in energy systems with justice issues emerging as a key theme in the energy literature (Baka and Vaishnava 2020). Energy justice revolves around three core tenets: Distributive justice, ensuring equal access to energy systems; Recognition justice, guaranteeing fair representation in the energy discourse and; Procedural justice, providing equal participation in the decision-making processes (Jenkins *et al*. 2016). It stipulates that when these three tenets are functional, then the injustices that people face will be solved.

Yet, global environmental governance is proving limited in its potential for change. The evidence from COP27 further points to limitations in transitions approaches – for example, the fossil fuel industry constituted the largest lobby group (COP27 2021). The failure to meaningfully address the climate crisis points to many conceptual blind spots and the need for a wider analytical lens, such as that provided by political ecology.

Newell and Adow (2022) argue that when it comes to regulating contemporary fossil fuel emissions, for example, the focus must shift to address supply side approaches, to regulation and to reduce global inequality caused by colonial exploitation and the generally highly racialised nature of extraction. Further, the significance of spatial dynamics, localised contexts, and power-relations in transition to low-carbon energy systems is emphasised by Huber (2015). Just energy transition must therefore be broadly examined to encompass the concerns, problems, and participation of those excluded (i.e. in social, economic, political and ecological contexts).

Much research on just transition has focused on technological research and development in the Global North (e.g. Carley and Konisky 2020; Overland and Sovacool 2020; Hearn and Castaño-Rosa 2021; Delina 2022). For instance, negative impacts from "green industrialisation" occurring in the Global North, has been documented very well by Brock *et*

[1] 'Private clean energy technology providers' refers to companies and individuals engaged in the provision/distribution of clean/modern/new technologies.

al. (2021), using a spatial justice and political ecology lens, in the collapse of the east German solar industries.

Issues of injustices suffered by people whose livelihoods are dependent on unclean fuels in the Global South are less discussed in the just energy transition discourse. More recently, research has examined energy transitions at the global level and recognised the potential for fundamental political change if the ongoing energy transformation upends the global balance of power, as well as transferring political authority away from the nation-state to citizens and local communities (Van de Graaf and Sovacool 2020; Newell 2021).

In the Global South, the deployment of simpler socio-technical innovations (e.g. solar home systems (SHS), photovoltaic (PV) lanterns and improved cookstoves) has typified the energy transition to date, a trend which has been less discussed in the energy geography literature. These innovations aim to address the energy needs of those without energy access and to transition people to clean energy solutions.

However, this transition goal is unlikely to be attained if issues such as power and participation are not addressed (Newell and Mulvaney 2013; Andersen and Johnson 2015; Ahlborg and Nightingale 2018). The need for inclusion of the marginalised in the production of socio-technical innovations has been raised in the concept of inclusive innovation. For years, inclusive innovation has gained growth in interest as evidenced in donor strategies, government policies and academic activities (OU 2013; UCT 2013; Stanley *et al*. 2018; Alam *et al*. 2019).

Proponents of inclusive innovation, such as Foster and Heeks (2015) and Sengupta (2016), argue that involving marginalised communities, developing pro-poor innovations, promoting equity and participation, and strengthening institutions are what constitutes a more inclusive innovation process. As Fressoli *et al*. (2014) and Foster and Heeks (2015) put it, for innovations to effectively achieve their intended objectives of combating inequality and social exclusion, the active participation of those excluded in the policymaking process and in its discourse is important (linked to ideas of procedural justice).

In spite of the relevance of the concept in attaining low-carbon transition in the Global South, it has yet to be applied frequently in energy geography (Rignall 2016; Yenneti *et al*. 2016; Baka 2017). Studies on socio-technical innovations have tended to be overtly technical and managerially focused, including sub-fields such as Strategic-Niche-Management (SNM), Transitions Management and Technological Innovation Systems (TIS) (Schot and Geels 2008;

El Bilali 2020). Accordingly, just energy transition objectives in the Global South can only be partially framed and enacted.

It is from this background that the analytical framework of the research was guided by a political ecology approach. Political ecology examines how power dynamics influence environmental policies and resource distribution, and the relationships between society and the environment, highlighting how communities are marginalised in the process (Bryant 2015). Political ecologists argue that marginalised people can be carried along in the campaign for environmental sustainability and development if they are incorporated in the current energy transition policies (Munro *et al*. 2017). The political ecology approach has been used in many marginalisation studies (e.g. Bloomer 2009; Taylor 2014; Marks and Miller 2022; Marks and Connell 2023) and it was equally useful in this research.

Through a novel political ecology approach, this research widens the discourse of energy justice and socio-technical transition (STT). It provides a conceptual discussion of energy justice, STT and political ecology, while providing a means to implement and examine low-carbon transition in the Global South to avoid the potential of perpetuating "enclosure" (power and resource capture), "exclusion" (biased planning and participation), "encroachment" (environmental hazard), or "entrenchment" (widening inequality) (Andersen and Johnson 2015; Ahlborg and Nightingale 2018; Sovacool 2021a, p. 2). Employing this approach as a comprehensive framework enabled a critical analysis of the subject matter – low-carbon transition in off-grid rural communities.

1.6 Research outcomes

Conceptually, this research presents a novel framework that integrates the theoretical perspectives of energy justice, inclusive innovations and political ecology. This framework enables the researcher to examine low-carbon energy transition at the household level, focusing on simple devices (e.g. PV lanterns, SHS and improved cookstoves) which have been comparatively underrepresented in the energy literature. Furthermore, it contributes to debates on a just energy transition in the Global South, and builds and expands on works done to-date, particularly in the social sciences, which has hitherto received little attention (Sovacool 2014a, 2014b).

As Nsafon *et al*. (2023) suggest, actors should draw on experiences of individuals and communities in the decision-making processes to ensure a sustainable energy transition. This research therefore provides empirical data to contextualise clean energy interventions in off-grid rural communities, in order to meet the specific needs of households, especially as studies have shown their willingness to transition to the use of clean energy technologies (Adjakloe *et al*. 2021). It specifically, contributes to energy and climate policies by identifying injustices that characterise low-carbon transition in off-grid rural households. This is vital in trying to achieve the global aim to ensure universal access to clean and modern energy technologies, as stipulated in the SDG 7.

Although countries in SSA have made some progress regarding access to electricity and clean cooking technologies, there is still significant room for improvement, particularly in rural communities (UNDESA 2023). Acknowledging the challenges ahead, the African Union's (AU) *Agenda 2063: The Africa We Want* identifies renewable energy as one of its priority areas. Consequently, the findings of this study are significant for policy formulation and implementation aimed at facilitating a clean energy transition in rural SSA, by ensuring a more sustained energy transition in remote and rural communities (Cantarero 2020; Liao *et al*. 2021; African Union 2024).

1.7 Structure of the thesis

This research is organised in nine chapters. ***Chapter 1*** introduces the research study. It outlines the research problem and research questions for the study and situates the study within the context of relevant literature on the subject matter. ***Chapter 2***, the literature review, is mainly presented in seven broad parts. The chapter discusses: social exclusion and the category of people usually excluded in the development discourse; socio-technical transition and innovations to protect the environment while addressing energy injustices; the political ecology approach, its origin, main themes and how it is applicable in the energy discourse and; how the political ecology approach can be used as a broad framework to link the concepts of energy justice and socio-technical transition/innovation. It finally gives an overview of energy access in rural SSA.

Chapter 3 presents the methodology of the research. It highlights the case study approach which was used to examine energy poverty in selected districts of Ghana. It discusses methods of data collection and analysis, as well as ethical considerations. Additionally, it provides details of the fieldwork activities, challenges encountered during the data collection, and strategies employed to mitigate these challenges.

Chapter 4 explores the energy situation of Ghana. It examines the state of energy in off-grid rural communities of Ghana while highlighting efforts by actors to transition these communities to clean energy technologies. The profile of the study districts and maps of the study areas are presented in this chapter.

The next three chapters provide empirical analysis addressing the research questions. ***Chapter 5*** explains the energy decisions of households in the study area. It identifies the energy options available to households and assesses if households are able to meet their energy needs based on the sources they use. It also explores gender biases in energy access and identifies the factors inhibiting a just energy transition in rural Ghana. This chapter heavily relies on primary data collected in the field.

Chapter 6, which is also empirically oriented, entails households' knowledge on energy sources and their links to the environment. It further explores the primary energy sources of households to ascertain if households' decisions are based on their environmental knowledge. The chapter also identifies the barriers to the adoption of clean energy technologies and discusses the potential benefits and drawbacks associated with a transition to clean energy technologies.

Chapter 7 uncovers the social relations between actors and rural households and how these dynamics contribute to a sustainable energy transition. It also identifies instances of marginalisation resulting from the pursuit of clean energy transition. The chapter highlights strategies used by various actors in the transition process and the collaborations that exist among these actors. This chapter is also based on the findings from the primary data.

Chapter 8 presents key insights of the research by reflecting the research's main findings and highlights the implications for research and policy. ***Chapter 9*** provides the conclusion of the research and policy recommendations for enhancing the uptake of low-carbon technologies in rural SSA.

2. A CRITICAL REVIEW: DEVELOPING A NOVEL POLITICAL ECOLOGY FRAMEWORK FOR JUST ENERGY TRANSITION

This chapter provides the foundation underlying the study. It reviews works done by scholars and researchers on energy justice, STT, and political ecology and presents a plausible and useful way to approach a just low-carbon transition using political ecology as a broad framework. The framework provides a more radical means to achieve just transition objectives with particular relevance for application in SSA and the Global South.

This Political Ecology framework for Sustainable Energy Transition (PESET) addresses power issues associated with low-carbon transition, while also identifying the role of inclusivity and justice in low-carbon transition. It presents a novel contribution, linking the concepts of energy justice, socio-technical transitions, and political ecology to provide a more comprehensive means of framing and analysing just energy transitions.

The framework thus, provides a novel overarching framework linking energy studies, sustainability transitions, development studies and innovation studies especially in an era where the globe is moving toward a clean and affordable energy for all (SDG 7). Parts of this chapter have been previously published in peer-reviewed journals.

The chapter will be presented in seven main sections. The first part discusses social exclusion and the category of people usually excluded in the development discourse. The second section delves into the emerging call for energy justice, its history and core tenets. The third part focuses on STT and innovations to protect the environment while addressing energy injustices.

The fourth section discusses justice in STT while the fifth highlights the political ecology approach, its origin, main themes and how it is applicable in the energy discourse. The sixth section examines how the political ecology approach can be used as a broad framework to link the concepts of energy justice and socio-technical transition/innovation. This section is followed by a general overview of energy access in rural SSA.

2.1 Social exclusion

Originating in the French context in the 1970s by René Lenoir, social exclusion has made a major contribution to the poverty and deprivation discourse (Lenoir, cited in De Haan 2000; Rawal 2008). Social exclusion occurs when a group is excluded from mainstream society and development because of factors such as poverty, disability and mental illness (Lenoir, cited in De Haan 2000). Having studied the phenomenon in detail in France, Lenoir (quoted in Silver 1994) identified excluded groups to be comprised of:

"mentally and physically handicapped, suicidal people, aged invalids, abused children, substance abusers, delinquents, single parents, multi-problem households, marginal, asocial persons, and other social 'misfits'" (Silver 1994, p. 532).

The social exclusion concept diffused to other European countries in the 1980s as states adopted it into their development discourse. Following its multidimensional nature, including social, economic and political connotations, the concept replaced the concept of poverty which only had economic connotations. In Europe for instance, the application of the concept in the development discourse has positively impacted the analyses of social disadvantages (Geddes 2000; Aasland and Fløtten 2001).

As a result of the positive impact the adoption of the social exclusion concept has had in the context of European nations, it has gained global recognition and is touted as a solution to underdevelopment of the Global South (Aalbers 2010). However, it is argued that since the forms and patterns of countries in the Global South differ from those of European countries, this 'northern' concept will not only be less suitable but could also, stifle local development models in the Global South (Kabeer 2000).

In this regard, it is important for societies to individually define what constitutes social exclusion since its meaning is contingent on the nature or the foremost model of the society from which exclusion arises (Silver 1994; Reimer 2004). Simply put, social exclusion occurs when there are poor socio-economic conditions and inequalities in the access of resources and services.

Social exclusion emerges through forms of oppression that characterise institutional arrangements and power relations, thereby marginalising a particular group and resulting in poverty (Sen 2000; Hickey and Du Toit 2013). This inequality in access to resources has a relatively greater impact on individuals' health and wellbeing. Hence, the World Health Organisation (WHO) has social inclusion and non-discrimination as one of its ten social determinants of health (WHO 2021). In the energy sector, exclusion is determined by inequality of access (Bouzarovski and Tirado Herrero 2017; UNDP 2021).

This form of exclusion has led to the call for inclusion to be better considered in the energy sector through the fight for energy justice and inclusiveness in development/innovations. This topic is further discussed in subsequent sections of the chapter.

2.2 Energy justice – a fight against social exclusion

2.2.1 Energy accessibility as a right

The call for justice must be preceded by a right. This raises the question – Is access to energy a right? Shue (2020) identified two broad categories of rights – moral and subsistence rights. According to him, a moral right offers a rational foundation for a legitimate claim to ensure that the fundamental enjoyment of something is guaranteed against threats. Thus, there must be existence of effective mechanisms to provide a level of protection. He further argues that the right to life can be seen as a moral right since it has to be guaranteed against threat. A right to resources can also be considered as a moral right if it is guaranteed against threat. In this regard, access to energy cannot be said to be a moral right since energy is not under threat and the world keeps increasing its access (World Bank 2021a). The second category of right discussed by Shue (2020) is the right to subsistence. This category of right, according to him, are concerned with the material conditions of life (Payne 2008). This includes essential elements that are needed for the survival of humans, such as clean air, potable water, adequate food and clothing, acceptable shelter and a good health care.

Arguably, energy falls within the right to subsistence category. This is because access to energy is vital for livelihood improvement. Thus, energy access is regarded as a critical condition for human survival. Consequently, many scholars, including Löfquist (2020), argue whether energy should be regarded as a basic right, especially when it plays a critical role in human's survival. He outlined three possible perspectives to look at the right to energy through the lens of electricity. The first perspective asserts that there is no inherent human right to energy but possibly, social-contractual rights related to particular societies; the second perspective posits that energy is a derived human right and; the third perspective suggests that there is a universal human right to energy, arguing that there is a complicated human right element in energy.

Löfquist (2020) argue that viewing energy as a human right implies treating it as a fundamental need. Consequently, the scope of the rights of people would be overly broad if everything beneficial to man is classed as a need. Simply put, it would be particularly challenging to define what constitutes a right, since what a particular group considers as beneficial may not be beneficial to the other. The second perspective, energy as a derived human right, was proposed by him as the best way of looking at energy since it supports the idea that energy is beneficial to human wellbeing, but not necessarily a need. He argued that access to energy is a right derived from the right to adequate housing. This notwithstanding, it is important to note that the work of Löfquist (2020) was narrowed to electricity and failed to consider other energy sources.

Regardless of the contentions on the category of rights energy falls under, there is a general consensus that access to energy is a form of a right. This view is supported by scholars such as Bradbrook and Gardam (2006), Clemson (2012), Ngai (2012) and Owoeye (2016). That is, energy is essential to life and it plays a key role in safeguarding other human rights. The idea that everyone has the right to access energy is the starting point of the definition of energy access, energy justice and energy poverty (Ahmad *et al*. 2024).

2.2.2 Energy access, poverty and justice defined

2.2.2.1 Energy access and energy poverty

The lack of a general consensus on what constitutes 'access' poses a threat to measuring, monitoring and managing energy initiatives (Jain and Shahidi 2019). This prompts the distinction between 'potential access' and a 'realised access', as explained in health studies (Gulliford *et al*. 2003). Whereas 'potential access', described by Gulliford *et al*. (2003), refers to factors that enhance one's chances of reaching a service (e.g. availability), 'realised access' refers to the actual utilisation of the service. Thus, 'access' to energy goes beyond the mere connection to an energy source.

People classified as the 'haves' (those with potential access to energy) could simultaneously be classified as the 'have-nots' (those not utilising or underutilising it), depending on how access is framed. This is what Betto *et al*. (2020) term hidden energy poverty – a situation where a consumer uses less energy in order to avoid high bills. To achieve SDG 7, there is a need to re-examine 'energy access', particularly in SSA, a region with low energy access rate

(Kojima *et al*. 2016) and where energy access is largely defined as the connection to an energy source.

Drawing on the International Energy Agency's and the World Bank's ESMAP Multi-Tier Framework for measuring energy access, it can be concluded that an individual has access to energy if connected to an energy source which is readily available (availability), cheap (affordability), standard and able to meet energy needs (quality/adequacy), dependable (reliability), delivering high access tiers in terms of capacity and formality (bills paid to utility providers), and safe (absence of past accidents) (IEA 2020a; World Bank 2022a). Thus, access to energy is a combination of 'potential access' and 'realised access' and hence, the lack of any can be termed energy poverty or substandard energy access, regardless of connectivity status.

If access to energy is not guaranteed, end-users are likely to resort to unclean alternatives and will be unwilling to pay more to enhance provision (Taale and Kyeremeh 2016; Karakara and Dasmani 2019). In examining electricity access in SSA, the major challenges that Avila *et al.* (2017) and Blimpo and Cosgrove-Davies (2019) identified were all linked to availability, affordability, adequacy and reliability. Therefore, efforts towards promoting energy access must also reflect these issues, while addressing energy poverty (Byaro *et al*. 2024).

The UNDP defines energy poverty as the "…inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting for reading or for other household and productive activities at sunset" (Gaye 2007, p. 4). Augmenting this, the Asian Development Bank views energy poverty as, "the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development" (Reddy *et al*. 2000, p. 45).

Energy poverty can therefore, be simply defined as the inability of consumers to access and/or afford energy (Bouzarovski *et al*. 2012; Sovacool 2013; Castaño-Rosa *et al*. 2019; Bouzarovski *et al*. 2021). Although some scholars equate energy poverty to fuel poverty (Bouzarovski *et al.* 2012; Boemi *et al*. 2017), others separate the two. Castaño-Rosa *et al*. (2019) and Sy and Mokaddem (2022) suggest that energy poverty applies to the Global South where issues such as availability, affordability, acceptability, reliability, quality and adequacy of energy services exist whereas fuel poverty is a Global North phenomenon – relating to social and material issues (e.g. low income, the absence of savings, and living in rented accommodations).

In the case of Ghana, fuel poverty can be used interchangeably with energy poverty. This is because the energy challenge is not only the lack of access (mere availability) for some households but also, the social and material issues preventing or limiting access (Adusah-Poku *et al*. 2023; Bloomer and Boateng 2024). Thus, the failure to re-examine and contextualise energy access could create, now and in the future, a situation where energy sources are available but not used by the marginalised.

Examining energy access is critical as access can be regarded as a universal right driven by SDG 7. This SDG suggests that every individual, regardless of the geographical location, should have access to energy, especially for cooking and lighting. In fact, the attainment of the SDGs is largely dependent on energy. For example, energy plays a crucial role in the eradication of poverty, health promotion, education, water supply and industrialisation, and combating climate change (UNDESA 2019). Hence, the lack of access is regarded as a justice issue.

2.2.2.2 Energy justice

The earliest definition of energy justice can be traced to the work of Guruswamy (2010) in which prominence was given to the distributional aspect of energy. He emphasised the need to look at the Energy Oppressed Poor (EOP) within the climate and energy discourse rather than focusing on high energy users in advanced countries. According to him, worldwide movement concerned with global warming and climate change primarily targeted users in the developed world since they have high emissions.

Guruswamy (2010) however, stressed on the need for the more developed world to act on the condition of the EOP, usually in the less developed world, since the energy systems they use also contribute to climate change. For instance, the use of unclean cooking and lighting sources in developing countries is associated with the emission of black carbon, methane, carbon monoxide and carbon dioxide – which are all climate-warming emissions.

New definitions of energy justice later emerged that widened the scope of the earliest definition of energy justice. For instance, McCauley *et al*. (2013) established the need to consider energy justice issues from production to consumption and identified three interlinked pillars: distributional, procedural, and recognition justice. This contributed to expanding the scope of defining energy access, which was previously narrow and focused predominantly on the production aspect of energy solutions.

McCauley *et al*. (2013) defined distributional justice as being inherently spatial and involving the distribution of responsibilities as well as the ills and benefits associated with the use of energy. Procedural justice, on the other hand, emphasises the importance for all actors to be involved in the decision-making process and for their views to be considered throughout the process. Recognition justice refers to acknowledging the rights of others devoid of physical threats and involving them in the energy process in order to prevent deprivation.

While accepting these three tenets, Sovacool (2016) added another tenet called the Cosmopolitan Justice. This tenet views energy injustices as transcending beyond nations and therefore, called for a global approach in addressing injustices. The core elements of this tenet of justice are individualism (persons being the focus and not society), universality (justice concerns equally applies to all), responsibility (treat others the way you wish to be treated) and identity (despite diversity, an individual is a member of the global community of humans). This tenet sees all individuals as having the same moral worth and hence argue that all deserve energy justice (Sovacool 2016).

More recently, new frontiers have emerged in energy related literature. These frontiers (e.g. Ubuntu, Taoism and Confucianism, Biocentrism and Ecocentrism) emerged from the criticism that the core concepts focused on only humans (i.e. no consideration for other life forms) and were predominantly western (Sari *et al*. 2017; McCauley *et al*. 2019). Hence, these new frontiers aim to expand the argument of energy justice beyond humans to include the rights of nature, consider the non-Western justice theorists, address cross-scalar justice issues, identify business models and benefits, and investigate trade-offs within energy justice principles (Sovacool *et al*. 2017).

Viewing energy justice as a way of addressing energy-related issues, Sovacool and Dworkin (2015) defined it as one that distributes the advantages and disadvantages equitably among people and also, treats people fairly in the decision-making process. According to them, energy justice should be the first point of call before decisions such as infrastructure development, creating energy resources, improving energy security or researching on new technologies.

In devising a critical tool to inform decision making in energy systems, Sovacool *et al.* (2016, 2017) named ten principles to consider in defining the concept of energy justice. These principles according to them, provide a mechanism to ensure that there is equity and justice in energy policies (Table 2.1).

Table 2.1: Principles defining 'Energy Justice'

Principles	Description
Availability	People deserve sufficient energy resources of high quality (suitable to meet their end uses)
Affordability	All people, including the poor, should pay no more than 10% of their income for energy services
Due process	Countries should respect due process and human rights in their production and use of energy
Transparency and accountability	All people should have access to high quality information about energy and the environment and fair, transparent, and accountable forms of energy decision-making
Sustainability	Energy resources should be depleted with consideration for savings, community development, and precaution
Intragenerational equity	All people have a right to fairly access energy services
Intergenerational equity	Future generations have a right to enjoy a good life, undisturbed by the damage our energy systems inflict on the world today
Responsibility	All actors have a responsibility to protect the natural environment and minimise energy-related environmental threats
Resistance	Energy injustices must be actively, deliberately opposed
Intersectionality	Expanding the idea of recognitional justice to encapsulate new and evolving identities in modern societies, as well as acknowledging how the realisation of energy justice is linked to other forms of justice e.g. socio-economic, political and environmental

Source: (Sovacool *et al*. 2017, p. 687).

Energy justice scholars have also embraced the decolonial turn over the last few years (e.g. Lennon 2017, 2021; Baker 2021; Tornel 2022). Tornel (2022), for example, highlights three main shortcomings among earlier work on environmental justice – including being rooted in Western thought and philosophy, being anthropocentric in character, and multi-scalar in nature (Sovacool *et al*. 2017).

Bullard (1994) highlighted the historical and contemporary environmental and racial injustice in the USA. Building on this, Baker (2019) developed an approach that is referred to as 'anti-resilience', which is rooted in an anti-racism and anti-oppression framework to ensure that mistakes of the past do not occur again through an approach that seeks to disrupt and upend existing power dynamics.

Feminist scholars have also engaged proactively in the debates around energy justice. These scholars have employed an intersectional approach that embraces political, economic, socio-ecological and technological dimensions to challenge "petro-masculinity" (Bell *et al*. 2020, p. 3). The common denominator among these different approaches is that the development and adoption of renewable energy systems in the emerging energy transition is not guaranteed to occur in a democratic or equitable fashion.

Sovacool *et al*. (2023) have sought to address this issue in an article that seeks to incorporate four perspectives – feminist, anti-racist, indigenous and postcolonial. By integrating these diverse viewpoints, the authors challenged the patriarchal and Eurocentric foundation of the energy scholarship. This provided a holistic way to understand energy justice by ensuring that it remains valid, transformative and rooted in an intersectional approach.

Heffron (2022) and Heffron and Sokołowski (2024) highlight the critical role of energy justice in advancing SDG 7. They argue that the integration of the five core principles of energy justice – distributive, procedural, restorative, recognition, and cosmopolitan – throughout the energy sector can contribute to the creation of a safer, more equitable, and inclusive society. By embedding these tenets into energy policies and practices, systemic inequalities can be addressed, ensuring fair access to energy resources while promoting sustainability and social justice.

Although scholars define energy justice in various ways, the concepts of equality and fairness serve as a common foundational principle. Additionally, there is broad recognition of the critical role of justice in achieving energy transition objectives. Thus, all definitions of energy justice given by various scholars ultimately aims to promote justice, fairness and social equity in energy systems in order to ensure that all individuals, regardless of geographical location, have access to safe, affordable and sustainable energy (McCauley *et al*. 2013; Sovacool 2016; Sovacool *et al*. 2017; Topal *et al*. 2017; Pellegrini-Masini *et al*. 2020).

History and tenets of energy justice

Before the emergence of the energy justice movement in academia, climate justice and environmental justice were the two globally oriented justice movements that existed (Lester *et al*. 2001; Pettit 2004; Schlosberg 2013). As social movements, they sought to protect minority groups and low-income earners from environmental harm, ensure the even distribution of environmental ills and promote grassroots participation in decision making (Draper and Mitchell 2001; Healy *et al.* 2019).

Although addressing energy issues, these two justice movements were quite broadly focused and therefore, could not tackle energy issues as hoped for. There was a need for a movement that focused solely on energy issues (Jenkins 2018; McCauley and Heffron 2018). Drawing on the sentiments of these movements, the energy justice movement was formed to uncover the injustices suffered by powerless or marginalised people, with emphasis on justice as fairness (Galvin 2019).

The emergence of 'energy justice' in the non-governmental organisation (NGO) and civil society spaces in the 21st century, inspired many scholars to write about the subject. These scholars explored the topic and presented many papers at seminars which had energy justice themes – e.g. at the Interdisciplinary Cluster on Energy Systems, Equity and Vulnerability (InCluESEV) conference in London on November 2011 (Galvin 2019).

Since then, there has been a lot of research works that use and discuss 'energy justice' (e.g. (Goldthau and Sovacool 2012; McCauley *et al*. 2013; Sovacool and Dworkin 2015; Jenkins *et al*. 2016; McCauley *et al*. 2019; Jenkins *et al*. 2020; van Bommel and Höffken 2021; van Uffelen *et al*. 2024). Also, special issues on the topic has been included in journals such as *Energy Policy*, *Applied Energy* and *Energy Research & Social Science* (Galvin 2019).

The energy justice theme has and is being widely applied by researchers in energy production, supply and consumption. It has been used as a theoretical, policy, political and management tool. Despite the concept having so many tenets, its core tenets are three: the distributional, procedural and recognition justices.

Distributional, procedural and recognition justice

Having its roots in earlier environmental and climate movements, the key tenets of energy justice were also drawn from the environmental justice thinking (Galvin 2019). Hitherto, scholars were mostly concerned about injustices in consumption of energy (e.g. Guruswamy 2010; Goldthau and Sovacool 2012). It was however, realised that to make good decisions in the energy system, it was necessary to address issues from production to consumption. This led to the emergence of the three pillars of energy justice (McCauley *et al*. 2013).

Distributional justice, from the environmental justice perspective, addresses the concerns of people who are believed to enjoy less resources than they are entitled to and those who enjoy less than they require (Draper and Mitchell 2001). This definition sits well within the context of energy justice where it is defined as the fair distribution of pros and cons of energy supply and consumption (McCauley *et al*. 2013). Empirical studies have shown that distributional justice can take three main forms.

Bouzarovski and Simcock (2017) argue that distributional justice can have a spatial dimension – people's location determines the gravity of the benefits. In answering questions raised by scholars (e.g. Dikeç 2009) on who should bear the responsibility for such injustices and how they are produced, Bouzarovski and Simcock (2017) stated that the spatial inequalities in energy was not caused by differences in individual choices but rather emanated from the structural geographic disproportions that are built in the stages of the energy systems and the composition of societies (infrastructural, economic, and cultural).

Distributional justice also has a temporal dimension. Jones *et al*. (2015) admitted that the decisions humans make concerning energy systems can have an enormous impact on the needs of future generations. Using the Prohibitive Principle, they argued that energy systems must not only prevent people from accessing energy now but also, in the future. Thus, putting in place measures for future generations to have access to energy can be regarded as a distributional energy justice issue (Sovacool and Dworkin 2014).

Drawing on Nussbaum's (1990) and Sen's (1994) concept of capabilities, Bartiaux *et al*. (2018) identified the social dimension of distributive justice. According to them, the access to energy services depends on the class or group individuals found themselves associated with. For instance, economically privileged households who have material resources tend to have a lot more access to energy services than deprived households. Following this, the energy services deemed necessary by a particular class or group of people may differ from one to the other (Walker *et al*. 2016).

The notion that the distributive paradigm cannot fully explain justice issues can be traced to the work of Young (1990) in which he stated that the paradigm cannot explain problems, such as decision-making issues, division of labour and culture. Young (1990) asserted that although distributive justice was a very important paradigm, there was a need to complement it with other paradigms, such as procedural and recognition justices.

Procedural justice, a ‘complementary’ paradigm to distributive justice, calls for equitable procedures for all actors to be involved in the decision-making process. Procedural justice deals with meaningful involvement and fair treatment. Thus, it requires that every stakeholder regardless of race, ethnicity, or other characteristics, must be involved in the process and that the affected individuals should have a fair representation (Davies 2006).

It necessitates the level of participation to move beyond being normative to one that takes the views of all actors into consideration. In summing up what constitutes procedural justice, Davies (2006) identified the existence of participation, impartiality and full information disclosure by government and industry as key elements. Todd and Zografos (2005) on the other hand, reiterated the importance of having an inclusive engagement mechanism, stating that community involvement is the heart of justice issues.

Recognition justice, another ‘complementary’ paradigm to distributive justice, refers to according individuals, particularly the marginalised and powerless, the needed recognition. It frowns on bypassing people who stand in the way of ‘progress’ because they do not wield power. This paradigm has to do with tolerance (Bartiaux *et al*. 2018; McCauley *et al*. 2019). Recognition injustice can manifest itself when people are not recognised and/or misrecognised (Schlosberg 2013).

The concept of energy justice has increasingly provided a foundation for challenging existing power structures and demanding equitable energy solutions aimed at achieving SDG 7. For instance, by leveraging the core tenets of energy justice, activist groups can push for systemic change, urging governments to prioritise social and environmental considerations in energy transitions. Through advocacy, these groups can hold policymakers accountable, promote decentralised energy initiatives, and ensure that the benefits of the energy transition are distributed equitably rather than being concentrated among powerful corporate or political entities (Allen *et al*. 2019; Müller *et al*. 2021; Apergi *et al*. 2024; Opoku-Mensah *et al*. 2025).

Overall, sections 2.1 and 2.2 have unpacked the definitions, origin and the three tenets of energy justice – distributive, procedural and recognition justice. It highlights the spatial, temporal and social dimensions of distributive injustices. Additionally, it highlights the role energy justice plays in promoting SDG 7. The inclusive development approach, another approach to address social exclusion is explained in the next section. Proponents of this approach argue that innovation systems, when made inclusive, will help combat social exclusion.

2.3 A space for justice in socio-technical transition

In recent times, geographers have shown interest in Science and Technology Studies (STS) to understand how environmental knowledge is produced and applied, with a focus on environmental and societal change (Ahlborg and Nightingale 2018; Goldman *et al*. 2019). In its formative years, STS was criticised for paying less attention to power, despite emerging from disparities, conflict and resistance (Laurier and Philo 1999). Scholars have as a result, addressed political and power dimensions of STS over the past decades (e.g. Bijker and Pinch 2012).

Ahlborg and Nightingale (2018, p. 391) argued that the true meaning of power is taken lightly and therefore identified four locations of power in resource governance: 1. "Knowledge and ontologies" (e.g. how superior actors shape views of projects); 2. "Contingent manifestation of power interplay in dynamic systems configuration" (e.g. actions taken to achieve a set goal); 3. "Access and entitlement" (e.g. who benefits and who loses); and 4. "The everyday lives of people" (e.g. the impact on people's lives). According to them, power emerges in all of these areas and can either stabilise or destabilise societies, discourses and practices. As such, power issues which STS aims to address, should consider justice.

Like STS, Innovation Studies (IS) aims to understand the dynamics of technologies that are relevant for addressing societal problems (Martin 2016). Innovation Studies, which focuses on emerging technologies, has gained traction in journals, professional associations and universities (Fagerberg and Verspagen 2009). Since science, technology and innovation are related, some scholars study it as a multidisciplinary field called Science, Technology and Innovation (STI) Studies (Molas-Gallart and Davies 2006; Meissner *et al*. 2013; Martin 2016).

The contribution of innovation to economic development in developing countries has been long known, and is noted as a critical contributor to the SDGs (Brook *et al*. 2013; Dionisio *et al*. 2024). However, its role in perpetuating inequalities across the Global South has only recently received attention and hence, the subsequent calls for deeper consideration of inclusive innovations and/or innovations for inclusive growth (Foster and Heeks 2015; Planes-Satorra and Paunov 2017; Schillo and Robinson 2017; Aghion *et al*. 2019).

2.3.1 Inclusion in innovation and development

The concept of inclusion, like that of social exclusion, was very profound in the European literature in the 1990s. Acknowledging that poverty has both material and non-material dimensions, Sen (2000) indicated that the material aspect was given comparatively more attention than the non-material element. This, he attributed to the tangibility of the material dimension and therefore highlighted the need to consider the non-material elements.

According to Sen (2000), the exclusion of the poor from participating in activities and accessing opportunities was a key non-material dimension of poverty that needed to be recognised and addressed, rather than focusing on the economic conditions. He thus, defined underdevelopment to entail the existence of institutions that exclude people from social engagements and denial of people the ability to choose willingly, grounded on value ratings and existing options.

It is from this backdrop that Johnson and Andersen (2012) define the concept of inclusive development as:

> *"a process of structural change which gives voice and power to the concerns and aspirations of otherwise excluded groups. It redistributes the incomes generated in both the formal and informal sectors in favour of these groups, and it allows them to shape the future of society in interaction with other stakeholder groups*" (Johnson and Andersen 2012, p. 25).

The concept of inclusive development has recently been applied to the idea of innovation, reflecting a shift to a more participatory and equitable approach. The idea of innovation as a means to attain economic growth can be traced to the 1930s when Alois Schumpeter, an economist, projected that old knowledge and/or old technologies will, through a process called 'creative destruction', give way to new ones (Diamond Jr 2006).

The traditional model of innovation sees the flow from invention to innovation and ultimately, to diffusion as chronological. Thus, the science of inventing something will lead to production and then, to consumption. This model suggested that societal acceptance was a direct response to innovation and so paid little attention to the kind of technologies being developed and the changed patterns (Williams and Edge 1996).

Social scientists and economists have since the 20th century, been developing alternative innovation models. Wieczorek *et al*. (2009) having reviewed different theories and policies, acknowledged three main models of innovation – evolutionary, systemic and knowledge-based models. Despite each model having a distinct perspective on what constitutes an innovation, the idea that innovation results from a complex activity of an increasing number and variation of diverse actors was common (Wieczorek *et al*. 2009).

Thus, including people in learning and innovation activities is essential for inclusive development (Nelson 2008). However, under the existing structure, a small group of people will potentially amass the economic rewards with the majority becoming further impoverished (Canalle 2018). This has resulted in the need for theoretical approaches to address social exclusions in innovation (Johnson and Andersen 2012; Dutrénit and Sutz 2014) – the inclusive innovations concept.

Even though inclusive innovation and innovations for inclusive growth are used interchangeably by some scholars, others argue that they should be treated discretely (George *et al.* 2012; Planes-Satorra and Paunov 2017). This notwithstanding, Schillo and Robinson (2017) noted that innovations for inclusive growth conveys a subset of the concerns of inclusive innovation. That is inclusive innovation aims to attain fair economic growth by ensuring that innovations are made accessible to all, particularly marginalised groups.

2.3.1.1 Inclusive innovation

Building on the traditional and alternative models, the inclusive innovations concept states that approaches for a more inclusive innovation process involve: engagement of the poor; application of equity and involvement principles and; reinforcement of actors (Chataway *et al*. 2014; Cozzens and Sutz 2014). In their works in developing regions, Arond *et al*. (2011), Arocena and Sutz (2012) and Dutrénit and Sutz (2014) emphasised the role of participation in promoting social inclusions, stating that social inclusion will not be possible in the absence of participation.

Recent literature on inclusive innovations see innovations as both a process and an output with multi-actor participation, particularly the marginalised groups, being crucial in reducing inequality (e.g. Cozzens and Sutz 2014; Heeks *et al*. 2014; Harman *et al*. 2025). Heeks *et al*. (2014) suggest aspects of innovations and how the marginalised can be involved in every aspect (Fig. 2.1).

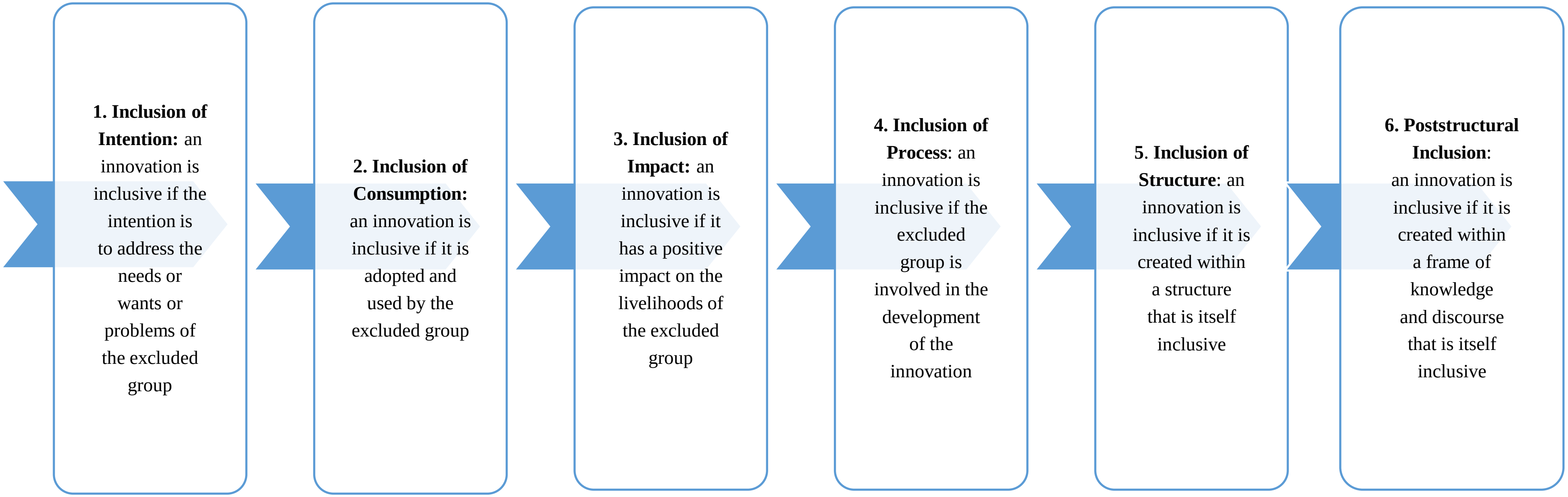

Fig. 2.1: Ladder of inclusive innovations

Source: Heeks *et al*. (2014, p. 177–178).

Following the levels of inclusion and how excluded groups can be involved at each stage, inclusive innovation can be explained as a structural change where the marginalised are actively engaged in the learning and innovation processes and also, where actors promote and respect the freedom of individuals and ensure that they have a voice at every stage of the process (Johnson and Andersen 2012; Cozzens and Sutz 2014; Heeks *et al*. 2014; Harman *et al*. 2025).

The Organisation for Economic Cooperation and Development (OECD) defines inclusive innovations as pro-poor – that is, innovations that use available inexpensive and simpler existing products, to be deployed in poor communities, with the aim to improve the welfare of users and reduce inequalities (Paunov 2013). These innovations, aside from improving the welfare of the poor, is capable of widening the market of companies to make profit (Prahalad 2012).

This definition by the OECD opens up debate about frugal innovations being inclusive. Frugal, often resulting from lack of resources and necessity, are innovations which employ low technology and materials in their production. As a result, they are usually cheap and expected to be affordable to the rural poor. Heeks *et al*. (2014) however, argue that frugal innovations can best be placed in Level 1 or possibly Level 2 of the ladder of inclusive innovations because they are not always pro-poor.

Cozzens and Sutz (2014) also argue that frugal innovations should not be classed as inclusive nor be discussed in the inclusive innovation discourse, since they make marginalised societies mere consumers and not co-creators. To them, inclusive innovation means not only the product, but also the process. They therefore, suggest that frugal innovations should not be regarded as inclusive innovations.

Recently, ‘social innovations’ and ‘grassroot innovations’ – drawn from ‘appropriate’ and ‘intermediate’ technology principles – have been designed to explicitly meet the demand of the marginalised, particularly in the developing world (Seyfang and Haxeltine 2012; Smith and Seyfang 2013; Phillips *et al*. 2024). In a study on social inclusion in Latin American countries, Thomas *et al*. (2012) identified that these innovations were external solutions to the problems faced by the marginalised. They therefore, recommended the need for participation of beneficiaries in the decision-making, design and implementation processes of innovations.

The concept of innovation has been widely applied in developing countries, particularly among production firms, contributing to regional and national economic growth. There is therefore, the tendency that focus would be placed on production of innovations, especially in this low-carbon transition era, like it has been done in times past (Lundvall *et al*. 2011). Innovations which are not inclusive, despite contributing to economic growth, do not always reach the intended beneficiaries. This can foster social exclusion and inequality (Kraemer-Mbula and Wamae 2010; Chataway *et al*. 2014; Bhakta *et al*. 2024).

Inclusive innovation is conceptualised to be the solution to the inequalities that may emerge from the development and deployment of innovations in the Global South (Fisher 2017). Although there is an increased reference to the concept of inclusive innovation in literature, there is no consensus among scholars on how the notion is, or should be formed (Mortazavi *et al*. 2021).

Literature on inclusive innovation (e.g. Chataway *et al*. 2014; Cozzens and Sutz 2014; Dutrénit and Sutz 2014) perceive innovations as both a process and an output with multi-actor participation, particularly the marginalised groups. This reflects a view of energy democracy which advocates for community members to take key decisions relating to their energy access (Antal 2015; Sweeney *et al*. 2015; Burke and Stephens 2017; Wahlund and Palm 2022; Fiander *et al*. 2024). Yet, there still remains a dearth of studies in energy geographies that target indigenous knowledge (Baka and Vaishnava 2020).

The concept of innovation has been applied in low-carbon transition – a sustainable energy development pathway which relies on low-carbon technologies (Streimikiene *et al*. 2021). In many geography journals (e.g. *The Geographical Journal* and *Geography Compass*), 'STT' is widely used to refer to structural changes in energy systems (e.g. policies, knowledge and technology) with sustainability as the end goal (Newell and Mulvaney 2013).

This notwithstanding, there is a tendency of scholarly geographical works on low-carbon innovations to focus on the production of innovations, based on historical precedent – what Stephens (2022) terms climate isolationism. There is a real risk that such a perspective might inhibit the goal of inclusion and participation in innovations for transition (Lundvall *et al*. 2011). This has raised concerns as to whether the introduction of low-carbon technologies can achieve the expected results (e.g. (Zehner 2012; Newell and Mulvaney 2013; Andersen and Johnson 2015; Dong *et al*. 2021).

2.3.1.2 Low-carbon innovations/technologies

The task of protecting the environment from GHG emissions and enhancing access to energy has initiated a low-carbon energy transition. The energy challenge in the 21st century is about how to create a sustainable energy system characterised by universal access, reliability of supply and reduced carbon emissions (Bridge *et al*. 2013; McCauley *et al*. 2019). The SDG 7 therefore aims to tackle this challenge by ensuring universal access to affordable, reliable and modern energy (UNDP 2021).

The concept of innovation has been applied in energy transition where low-carbon technologies are developed to replace carbon dependent technologies. These technologies are known to provide secure energy services to households with less environmental impacts. Known for its efficiency, low-carbon technologies are expected to promote health, comfort, safety and security to the users (Omer 2008; Jaiswal *et al*. 2022).

Like many other innovations, low-carbon technologies are not well diffused and thus not reaching everyone, particularly the marginalised. Jaffe *et al*. (2005) attribute this to the absence of a strong environmental policy. According to them, the absence of a vibrant environmental policy leads to weaker investment in a technology's production and diffusion. Not disputing this, Kemp and Volpi (2008) recognised the roles that both endogenous (awareness of the innovation, learning and increased competition) and exogenous (changes in market structure and energy prices) mechanisms have to play in the diffusion of a technology.

After reviewing literature on the factors affecting low-carbon technologies' adoption, Montalvo (2008) identified seven main factors – government policy, economics, markets, communities and social pressure, attitudes and social values, technological opportunities and technological capabilities and organisational capabilities. However, the unit of analysis in the study was largely the firm (Montalvo 2008).

At the consumer level, Ding *et al.* (2018), recognised three broad factors as the key determinants of low-carbon technologies' consumption – self-factors (e.g. psychological factors and demographic factors), family factors (e.g. household structure, size and ownership) and situational factors (e.g. strategies, societal customs and geographical influences). They acknowledged that the background of households will affect households' energy decisions.

Thus, findings from a rural setting might differ from that of an urban setting, indicating the need to contextualise transition efforts.

The few studies on the uptake of low-carbon energy solutions in poor-resource settings do identify the poor economic condition of inhabitants as a common inhibitor of low-carbon technologies' consumption (e.g. Puzzolo *et al*. 2016; Sovacool and Griffiths 2020). To achieve the goals of a sustainable low-carbon energy system and an enhanced affordability and equity of new innovations, especially among the marginalised, there is the need to critically address their social justice and inclusive development concerns (Heffron and McCauley 2018; Jenkins *et al*. 2018). Efforts aimed at attaining these goals have led to the notion of justice in low-carbon transition – Just Energy Transition.

2.4 Justice in low-carbon energy transition

The need for transition to clean energy is paramount in the face of global climate change, especially as the energy sector is a major contributor to GHG emissions. Despite the pressing need for energy transition, its rate is very slow since it will take 53 years and 92 years (per current rate) to achieve universal access to electricity and clean cooking fuels respectively (SE4ALL 2015; United Nations 2021). This can partly be attributed to the fact that many of the discussions around the subject, focus on technological advancement with little regard for the 'justice' aspect (Stephens 2022).

The transition management approach has emerged as an approach to ensure the smooth and sustainable transition to clean energy (Markard *et al.* 2012; Goddard and Farrelly 2018). This approach is committed to ensuring affordability and reliability in the supply of energy, which is in line with distributive justice. Again, it renders itself useful to energy justice as it is consistent with recognition and procedural justice. Thus, this approach seems to have a potential to help spur sustainable energy transition (Rotmans *et al*. 2001).

This notwithstanding the failure of the approach to recognise the role of democracy and politics is a major concern raised by scholars, such as Meadowcroft (2007) and Jhagroe and Loorbach (2015). Failure to recognise the roles of democracy and politics is perceived by these scholars to inhibit the goal of transition management. Goddard and Farrelly (2018) in their qualitative study of just transitions in Australia identified factors like the lack of consistent and supportive policies as inhibiting the just transition process. They thus, advocated for a recognition of politics in transition management approaches.

Proposing the solution for a low-carbon transition, Sareen and Haarstad (2018) iterated the need for a synthesis of both socio-technical and justice aspects of transition. Thus, sustainable transition could only be attained if the issue of justice is incorporated in the discourse. According to them, any analytical approach that aims to achieve just transition objectives should focus on three interrelated elements – institutions, materiality and rationality.

Heffron and McCauley (2018) identified the need for a united just energy transition encompassing climate, energy and environmental justice. In their work, they stated that each field having a distinct definition of justice could mar the just transition process, if applied exclusively to low-carbon transition. They therefore advanced the argument that a more united approach to just transition would result in more significant impact. This united approach is essential since the aim of just transition is to reduce inequality in energy systems (i.e. focus of energy justice) while protecting the environment (i.e. focus of environmental and climate justice).

The essence of time and place in just transition was also emphasised in the work of Heffron and McCauley (2018). According to them, there is the need to have timelines and also, identify places where inequalities exist in the just transition process to make the process a more sustainable one. Broto *et al*. (2018), in line with Heffron and McCauley (2018), advocated for the need to contextualise the just transition process.

According to them, the 'one size fits all' approach that has been widely practiced will not be fruitful in all areas, particularly the Global South. They therefore advocated for a new postcolonial approach to energy justice, which considers the reality of energy access, socio-political and historical conditions of a particular place (Broto *et al*. 2018). Like the traditional economics, the concept of transition is likely to further worsen inequalities if things are not properly contextualised (Heffron and McCauley 2018; United Nations 2021).

The past few years have witnessed an increase in research works and policies geared towards a just energy transition (e.g. Sovacool 2014b; Sovacool and Dworkin 2015; Jenkins *et al*. 2016; Sovacool *et al*. 2017; Jenkins *et al*. 2018; UNDP 2021). However, these calls have yet to yield the expected results as the focus of low-carbon transition continues to remain on economics and production of technologies where the neoliberals seek to take advantage of, perpetuating economic and social injustice (Heffron and McCauley 2018; Stephens 2022).

Expanding on this, Healy and Barry (2017) highlighted the political dimensions of a just energy transition, which has been less discussed in the energy literature. They argued that it is important to look at the politics surrounding just transitions since it is deeply political, being characterised by issues such as power, access to and distribution of resources. Thus, politicising energy justice is a way to decarbonise the carbon-based energy systems. In accordance with this, Goddard and Farrelly (2018) argued that the lack of a consistent and supportive government policy, long-term visions and front-runner networks representing actors are factors that prevented a sustainable just transition.

Axon and Morrissey (2020) identified the role of politics in just energy transition. According to them, the top-down decision-making choices and mechanisms further worsened the inequalities and inequities that just energy transition sought to solve. They recommended that the engagement of the vulnerable should be given the needed consideration in the quest for a just energy transition. Thus, the need for a shift from a more technologically focused approach to one which involves the participation of communities and beneficiaries.

Goddard and Farrelly (2018) recommended a participatory, adaptable and reflexive government approach where all actors are engaged at all phases of the sustainable transition – pre-development, take-off, acceleration and stabilisation. This approach, termed transition management approach, can address the inequalities arising from energy transitions since it involves careful planning and is associated with affordability and reliability of supply. However, this approach, when not used or properly implemented, will make the powerful regime actors take advantage of the just transition process to make profit.

Climate change, specifically clean energy transition, is becoming an avenue for wealth creation with the powerful elite taking advantage of the process (Goddard and Farrelly 2018; Surprise 2020). Following this, many works on energy focus on the production of sophisticated technologies (Sovacool 2014b). In many cases, there is low community participation in the transition process, leading to the creation of technologies that are not affordable (Stephens and Surprise 2020). The affordability of clean technologies has been well documented by researchers, such as Venkateswaran *et al*. (2018), Crentsil *et al*. (2019) and Nathwani and Kammen (2019).

The culture – ideas, customs and human behaviour – of people is also a major factor that impedes the success of a just energy transition and hence, a need for cultural consideration in the just energy transition discourse (Sovacool and Griffiths 2020; Lin and Kaewkhunok 2021; Kaputo *et al*. 2023). Notably, Sovacool and Griffiths (2020) recommended governments, policy makers and planners to ensure that they factor in culture into just transition processes so as to minimise cultural bias. They also recommended that consultations should be done with community members before energy transition programmes or interventions are implemented. According to them, this would help identify the type of behavioural energy conservation efforts and suggestions which could be useful in the project design.

Thus, actors need not only be concerned about reducing the costs of low-carbon technologies and producing innovations that are capable to meet the energy needs of households but also, about building the institutional capacity of local-based organisations if possible, to develop their own technologies. This is because local organisations are aware of the cultural dynamics of the community members and so, likely to produce clean technologies that would be more acceptable (Sovacool and Griffiths 2020).

Globally, introducing justice in energy transition is steadily yielding positive results, as highlighted by Heffron and Sokołowski (2024). For instance, the global electricity deficit reduced from 1.2 billion people to 759 million people in 2020. Also, the 3 billion people who had no access to clean cooking fuels have been reduced to 2.6 billion (World Bank 2021b). However, achieving the SDG 7 targets is beyond reach and therefore, important to critically look at the political, economic and social factors affecting just energy transition (United Nations 2021) – the core focus of the political ecology approach, which is explained in the next section.

2.5 The political ecology approach

Political ecology developed from cultural ecology – a research field that delves into the adoption and reasons of environmental activities (Robbins 2004). Cultural ecology studies how a local group of people adapt to their environment. Since cultural ecology focuses on the local scales, little to no consideration is given to external factors from the other scales (regional, national or global). Political ecology, however, transcends the focus of cultural ecology to include external factors. The political ecology approach is therefore regarded as an effort to address the limitation of cultural ecology, which appeared to be uniscalar (Brown and Purcell 2005; Sutton and Anderson 2020).

According to Sutton and Anderson (2020), political ecology focuses on power dynamics and the everyday conflicts, alliances, and negotiations that shape behavioural outcomes. It emphasises the socio-political processes that define a community at a given time (e.g. Marks and Connell 2023). Political ecology research generally falls under two main categories. The first examines resource management in complex societies, encompassing both community-owned and non-community-owned resources, as well as common-pool resources (e.g. Tornel 2023; Zinzani 2023). The second category investigates the impact of modernisation on small-scale, indigenous societies and their socio-environmental transformations (e.g. Sovacool 2021a).

The past few years have seen the expansion of the scope of political ecology to examine the intricate interconnections between societies worldwide. Rather than focusing solely on localised environmental and social dynamics, it now considers the broader global systems that shape resource distribution, economic development and social inequalities. This shift moves beyond traditional dichotomies such as rural versus urban, wealthy versus impoverished and developed versus developing, which have long dominated discussions in development studies. Instead, political ecology acknowledges that the fortunes of nations and regions are deeply intertwined, where the economic rise of one can contribute to the decline of another (Sutton and Anderson 2020).

As a result, the field of political ecology has expanded and continues to incorporate diverse perspectives and scholarly communities (Bryant 2015). Among these perspectives are Feminist Political Ecology, Urban Political Ecology, Postcolonial and Decolonial Political Ecology, and Critical Political Ecology (e.g. Chagani 2014; Schulz 2017; Goldman *et al*. 2018; Gandy 2022; Harcourt *et al.* 2023). These perspectives highlight the complex power structures, historical legacies and geopolitical forces that drive environmental and social change on a global scale.

Poststructural dimension of political ecology on the other hand, opposes the materialist political ecology which is influenced by Marxist political economy. This perspective of political ecology critically examines the varying understandings of environmental issues and how culture, knowledge and power shape policies and perception of the environment. Thus, the poststructural dimension of political ecology deconstructs dominant narratives and is according to Escobar (1996, p. 326), a "social theory, a theory of the production of social reality which includes the analysis of representations as social facts". It therefore helps to uncover underlying power structures that determine for instance, what is prioritised and whose perspectives matter (Escobar 1996; Tetreault 2017).

Simply defined, political ecology is concerned with the relations between nature and society and the struggles for resources (Bryant 2015). As an approach, political ecology is concerned about concrete questions that addresses issues in society such as: what (accessibility and resource control); why (explanation required) and; so what (impacts on health and livelihoods) (Paulson *et al*. 2003). The political ecology approach originates from political economy (i.e. an offshoot of Marxism) (Walker 2005). Consequently, the definition of political ecology largely relates to political economy, as summarised in the work of Robbins (2005).

Blaikie and Brookfield (1987) for instance, identified the role of ecology and political economy in political ecology. Greenberg and Park (1994) also acknowledged political ecology as a blend of political economy which emphasises the distribution of power and broader bio-environmental relationship. To Watts and Peet (2004), political ecology is an amalgamation of the ideologies of political economy and a social science which is ecologically entrenched. Hence, a lot of research on political ecology theory deals with a broader aspect of political economy (Robbins 2005).

Appearing as a government policy in the early 18th century, political economy focuses on role and impact of political activities on the economy. Marxist political economy identifies three main characteristics of political economy. Firstly, political economy looks mainly at the domain and mode of production, while acknowledging the role of social relations. Thus, political economy's object of study is mainly the production of goods and services. Secondly, political economy highlights historical viewpoints of economic spheres – progressive growth in the forces of production (e.g. Peet 1998). Thirdly, political economy analyses economic issues using classes existing in societies (Gregory *et al*. 2011).

The contemporary definition of political economy is linked to neoliberalism. Therefore, the understanding of neoliberalism by an individual informs the view of political economy. Harvey (2006) defines neoliberalism as a:

"*theory of political economic practices which proposes that human well-being can best be advanced by the maximization of entrepreneurial freedoms within an institutional framework characterized by private property rights, individual liberty, free markets and free trade"* (Harvey 2006, p. 145).

Neoliberals advocate for the creation of free markets characterised by privatisation, deregulation and financialisation (Harvey 2007). Hence, in the process of liberalisation, all forms of public industries are transferred into the hands of private owners, all kinds of materials are turned into commodities and there is less government interference. Although believed to be a solution to inequality and poverty, neoliberalism has compounded the problem of inequality and poverty through dispossession. Also, the state's role has not shrunk even in the advent of neoliberalism and income inequality still persists (Harvey 2006, 2007).

One criticism levelled against neoliberalism is its impacts on the environment. Corporations tend to neglect their responsibility to nature, all in the name of a free market. In times past, nature was locally owned and therefore, the degree of environmental degradation was relatively low. In the advent of neoliberalism, there is the externalisation of environmental responsibilities which make big corporations evade their environmental responsibilities. As a result, environmental movements have attacked neoliberals and capitalists in the light of rapid environmental degradation (Harvey 2007). This notwithstanding, little attention has been given to environmental justice in the neoliberalism discourse. Therefore, political ecology can be applied to the fields of environmental justice and just transitions in ways such as politics of scale and justice issues.

2.5.1 Justice and scale in political ecology

Justice debates tend to focus on issues of inequality among people in the developing world and/or marginalised classes. For instance, Blaikie (2001) looks at justice in relation to rights, equitable distribution and knowledge application. In fact, theories of political ecology were shaped by the demand and/or concerns for justice by marginalised groups. These theories address issues such as unfair exclusions, local politics and uneven distribution of livelihoods (McCarthy *et al*. 2005).

Political ecology answers questions such as: who gains and who pays? and; how do power relations construct unjust socio-environmental conditions and how is the power maintained? (Swyngedouw and Heynen 2003; Marks and Miller 2022; Marks and Connell 2023). Thus, justice should not be relegated in the political ecology discourse. As a normative discipline answering how and why a phenomenon ought to be, political ecology can serve as a yardstick to ascertain the good or bad and right or wrong; justice being one. Thus, environmental and energy justice can be bound with political ecology, especially when dealing with marginalised groups (Lee 2009).

Scale, despite being an essential element in fields, such as geography, has been a contested word among social scientists (McCusker and Weiner 2003). Simply defined, scale refers to a level of representation (Miller 1997; Marston 2000). This definition makes some scholars perceive 'scale' as a cartographical phenomenon. Since the early 20^{th} century, political perspectives have been included in the study of scale. Marston (2000) states that scale is the result of tensions existing between structures and the practices of human agents. Thus, in the context of politics and social relations, scale is a construct that gives and/or resists legitimacy of a specific group in a particular region (Lee 2009).

Human geographers agree that there is a relationship between social construction of scale and the cultural and political landscapes (Howitt 2003). Thus, the various levels of scale (i.e. local, regional and national) are formed by humans and they reflect and shape social relations. This implies that scale can be deliberately created and manipulated to suit the interest of a particular group. More often, this manipulation is or has been done by people with power. As a result, the powerless create their personal scale which leads to scale struggle (Lee 2009). Scale can therefore be said to be a social product that protects the scale of the powerful, while hiding the biases of the powerless and preventing them from an uprising or resistance.

The politics of scale ranges from the spectrum of the individual and local community levels to the national and intra-state domains and extends to international governance (Watts and Peet 2004). Political ecologists therefore study how local landscapes have been impacted by local, regional or global phenomena. Thus, political ecology examines how indigenous or local groups have been impacted (environment and livelihood) by a larger scale of action. Political ecologists demand emphasis to be placed on local and indigenous communities in a set of wider political-economic processes since such processes have local impacts (Brown and Purcell 2005). As such, it has been applied in many rural studies in developing countries (McCarthy *et al.* 2005).

Scale is argued to have emerged as a construct that is regularly created and manipulated to restore the conferred rights of the powerful, conceal injustices faced by the disadvantaged, destroy the environment and prevent resistance by the marginalised (Lee 2009). This theoretical background renders it useful to examine a just energy transition under a political ecology lens. For instance, developers/innovators justify the need for energy transition at the state level and the policies that disempower rural dwellers are formulated at the national, regional and district scales. Yet, environmentalists are least concerned with the problems at the individual, family, community and livelihood scales.

2.6 Towards a political ecology approach to low-carbon transition

The existence of injustices and exclusion in energy access prompts discussion as to which concept best fits, especially in a just transition era (Andersen and Johnson 2015; Sovacool and Dworkin 2015). Two different but related concepts are energy justice and inclusive innovations, as discussed in preceding paragraphs. As has already been established in this chapter, energy justice is based on three core tenets: distributive justice – equal access to energy systems; recognition justice – fair representation in the energy discourse and; procedural justice – equal voice in the decision-making process (Jenkins *et al.* 2016). Similarly, the inclusive innovation concept agrees that there are injustices in the energy sector. The concept, like that of energy justice, recognises the role inclusion plays in warranting energy access (Foster and Heeks 2015; Sengupta 2016).

Despite the importance of these concepts in the energy justice discourse, there are many gaps that need to be addressed. For instance, discussions of marginalisation of rural dwellers have been scarcely discussed in the energy justice discourse. More so, studies on energy justice focus on distributive justice – uneven distribution of energy resources – and pay considerably less attention to the social processes (e.g. capitalism) that marginalise people.

The concept of low-carbon energy transition has been actively pursued in many countries. This notwithstanding, actors such as governments and businesses tend to protect the status quo by not enhancing the process, especially at the local scale. Consequently, many research works and funds on just transition have focused less on simple technologies deployed in developing countries. Again, key actors pay little regard to how the livelihoods of households would be impacted by a low-carbon transition (e.g. Carley and Konisky 2020; Overland and Sovacool 2020; Hearn and Castaño-Rosa 2021; Delina 2022).

Research works on inclusive innovations also focus on the adoption and distribution of low-carbon technologies, status of households and energy poverty indices (e.g. Obeng and Evers 2009; Nussbaumer *et al*. 2012; Karimu *et al*. 2016; Adusah-Poku and Takeuchi 2019; Crentsil *et al*. 2019). As Arond *et al*. (2011), Arocena and Sutz (2012), Thomas *et al*. (2012), Fressoli *et al*. (2014), and Foster and Heeks (2015) argue, for innovations to achieve its intended goal – to combat inequality and social exclusion – there must be among other things, a review of government policies to reduce barriers and measures to drive the innovation and the participation of the excluded in the policymaking process and in its discourse.

Accordingly, these concepts (energy justice, just transitions and inclusive innovations) fail to look at the larger framework that shapes energy injustices. Energy-related issues must be broadly tackled to encompass how society deals with energy problems, namely in social, economic and political contexts and how individuals have been environmentally and ecologically impacted by actions aimed at promoting low-carbon transition.

In the quest to ensure a just energy transition, particularly among households in rural communities, it is important to widen the discourse of energy justice and inclusive innovation, something that is offered by the application of the political ecology approach. This research therefore creates a framework to examine low-carbon energy transition under a political ecology lens, incorporating the concepts of energy justice and inclusive innovations.

2.6.1 A novel conceptual framework for examining low carbon energy transition

The body of literature reviewed offers insight on the concepts of energy justice, STT and political ecology and their application in achieving a just transition. While all of these concepts have elements of justice, there is less reflection on the roles these concepts can in unison, contribute to a just transition.

The closest reflection is observed in the systematic review of Upham *et al*. (2022) where they identified the connections between innovation, participation and justice and developed a guide for the design of just transition processes. However, their work focused on industrialised economies and hence, attention was on larger technologies deployed in these regions with less consideration for political ecology and for Global South contexts.

As countries in the Global South have historically been low emitters of carbon, they are unlikely to enact emissions reduction policies that impede economic development. This reluctance is particularly pronounced given how developed countries have benefitted historically and continue to benefit from disproportionate carbon emissions (Newell and Mulvaney 2013). Another reason for reluctant attitude toward a transition is that, in certain parts of the Global South, the livelihoods of the local people are tied to the production of unclean fuels, such as charcoal (Nketiah and Asante 2018; Ablo *et al.* 2022).

A swift shift to low-carbon technologies will possibly affect local livelihoods in the region and as such, would unlikely be welcomed. This makes it challenging to achieve just and equitable transition (Fuhr 2021), further highlighting the need to develop a broad scope of understanding and comprehensive framing of transitions, incorporating social context, innovation, policy and politics, participation and justice concepts, particularly in the Global South.

Consequently, the research advances a novel framework, titled a Political Ecology framework for Sustainable Energy Transition (PESET), that serves as a connection between energy justice, STT and political ecology, with the aim of providing a blueprint for promoting the adoption of low-carbon technologies in the Global South. This framework emphasises local participation as a key foundation in low-carbon transition and views power not solely as a source of top-down dominance but also, as an empowerment dynamic, from the bottom-up (Ahlborg and Nightingale 2018; Hughes and Hoffmann 2020).

The PESET framework draws on the existing work of Sovacool (2021a) that envisages the political ecology of low-carbon transition as entailing four processes: "enclosure (resource capture), exclusion (unfair planning), encroachment (damage to the environment) or entrenchment (promoting inequality)" (Sovacool 2021a, p. 2). The three key tenets of energy justice (distributive, recognition and procedural), as well as the six main stages of inclusion (inclusion of intention, consumption, impact, process, structure and post-structural stages) all fall under the four dimensions of political ecology – political, economic, social and ecological dimensions.

For example, distributive justice which aims to ensure that there is equality in access to energy can be classed under the social dimension of political ecology since it can combat entrenchment (inequality). Recognition and procedural justices, based on their definitions and the political ecology processes they address, can also fall under political, economic and social dimensions of political ecology. Therefore, the political ecology approach can be used as a wider framework to incorporate socio-technical innovation and energy justice to attain just energy transition objectives, through the promotion of participation and justice (Fig. 2.2).

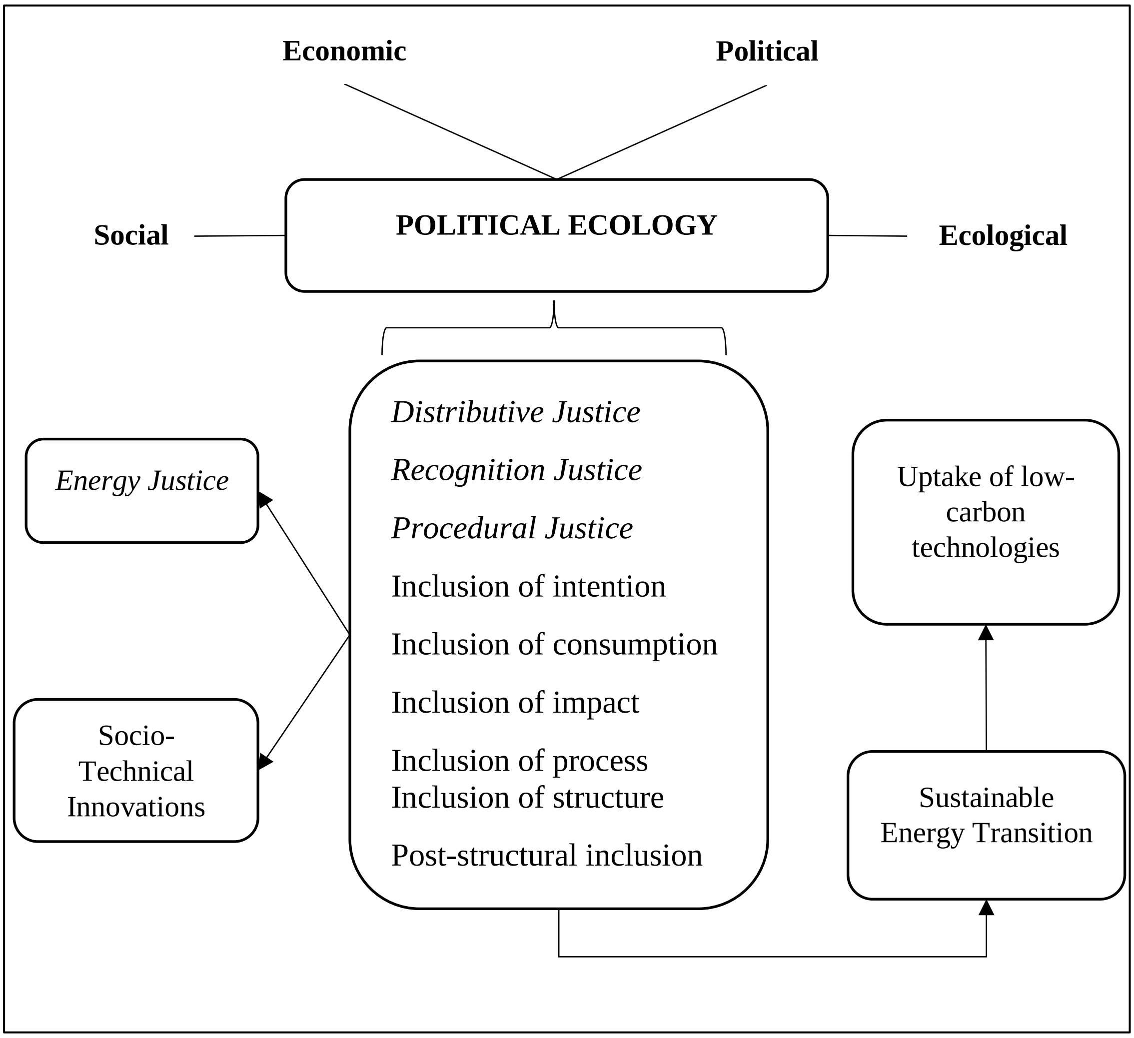

Fig. 2.2: A Political Ecology framework for Sustainable Energy Transition (PESET): incorporating energy justice and inclusive innovations

(Source: Author's construct).

2.6.2 Synthesis; Application of the framework

After examining the adverse impacts of low-carbon transitions on local communities, Sovacool (2021a) suggested five critical areas for future research: "greater inclusivity and diversity, rigor and comparative analysis, focus on mundane technologies and non-Western case studies, multi-scalar analysis, and focus on policy and recommendations" (Sovacool 2021a, p. 10).

In the Global South, the deployment of mundane or simple low-carbon technologies (e.g. improved cookstoves, SHS and PV lanterns) has typified transition processes to date (Amankwah-Amoah 2015; Jürisoo *et al*. 2018; Lemaire 2018; Karanja and Gasparatos 2019). Following the dispersed nature of energy demand and the increasing cost of grid extensions, these technologies represent avenues for providing rural communities with clean energy (Barrie and Cruickshank 2017; Cross and Neumark 2021).

Despite the significant impacts which simple low-carbon technologies can have on the lives of users and the environment, the roll-out of such technologies can fail to promote inclusivity (Lemaire 2018; Mukisa *et al.* 2022). Recognising the potential to enhance inclusivity and increase adoption levels, Barrie and Cruickshank (2017) and Karanja and Gasparatos (2019) recommended policies and research that consider roll-out and adoption processes for these technologies, further underlining the importance of the inclusively factor.

Similarly, the PESET framework is directed at policy formulation and implementation aimed at a just and equitable transition to low-carbon technologies, specifically simple or mundane technology roll-out in the Global South. The framework examines elements such as the forms of power created, possessions and dispossessions, including resource capture. It explores the participation/involvement of individuals, particularly the marginalised, and how they are involved or treated in the transition process.

The framework also addresses heavy commodification processes that may arise in the transition process to identify the winners and losers. By doing so, it examines the impact of transition on livelihoods, taking into consideration elements such as inequality and wealth concentration (social impact analysis), thereby contributing to an emerging field in geography – impact geography (Haggerty *et al*. 2018). Additionally, the framework can critically probe the environmental concerns of the marginalised (e.g. pollution and shifting emissions) and ensure that these concerns are taken into consideration. Energy challenges in developing countries, particularly SSA, differ significantly from those in developed regions. Therefore, understanding the specific energy landscape in SSA is crucial for designing effective policies and interventions that address these unique challenges. Tailored strategies must consider local resource availability, community energy needs and socio-economic conditions, to ensure that clean energy transitions are both feasible and sustainable. Without such a contextualised approach, efforts to improve energy access risk being ineffective (United Nations 2021; Sy and Mokaddem 2022).

2.7 Energy trends in SSA

Following the socio-economic benefits associated with access to energy, many governments in the SSA region have been committed to providing citizens with access to energy. This commitment by governments sometimes, results in the politicisation and bureaucratisation of energy access, which at times inhibits access and clean energy transition (Kirubi *et al*. 2009; Bos *et al*. 2018; Thomas *et al*. 2020; Pandiyan *et al*. 2022; Lo and Kibalya 2023; Shyu 2023; Wibisono *et al*. 2023; Tettey *et al*. 2025).

In rural SSA, household energy demand constitutes the largest percentage of energy demand (Muhumuza *et al*. 2018). This results from the limited number of industrial and commercial activities, leading to reduced energy demand for commercial and industrial purposes. Although access to energy, particularly for lighting, plays a vital role in rural households, some scholars argue that it can potentially disrupt the culture of households which can in the long run, negatively impact them (De La Iglesia *et al*. 2015; Pellegrini and Tasciotti 2016; Tasciotti 2017).

Inside households in rural SSA, energy is primarily used for cooking and lighting purposes, particularly in the evening (Muhumuza *et al.* 2018; Saim and Khan 2021). This indicates the key role energy plays in the lives of households. Yet, the poor economic conditions of households make it challenging for them to afford larger and sophisticated appliances like fridge, air conditioners and washing machines. Consequently, many rural households use simple and small energy equipment in their homes (Shahi *et al*. 2020; Twerefou and Abeney 2020).

Regarding energy for cooking, rural communities have access to a variety of energy sources, both clean and unclean sources. However, many households in the SSA region utilise unclean energy sources, specifically firewood and charcoal, for cooking (Olugbire *et al*. 2016; Karakara and Osabuohien 2021). The use of LPG, biogas and other renewable cooking energy sources is not prominent in rural parts of the region. Electricity for cooking, which is regarded as a clean energy source, is also not popular in many parts of the region (Ali *et al*. 2019; Aemro *et al*. 2021; Kojima 2021).

Regarding energy for lighting, connection to the electricity grid is an urban phenomenon in SSA, with relatively few rural areas having access to electricity (Trotter 2016). Many countries, in the bid to enhance access to electricity in rural communities, have embarked on rural electrification (Moner-Girona *et al*. 2018). These programmes aim to expand the electricity grid to ensure that rural communities, like their urban counterparts, are connected to the national electricity grid. Because households spend more on alternative sources of electricity, electrification in SSA can be used as a tool to alleviate poverty that plagues the region (Valickova and Elms 2021).

2.7.1 Renewable and clean technologies in SSA

Being geographically well positioned to exploit wind and solar resources for energy, governments of SSA countries have been encouraged to invest in renewables (Mohammed *et al*. 2013). This investment, aside from addressing the energy needs of citizens, particularly those in rural communities, is also linked to economic growth (Nduka 2021; Sovacool 2021b; Ram *et al*. 2020; Mutezo and Mulopo 2021). In response to this call, many actors have embarked on the deployment of clean energy technologies. The extensive deployment of these technologies is known as one of the major means of keeping the rise in average global temperatures below 1.5°C (IEA 2022a).

As recommended by Mohammed *et al.* (2013), regional and international agencies have collaborated with governments across SSA in developing mechanisms for renewable energy. Agencies, such as the World Bank, the European Union, the African Union, civil society organisations (e.g. Gesellschaft für Internationale Zusammenarbeit (GIZ) and Renewable Energy and Energy Efficiency Partnership (REEEP), faith-based organisations and companies (e.g. Engie, EDF Renewables and Schneider Electric) have invested in renewable energy by deploying clean energy technologies in the region (Gunda 2020; Aboagye *et al*. 2021; Mungai *et al*. 2022).

Given the urban bias nature of energy access in SSA, clean energy technologies have been introduced in rural communities (Peters *et al*. 2019; Grimm *et al*. 2020; Abada *et al.* 2021). In recent years, rural communities of SSA have increasingly adopted solar technologies to replace diesel generators. Although generators had been widely used in these communities to replace traditional energy sources because they are simple, quick to install and cheap, solar technologies have recently dominated the landscape because they are cleaner and more sustainable (Kenfack *et al*. 2009; Díaz *et al*. 2010; García and Bartolomé 2010; Kamalapur and Udaykumar 2011; Luque and Hegedus 2011).

Cleaner energy technologies, both for cooking and lighting, vary widely in scale, ranging from simple to large technologies. However, the cost of these technologies makes it challenging for households to afford the sophisticated ones and hence, making it difficult to fully satisfy their energy needs (Hassan *et al*. 2020; Bharadwaj *et al.* 2023). As Saim and Khan (2021) noted, some clean energy technologies may not be beneficial for households, especially when they are unable to meet their needs.

Since some households are unable to afford sophisticated energy options, particularly for lighting, they are often unable to light up all rooms in their homes. Stojanovski *et al.* (2017) noted in their work that solar technologies are not used to light kitchens and for food preparation. Wallach *et al*. (2022) underpinned this, citing that rural households are less likely to place light bulbs in the kitchen, with preference given to locations like living rooms and bedrooms. Despite this, simple low-carbon technologies are to some extent, able to positively impact the living standards of users (Kabir *et al*. 2017; Lemaire 2018).

However, the socio-demographic characteristics of households, such as sex, age, community status, household size and educational level, are known to influence their energy choices (Adeyemi and Adereleye 2016; Mashhoodi 2018; Guta 2020; Xu *et al*. 2020; Twumasi *et al*. 2021; Utomo *et al.* 2021; Sharma and Dash 2022). Rural households are eager to connect to energy sources. Yet, due to some barriers, they fail to exclusively use cleaner technologies even when they have access to them (Arraiz and Calero 2015; Tesfamichael *et al*. 2020; Saraji *et al*. 2023).

2.7.2 Barriers to clean energy adoption

Amidst multiple energy sources, households consider factors such as availability, cost, environmental impact, reliability, income, culture, accumulated knowledge and technical support in selecting their main energy source as highlighted in many works (e.g. Jan *et al*. 2012; Blenkinsopp *et al.* 2013; Azimoh *et al*. 2016; Danlami *et al*. 2017; Giri and Goswami 2017; Sampaio and González 2017; Acharya and Marhold 2019; Hellmuth *et al*. 2019; Adenle 2020; Guta 2020; Hansen and Xydis 2020; IEA 2020; Bharadwaj *et al.* 2021; Twumasi *et al*. 2021; Wassie *et al*. 2021; Sharma and Dash 2022).

These factors can also act as barriers to households' adoption of clean energy technologies. For instance, the culture of a group and familiarity with technologies are known to have an impact on their adoption. Consequently, some rural households still cling to the use of traditional fuels, even when provided with access to cleaner solutions. This makes it challenging for households to smoothly transition to cleaner cooking technologies (Goswami *et al*. 2017; Khandelwal *et al*. 2017).

In rural communities of SSA, the use of woodfuels, particularly firewood, is predominant among households, even though the use of cleaner alternatives can reduce energy consumption and carbon emissions (Sola *et al*. 2019; Aemro *et al*. 2021). In households, the search of firewood for cooking is usually regarded as the 'preserve of women' (Robson 2006; Bamwesigye *et al*. 2020; Waswa *et al*. 2020). The use of woodfuels for cooking is directly associated with negative health impacts on women and children as they are the group that usually use the kitchen (Bede-Ojimadu and Orisakwe 2020; Hussein *et al*. 2020; Weber *et al*. 2020; Adjei-Mantey and Takeuchi 2021). While households are able to meet their cooking energy needs through the use of woodfuels, their increased reliance is linked to forest degradation in SSA (Sola *et al*. 2019).

2.7.3 Key strategies to foster clean energy adoption

Public-private partnerships have been fundamental in the energy transition discourse of SSA. This partnership has fostered the involvement of various private actors in the energy sector (Awuku *et al*. 2022). Investment in the energy sector is recognised for its potential profitability, which investors are not overlooking (Van den Heuvel and Popp 2023). Consequently, the transition process, aside enhancing energy access, provides an attractive avenue for actors seeking financial gains to make profit (Goldthau 2017).

Although actors may have differences in visions, collaboration can effectively increase the adoption of cleaner technologies (Adenle 2020; Karanja *et al*. 2020; Nwokolo *et al*. 2023). Effective collaboration and communication among actors are critical factors that can prevent duplication of efforts and enhance the deployment of appropriate strategies (Dyner *et al*. 2005; Ambole *et al*. 2019; Sanderink and Nasiritousi 2020; Sorman *et al*. 2020; Singh and Ru 2022). Building on this, Francis *et al*. (2022) emphasised the vital roles that NGOs can play in the transition process, by facilitating collaboration among actors in the energy sector to advance clean energy initiatives.

Despite the usefulness of a top-down approach in achieving development objectives, it is important to complement this with a bottom-up approach in attaining sustainable development, as both are effective (Kaiser 2020). Integrating both approaches ensures a more sustainable and inclusive strategy in achieving transition objectives, by the involvement of citizens (Sanga *et al*. 2022). It is therefore important for actors to align their activities with the specific circumstances of households. Failure to do so could make it challenging for households to adopt clean energy technologies (Hassan *et al.* 2014; Acharya and Marhold 2019; Agyarko *et al*. 2020). Cantarero (2020) therefore advocates for citizens to be actively involved in energy transition by giving them a voice in the decision-making process.

The roles community involvement plays in promoting clean energy access and utilisation have well been documented and recommended in the works of Cloke *et al*. (2017), Baxter *et al*. (2020), Sovacool (2021a) and Boateng *et al*. (2023a). Haque *et al*. (2021) argue that for energy transition to be sustainable, it should be conceptualised as a socio-cultural, technical and environmental intervention, suggesting the need for actors to engage households in the transition process (Lindgren 2020).

Household interactions and connections with actors are recognised as playing a vital role in the adoption of clean energy technologies. A positive relationship with actors can build trust within households which can foster a sense of agency among members of the community (Shoemaker *et al*. 2018; Goggins *et al*. 2022). Interaction with actors is however, more challenging to achieve in off-grid rural communities where households have limited access to digital information following their non-connection to the electricity grid (Hirmer and Guthrie 2017).

Access to information or prior knowledge on cleaner technologies plays a pivotal role in the adoption of technologies. Suggesting ways of enhancing the adoption of clean energy in developing countries for instance, Ibegbulam *et al*. (2023) recommended actors to provide potential users with requisite knowledge, by actively interacting with them. Requisite knowledge, specifically on the socio-economic and environmental benefits of clean technologies can enhance the uptake of clean energy technologies (Irfan *et al*. 2021; Boateng *et al*. 2023b).

2.7.4 Households' expectations in the energy transition process

Energy transition, in the context of SSA, incorporates various expectations such as energy efficiency, economic growth and reduced vulnerability (Cantarero 2020). However, these general expectations often mask the specific expectations of households at the local level. As has been argued by Sovacool (2021a) and Bharadwaj *et al*. (2021), low-carbon transition is not always associated with positive impacts and hence, it should be thoroughly and carefully examined, since it can negatively impact some aspects of households.

Despite a transition having a plethora of positive impacts on households, such as improvement in health and income, increased savings, enhanced food safety and reduced cooking hours, personal safety and reduced GHG emissions, there are also some negative impacts associated with the process (Hellmuth *et al*. 2019; Troncoso *et al*. 2019; Diallo and Moussa 2020; Acheampong *et al*. 2021; Aemro *et al*. 2021; Chillrud *et al*. 2021; Liao *et al*. 2021; Miller *et al*. 2021; Mugisha *et al*. 2021; UNDESA 2021; UNDP 2021; Liu *et al*. 2022).

A notable negative impact associated with a transition to clean technologies is the cost associated with the use of clean technologies, which can at times be burdensome for households, particularly those with low-income. Moreover, a clean energy transition can result in a reduction in the incomes of households whose livelihoods depend on unclean energy sources, specifically charcoal (Hellmuth *et al*. 2019; Wekesa *et al*. 2023). Globally, the charcoal sector, largely informal, is reported to generate income for over 40 million people.

The charcoal sector is very vibrant in rural SSA and is a source of income for many households (FAO 2017; Nketiah and Asante 2018; Kiruki *et al*. 2020; Ablo *et al*. 2022). Despite charcoal production being a source of income, households do not only rely on it as their sole income-generating source. Examining the contribution of charcoal to the income of rural households in Kenya for instance, Kiruki *et al*. (2020) identified that about 20% of households' income came from engaging in the production of charcoal.

Regardless of the perceptions of households on the impacts of clean energy transition, whether positive or negative, these perceptions are recognised as factors influencing their adoption of clean energy technologies (Zulu *et al*. 2022). That is, while some households might see a transition as beneficial, others may have concerns about the associated negative impacts. These varying perspectives, however, influences households' adoption of clean technologies.

The vital role woodfuels play in rural communities, in terms of energy access and income generation, accentuates the need to promote reforestation practices and sustainable charcoal production. Failure to do this can negatively impact the environment and further degenerate the living conditions of rural dwellers. In rural Kenya for instance, households responded to a scarcity of woodfuels by cooking food with low nutritional value (since it took less time) and skipping meals (Mendum and Njenga 2018; Waswa *et al*. 2020), even though there were available alternatives such as LPG.

Conclusion

Energy justice and STT are critical concepts applied in energy transition as has been validated by numerous scholarly works. However, energy justice concerns have largely centred on the distributive dimension, often overlooking other critical tenets such as procedural and recognition justice. Similarly, the concept of inclusive innovation has received limited attention within human geography, particularly in its application to energy transitions. In practice, large-scale energy solutions are frequently prioritised, while small-scale technologies and Africa's clean energy future receive comparatively less emphasis. In addition, although political ecology has been widely applied in marginalisation studies, its application to energy transitions remains underexplored. This highlights the need for a more comprehensive approach that integrates political ecology, inclusive innovation, and a broader understanding of energy justice to ensure equitable and context-specific energy solutions.

This chapter advocates for the use of the political ecology approach as a nexus between energy justice and STT approaches, particularly in addressing the energy gaps in rural SSA. It prompts the importance of having a novel framework in examining and achieving low-carbon transition objectives in the Global South. With the aim of informing and fostering just energy transition (i.e. to help carry the marginalised along the low-carbon transition journey) in the Global South, this chapter has reasoned that the political ecology approach can be used as a core component of a novel analytical and conceptual framework to achieve sustainable energy transition by ensuring an integrated framing of justice, inclusion and other important transition-related issues, including policy, politics, technology and innovation.

3. SYNTHESISING APPROACHES FOR A COMPREHENSIVE INSIGHT

This chapter comprehensively explores the research design, methods, tools as well as techniques that aided the selection of the study area, preparation of the data collection instruments and data analysis. It begins by elucidating the philosophical approach which guided the chosen research framework. Laying this foundation is essential as it informs the methodological choices and provides a strong foundation for subsequent data analysis and discussion.

The chapter also outlines the sampling techniques used in the research. It details the criteria used in selecting a sample size and how participants were selected to be involved in the study. The ethical considerations of the research are also thoroughly discussed in the chapter, detailing the measures employed to ensure the confidentiality of participants, while upholding ethical standards in the conduct of the research.

The practical aspects of the research are expansively outlined in this chapter which details the role of the researcher in the field, highlighting how the researcher gathered accurate and objective data. The challenges that the researcher faced in the field and how these challenges were addressed are also provided in this chapter. This account illustrates the practicalities of conducting field research and the need for researchers to be flexible and adaptable, in the face of unforeseen challenges.

3.1 The study setting

The study setting for this research was the West African country of Ghana. Ghana was chosen due to its significant rural-urban disparities in energy access, where rural households often struggle to benefit from available clean energy solutions (Energy Commission of Ghana 2020). Given these inequalities, addressing distributive injustice in energy access is crucial (Akrofi *et al*. 2024). As Ghana advances efforts to expand clean energy access, it is essential to move beyond a simplistic binary perspective that equates energy provision with actual utilisation. Bloomer and Boateng (2024) argue that this limited approach fails to support the realisation of SDG 7 in the country. A more nuanced understanding of energy access challenges in the country is therefore necessary to develop inclusive and effective policies.

Geographically, Ghana is bordered by Burkina Faso in the north, Côte d'Ivoire in the west, Togo in the east, and has a littoral southern border with the Gulf of Guinea. It is classified as a less economically developed country with an estimated 31 million people spread across its 16 regions, including 6 newly created regions that were formed following a referendum in 2018 (World Bank 2021a; UNDP 2023) (Fig. 3.1).

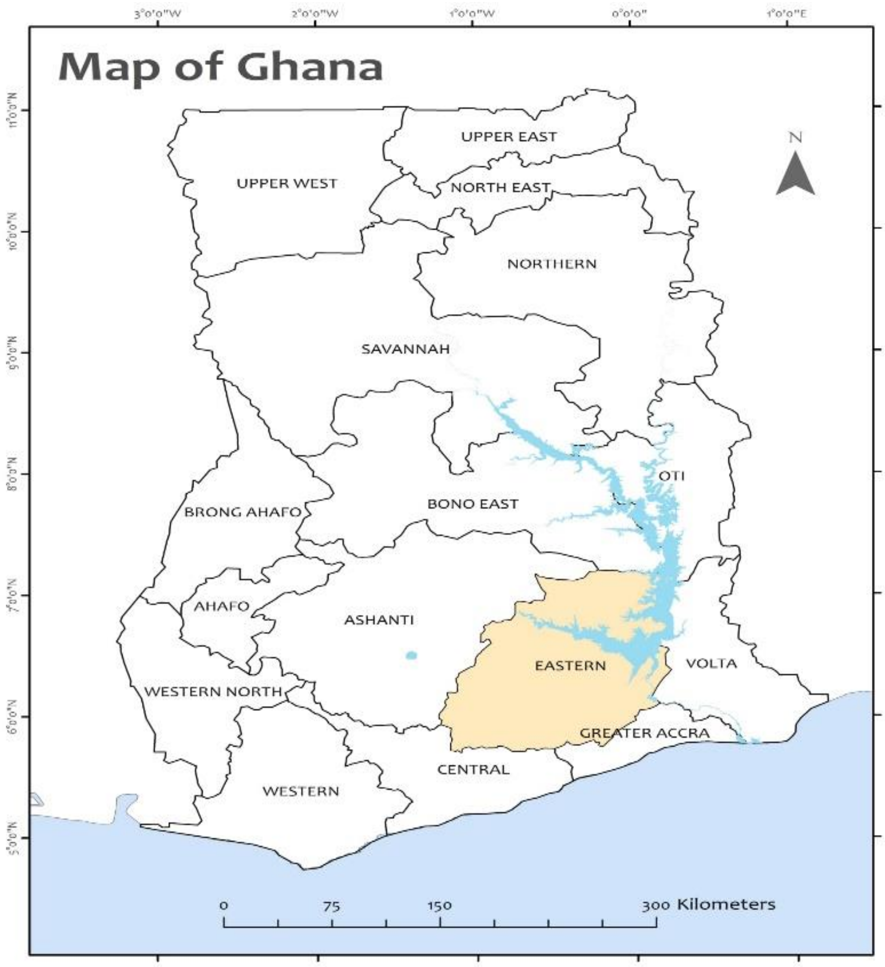

Fig. 3.1: Map of Ghana showing 16 regions and the study region; based on ESRI shapefiles using ArcGIS 10.6

Compared with its neighbouring countries, Ghana has a relatively large labour force, with about 68% of the working age population engaged in employment. However, a significant majority of this employed population are placed under the vulnerable employment category by the Ghana Statistical Service. This category encompasses individuals such as 'own account' workers and 'contributing family' workers. These vulnerable employees, a significant number of whom live in rural communities, are not entitled to tenure security, social security, wages and leave benefits (Ghana Statistical Service 2016).

Since 2017, Ghana has experienced a decline in GDP which has significantly hampered efforts towards poverty alleviation (World Bank 2022b). As such, the percentage of the country's population living below the international poverty line of $1.90 a day, is expected to increase, especially in the aftermath of the Covid-19 pandemic (World Bank 2019; Bukari *et al*. 2021b). Poverty in Ghana is a rural phenomenon – with rural poverty being about four times as higher as urban poverty (Cooke *et al*. 2016). It is therefore not surprising that beneficiaries of the government's poverty alleviation programmes such as the Livelihood Empowerment Against Poverty (LEAP), are largely rural residents.

3.1.1 The case study

For the purposes of this research project and to ensure detailed analysis of low-carbon transition in Ghana, the approaches of Arias *et al*. (2023) and Broers *et al.* (2023) were adopted. This involved a comprehensive review of related literature and the use of primary data to explore energy access. For an in-depth examination of relationships linked to the subject matter, Ghana was used as a case study (Yin 2003; Crowe *et al*. 2011). The use of a case study approach is considered as "a strategy that examines, through the use of variety of data sources, a phenomenon in its naturalistic context, with the purpose of confronting theory with the empirical world" (Piekkari *et al*. 2009, p. 569).

Although the case study approach is credible for gaining social knowledge, it has been criticised as lacking scientific rigour, generalising from a single unit and being subjective (Yin 2009). These criticisms notwithstanding, the case study was appropriate for the study as it provides analytic generality and contributes to knowledge via theorisation (Yin 2009). To enhance the robustness of the case study, the actions recommended by Crowe *et al.* (2011) were employed to mitigate the associated pitfalls (Table 3.1). The case study approach was useful in addressing the research problem, which is a social phenomenon (i.e. low-carbon energy transition).

Table 3.1: Potential pitfalls in case studies and mitigation measures

Potential pitfalls	**Mitigation actions**
Wrong case selections which might result in poor theoretical generalisations	The researcher acquired a comprehensive understanding of theoretical and empirical literature, and provided justifications for the decisions made.
Collection of large amounts of data that are irrelevant or little data that is not enough for the research	Data collection was focused and in alignment with the research questions, while maintaining flexibility to explore various paths.
Defining/bounding the case	Focused on components related by time and/or space, and clearly defined what was beyond the scope of the case.
Lack of rigour	The research utilised triangulation, respondent validation, theoretical sampling, and ensured transparency throughout the entire research process.
Ethical issues	The cases were anonymised properly as they were often easily identifiable to insiders, and the participants' informed consent was obtained.
Integration with theoretical framework	Unexpected problems were given room to arise without trying to force solutions. Initial explanations were tested, and epistemological stances were clearly defined beforehand.

Source: Crowe *et al*. (2011).

3.1.2 Selection of case study communities

The selection of communities for this research started by outlining districts that are isolated or cut-off from the mainland. From this list of island districts, two were purposely selected, the Kwahu Afram Plains North (KAPN) and Kwahu Afram Plains South (KAPS) districts to maximise the effectiveness of limited research resources. These districts were selected because of their relevance to the study and their high rural occupancy rate, making it possible to generate impactful, context-specific insights (Patton 2002; Palinkas *et al*. 2015; Campbell *et al*. 2020).

The districts are noted for agriculture, primarily fishing and farming, due to their rich soils and proximity to the Afram River. The KAPN and KAPS districts are both, predominantly rural with a few scattered small urban communities (Ghana Statistical Service 2014a, 2014b). In consultation with officials of the District Assemblies, the highest political authority at the local level, specific rural communities were selected to be involved in the study (The Constitution of the Republic of Ghana 1992). The selection of the study communities was guided by three main criteria: poverty levels, non-connection to the national electricity grid, and the length of access to clean energy interventions, with preference given to communities with longer access periods. These criteria helped to identify vulnerable communities and provided insights into how the marginalised were leveraging clean energy interventions.

Consultation with officers of the District Assemblies, facilitated the identification of rural communities that were off-grid, which was the subject matter under enquiry. In total, ten communities in the districts constituted the case study areas for the study – Ayebeng, Aduonum, Adukrom, Asimpanyin, Mmradan, Kwasi Addae, Apesika, Sawua, Sodzikope and Abotanso 1. These communities were selected as case studies because they possess characteristics required for comprehensive examination of low-carbon energy transition – being economically disadvantaged and off-grid, and having long-standing history of clean energy interventions (Denscombe 2017).

3.2 The research paradigm

Since this research relied on a diverse array of schorlarly works, it was important to conduct it using the pragmatist paradigm to inform and guide subsequent research works through its findings. Again, the research did not align peculiarly with either the qualitative or quantitative approaches, but instead integrated aspects of the two approaches. Consequently, the pragmatic research paradigm emerged as the most suitable paradigm to adopt (Lowe and Phillipson 2006; Kivunja and Kuyini 2017).

The pragmatic research paradigm was employed in this study to comprehensively explore the problem at hand. Pragmatists hold the view that there is no absolute truth and acknowledge the dynamic nature of the world. This relative perspective of pragmatism renders it particularly useful in understanding the changing nature and complexities of both micro and macro-organisational factors (Saunders *et al*. 2015; Kivunja and Kuyini 2017).

Unlike the realist paradigm, pragmatism identifies humans as primarily actors and secondarily knowledge seekers. This implies that people are capable of solving problems through actions and learning lessons from the outcomes. This reflexive and iterative process of the pragmatic research paradigm contributes to the generation of a new body of knowledge (James 1975; Saunders *et al.* 2015; DePoy and Gitlin 2019).

The pragmatist paradigm employs multiple approaches in mapping and analysing the 'whys' and 'whats' of research problems (Biesta 2010). By adopting a multi-stage approach and method in data collection, the pragmatist paradigm helps to create knowledge rooted in the opinions of participants and their lived experiences.

Therefore, the choice of the pragmatist approach in this research was closely tied to the research objectives and the specific nature of the research questions posed (Creswell 2003). The pragmatic paradigm has been extensively used in a number of scholarly works focusing on sustainability and environmental studies, as evidenced in the works of McMeekin and Southerton (2012), Popa *et al*. (2015) and Willand *et al*. (2019). It was therefore applied in this study as it sought to find solutions to complex problems associated with energy transition (Popa *et al*. 2015).

Since pragmatism is underpinned by the ideology that there is no absolute truth, it has been criticised on the basis that its findings cannot be generalised (DePoy and Gitlin 2019). However, since it is aligned with inductive reasoning, the findings can indeed be generalised, albeit carefully. These generalisations are however, subject to change and should therefore, be contingent on the specific context under which the research was carried out (Saunders *et al*. 2015). This approach underscores the need to identify contextual factors and limitations that may influence the findings.

3.3 Research methods and design

Following the nature of the research questions, a mixed-method approach was deemed appropriate for the research. The mixed methodological framework involved gathering, analysing and integrating both quantitative and qualitative data in a single study (Sweetman *et al*. 2010; Bryman 2016). Clark *et al*. (2021) expand the debate on the mixed-method approach highlighting that, it enables methodological triangulation even though quantitative and qualitative research approaches have different epistemological orientations.

The mixed-method approach offsets the discrepancies inherent in both quantitative and qualitative methods when applied individually and thereby, strengthens the potential for triangulation to enhance the validity and credibility of the data collected (Tashakkori and Teddlie 2010). The reasons for applying the mixed-method approach in this research are detailed in Table 3.2.

Table 3.2: Reasons for using the mixed-method approach

Purpose	Description	Application to the research
Triangulation	Converge and corroborate results from different methods	The study corroborated findings of the different results from the qualitative and quantitative analysis.
Complementarity	Enhance and clarify the results of one method using the other	Qualitative data were used to complement the quantitative data for a comprehensive account of a low-carbon transition in the study communities.
Development	Use results from one method to develop or inform the other method	Some qualitative instruments were informed by the quantitative data and overlaps in data from the different methods was used to explain phenomena.
Initiation	Discover contradiction, new perspectives and recast questions	Results were analysed from different perspectives of different methods and there were plans for the collection of more data if results are unexplained.
Expansion	Extend the range of inquiry through the use of different methods for different component	There were concurrences across studies and both qualitative and quantitative tools were used to expand and increase the confidence in the findings.

Source: Author's construct, adopted from Greene *et al*. (1989).

3.4 Scope of the research

The scope defines the boundaries of the research and indicates the geographical and contextual areas of the research to make it SMART[2] (Akanle *et al*. 2020). This research aimed to understand low-carbon energy transition in rural Ghana. Hence, the data collected was related exclusively to the Ghanaian context, with no countries outside Ghana directly considered as part of the study. Regardless of the nationality of individuals, they were considered eligible to be involved in the study, as far as they were residents of Ghana and had lived experiences relevant to the subject matter.

For the purpose of this research, a working definition of energy was operationalised. Energy in this context, was limited to sources used for cooking and lighting. This working definition was used as a result of energy being commonly used in rural communities for domestic purposes,

[2] Simple, Measurable, Achievable, Researchable and Time Bound

such as cooking and lighting, and the limited time constraints of the data collection exercise (Shahi *et al*. 2020; Twerefou and Abeney 2020).

Even though a wide array of actors hold claims in the transition to clean energy technologies and can as such, be classified as actors, this research defined actors specifically as individuals or groups who have a personal stake and play significant roles in clean energy transition. These actors were narrowly defined to comprise of clean energy technology providers, NGOs, District Assembly officers, faith-based organisations, and community-based organisations. Including these diverse entities ensured that the research captured a holistic understanding of the actor landscape in the context of advancing clean energy technologies.

The research incorporated multi-scalar actors across different levels of governance. At the local scale, households and private clean energy technology providers participated. At the regional and national levels, District Assembly officers (state actors) and NGOs were involved (e.g. Antwi-Boasiako and Nkrumah, 2018). Although national-level actors, such as ministries and government departments, play a critical role in energy governance and influence the low-carbon energy transition, they were not included in the study due to time constraints in the data collection process. However, the involvement of District Assembly officers provided insights into governmental policies relevant to the research.

Various themes and concepts, such as energy poverty, inclusive innovations, STT and energy communities were covered in an attempt to arrive at the central theme of this research. However, an in-depth analysis of such themes was beyond the scope of the research. The central focus of the research remained on low-carbon transition in off-grid rural communities. The research was conducted over a four-year period, from January 2020 to December 2024.

3.5 Data collection methods and tools

Data were gathered from both primary and secondary sources. Secondary data were gathered from peer-reviewed academic journals and reports (Rabianski 2003; Daas and Arends-Tóth 2012). In gathering the data, Boolean (AND, OR, NOT) and words as search operators (e.g. (intitle, source) were used in searching within Google and Google Scholar. This helped to narrow the search to topics related to low-carbon energy transitions.

The secondary data provided a framework which gave a snapshot of energy access in Ghana (Chapter 4) and guided the discussion of the empirical results (Chapters 5, 6 and 7). The review of the secondary data also helped to design interview schedules and questionnaires according to the objectives of the research, which enhanced the gathering of valuable information in the field during primary data collection.

Primary data were collected between September 2022 and February 2023 from relevant actors and rural households through direct observation, surveys and interviews. This was done using questionnaires and interview schedules, in a semi-structured interview format (Rabianski 2003; Sileyew 2019). A semi-structured interview format was used to keep the interviews in line with the subject matter, with discussion directed along key thematic lines, whilst also providing the opportunity for unforeseen new information to surface (Brinkmann 2014; Husband 2020).

The stakeholder/actor/institutional interviews were mostly conducted in English. However, in some cases, the interviewees opted to speak in a local dialect (Twi)[3] which they are fluent in. Interviews were audio-recorded with the consent of participants. Because of their positions in the district and for other personal reasons, some officers of the District Assemblies and other actors did not allow the interviews to be audio recorded and hence, these responses were recorded in a field notebook. All such responses were recorded in English.

Questionnaires were however, used in conducting community surveys. Questionnaires were used because they provide an efficient and rapid means of data collection, accompanied with a high response rate, when properly designed (Parajuli 2004; Taherdoost 2021). The questionnaires were put in three sections: with the first section targeting the demographic characteristics of the respondents, such as their ages, gender and levels of education; the second section concentrated on household energy sources and choices, as well as their knowledge on the environment and low-carbon interventions; whilst the third section focused on social relations with clean energy actors, and the (dis)possessions associated with clean energy transition process. The questions were mainly closed-ended with a few open-ended ones. All community surveys were conducted in Twi since survey participants were not fluent in written and oral English.

On average, a minimum of 45 minutes was spent with every survey and interview participant during primary data collection. The primary and secondary data were therefore, used to address the questions that guided the research (Table 3.3).

[3] The researcher is fluent in the Twi Language.

Table 3.3: Data requirement sources and techniques

Specific research questions	Data requirements	Data sources	Techniques for collection
How can the concepts of energy justice, inclusive innovations and political ecology be unified in achieving a just energy transition?	Literature on energy justice, inclusive innovations, political ecology and just energy transitions	Articles, publications and research reports	Boolean (AND, OR, NOT) and words as search operators (e.g. intitle, source)
What energy sources are available for rural households and what criteria do households prioritise when selecting an energy source?	Type of energy technology used for lighting and cooking The criteria for selecting the type of energy source to use Factors that influence one's choice of light and cooking source	Participants in rural communities and actors at the local level	Community survey and interviews
Are rural households able to meet their energy needs with their primary energy sources and why do households resort to woodfuels, in particular?	Primary energy sources used by households Households ability to meet their energy demands Why rural households predominantly use woodfuels	Participants in rural communities and actors at the local level	Community survey and interviews
What are the gender dimensions associated with access to woodfuels and cooking practices in households?	Sex, age, marital status, occupational and educational levels of respondents	Participants in rural communities	Community survey and interviews
What insights do rural households have on energy-environment issues and clean energy options, and how does that influence their energy choices?	Household knowledge on clean energy interventions Household knowledge on energy-environment issues	Participants in rural communities and actors at the local level	Community survey and interviews

	How households translate their energy-environment knowledge into current energy decisions		
What are the barriers preventing the adoption of clean energy technologies by rural households?	Challenges households face in accessing clean energy technologies	Participants in rural communities and actors at the local level	Community survey and interviews
What are the potential (dis)possessions associated with a low-carbon transition and how are households' livelihoods tied to unclean energy sources?	Losses associated with a just energy transition Gains associated with a just energy transition Livelihoods and how they are tied with unclean energy sources	Participants in rural communities and actors at the local level	Community survey and interviews
Which actors are active in off-grid rural communities, and what strategies do they deploy?	Vibrant actors in the communities Strategies used by actors to promote just energy transition and the associated challenges and opportunities	Participants in rural communities and actors	Community survey and interviews
What motivates private clean energy technology providers to invest in clean energy technologies, and how do households perceive the cost of these technologies?	Households perception on the cost of clean energy technologies Motivation of private clean energy technology providers to get involved in the energy sector	Participants in rural communities and actors, particularly private clean energy technology providers	Community survey and interviews

Source: Author's construct.

3.6 Sampling methods

In this study, two levels of sampling were designed: the actor level sampling and the community level sampling. With the actor level sampling, non-probability sampling was adopted – purposive, snowballing and convenience sampling (Mweshi and Sakyi 2020). That is, actors who had knowledge on energy access in the districts, were initially interviewed. These officers were then asked to provide referrals to recruit other actors who had knowledge on energy access or were engaged in its provision. This process continued until a point of saturation was reached (Saunders *et al*. 2018).

This non-probability sampling ensured the involvement and selection of appropriate actors with adequate knowledge and experiences on the subject under study (Etikan *et al*. 2016). The involvement of these actors gave insight into some institutional strategies used to enhance a transition to clean energy technologies in rural communities. Key community leaders were also purposely selected to provide requisite information needed to answer the research questions. These consisted of chiefs, elders and local government officials in the communities.

Key community leaders comprised of household heads who had lived in the communities for years and hence, had in-depth knowledge of the energy situation of the communities. At the District Assembly, Community Development Officers and District Planners were interviewed. These officers were selected because they work directly with the local communities and hence, knowledgeable about the 'on-the-ground' information on the energy situation. As energy in the research context was related to sources for lighting and cooking purposes, providers of clean energy technologies for these purposes were interviewed. At the actor level, 23 interviews were conducted.

Due to the predominance of woodfuel use in rural communities in Ghana (Bawakyillenuo *et al*. 2021), an in-depth exploration of the cooking energy situation of households was conducted, incorporating the 23 general qualitative actor data gathered. This comprehensive study focused on five of the rural communities involved in the research – three in Kwahu Afram Plains South (Kwasi Addae, Asimpanyin and Mmradan) and two in Kwahu Afram Plains North Districts (Abotanso 1 and Adukrom). In total, the exploration involved 45 key informant interviews (including the 23 actor interviews) with key community leaders, District Assembly officials and improved/cleaner cookstove providers (Table 3.4).

Table 3.4: Demographic characteristics of relevant actors interviewed

Variables	General qualitative data		Qualitative data on cooking fuels	
	Category	*Frequency (N=23)*	*Category*	*Frequency (N=45)*
Gender	Male	15	Male	28
	Female	8	Female	17
Age	31-40 years	7	31-40 years	12
	41-50 years	6	41-50 years	23
	51-60 years	5	51-60 years	8
	>61 years	5	>61 years	2
Status	District Assembly and local government official	8	District Assembly official	5
			Local Government official	3
	Chiefs and opinion leader	8	Chief	8
			Elder and opinion leader	27
	Clean energy technology providers (including NGOs)	7	Improved cookstove provider	2
Size of household	<3	3	<3	4
	3-5	13	3-5	15
	6-8	7	6-8	26
Educational level	Never schooled	3	Never schooled	11
	Basic	7	Basic	20
	Secondary	5	Secondary	6
	Tertiary	8	Tertiary	8

Given the constraints of time and resources, a representative sample was selected using a multi-staged sampling for surveys. By means of the 2021 Population and Housing Census, the sample size was determined, using Krejcie and Morgan's (1970) table for determining sample size. As the total number of households in the two districts is 37,054 (19,431 in KAPS and 17,623 in KAPN), the sample size should ideally be around 380 (Krejcie and Morgan 1970; Ghana Statistical Service 2021). Thus, not less than 190 rural households from each district should be involved in the survey.

This number was scaled up to 419 in the survey to get a more diverse input and include households of varied socio-economic backgrounds (Taale and Kyeremeh 2016). Therefore, every district had more than 200 rural households involved in the survey. Despite some communities having fewer number of households, some less than 10, they were still considered relevant for the study. This ensured the representation of diverse rural settings within the scope of the study.

Having identified the off-grid rural communities after deliberations with officers of the District Assembly, a simple random sampling was used to recruit households for the study. That is, equal chance was given to every rural household within the rural communities. This approach was justified by the understanding that the selected communities are predominantly rural and off-grid, and so it would be easier to recruit participants for the study (Davis and Scott 2007).

Within households, preference was given to household heads for participation in surveys and in the absence of a household head, a mature household member was selected. Household heads were selected for interviews as they typically serve as the primary decision-makers and spokesperson for households (Posel 2001; Bookwalter *et al*. 2006; Ali *et al*. 2019). Children were excluded from the survey due to their limited knowledge and influence on the type of energy used in a household. In all, 208 households of the KAPS district and 211 households of the KAPN district were involved in the survey (Table 3.5).

Table 3.5: Selected study communities with sample sizes

District	Name of community	Sample of household	Total
Kwahu Afram Plains South District	Ayebeng	4	
	Aduonum	28	
	Asimpanyin	27	
	Mmradan	57	
	Kwasi Addae	55	
	Apesika	37	208
Kwahu Afram Plains North District	Adukrom	28	
	Sawua	18	
	Sodzikope	76	
	Abotanso 1	89	211
Total			419

Prior to commencing data collection in the communities, permission was sought from key actors including the District Assembly, chiefs and opinion leaders. This process was done by introducing the research objectives to the officials and explaining the role of the researcher to them. Through the traditional leaders, community-level announcements were made at the various communities to make households aware of the impending survey activities. These measures helped to keep the researcher safe during the field activities and adequately prepared participants for their interaction with the researcher.

The overall response rate was 90%. Many community surveys were held at the residence of respondents and in open spaces for convenience – minimising the need for participants to travel long distances to be involved, whilst also allowing them to attend to some domestic chores, if need be. In some few occasions, surveys were conducted at the workplace of respondents. Interviews with actors were mainly conducted in their offices and homes and in a few instances, conducted via telephone.

3.7 Ethical considerations

Since the study involved human participants, ethical issues were addressed prior to data collection. This was done in consultation with the Mary Immaculate College Research Ethics Committee (MIREC), with reference number "A21-056". Informed consent is regarded as, "a benchmark for social research ethics" (Denscombe 2002, p. 183). It entails informing participants about the purpose of the study, the probable risks associated with participation and ensuring that their participation is voluntary and devoid of coercion (Israel and Hay 2006; Denscombe 2017).

In obtaining informed consent, I introduced myself by providing my name, university affiliation, and programme details, and I explained the purpose of my visit to participants. A Participant Information Sheet was used to explain to participants how responses would be used for academic purposes. Participants were required to read and sign an Informed Consent Form to indicate their consent to be involved in the study. This form contained the details of the research and in a situation where participants were unable to read the consent form, the researcher explained the content to them and oral consent was obtained.

Participants were informed that they could freely opt out of the survey and interview at any point in time. Audio recordings, notes and photographs of natural settings were taken, following the permission of participants. More so, participants were assured of confidentiality before involvement in the study. Measures were taken to ensure that the identity of participants and information shared were securely protected to prevent third party access. Audio and visual records were stored in a password protected folder on the researcher's laptop to prevent unauthorised access. All notes written during interviews were compiled and safely kept, ensuring they remained inaccessible to third parties.

A safe environment was created to allow participants to share and express their opinions under no intimidation. The privacy of participants was respected, and they were at liberty to suggest locations they wished to have interviews conducted, as far as these were open places. For female participants, interviews were conducted in the open in order not to disrupt household relations, particularly given the patriarchal nature of the selected study communities. This process ensured that the cultural norms and sensitivities that govern gender interactions are respected, creating a more friendly and respectful research environment.

3.8 Data reliability and validity

Reliability and validity of data collected were enhanced via pretesting and piloting research instruments in advance. This involved a small number of respondents, consisting of approximately 7 rural households and 2 actors, to test the clarity, significance, and appropriateness of the research instruments. This process ensured that the research instruments were capable to address the research questions effectively and adequately (Kelley *et al*. 2003).

Additionally, the quantitative data obtained from the study were triangulated with qualitative data collected through interviews. The secondary data were compared with energy data and interviews to establish patterns and identify the relationships. The reflexive thematic analysis of data ensured that the data were systematically analysed in response to the research questions, from which the qualitative themes were derived.

3.9 Data analysis and management

The quantitative data were checked to ensure that all protocols were followed for anonymity. All questions in the administered questionnaires were coded and keyed into Statistical Package for Social Sciences (SPSS) Version 26.0 and Microsoft EXCEL for analysis. A descriptive analytical approach was used, and empirical results were presented in tables. Specifically, a non-parametric tests (Kendall's coefficient of concordance and chi-square) were conducted to make logical conclusions and inferences from the results (García *et al*. 2009; Turhan 2020).

Additionally, the Kolmogorov-Smirnov test with Lilliefors correction was conducted to assess means, standard deviations, and normality tests. A multiple regression analysis with robust standard errors was employed to examine relationships between variables. These tests were employed due to their relevance, widespread use and endorsement in various scholarly fields, including energy studies (Devore 2000; Hayes and Cai 2007; Stephens and Spiegel 2009; Gomes *et al*. 2018; Field 2024).

Qualitative data, obtained from interviews, were transcribed, and translated into English. Following transcription, the analysis commenced with a thorough reading of all the transcribed data, complemented by field notes. The process was intensive, with approximately 5 hours required to fully process and transcribe each 45-minute audio recording. A reflexive thematic analysis was manually conducted to identify emerging themes from the interviews. This method was chosen for its flexibility, data-driven nature, and its capacity to accommodate the creation of new themes. The data were analysed inductively, beginning with semantic coding, which involved reading the data and grouping related words or sentences. These codes were subsequently organised into themes related to access to clean energy (Braun and Clarke 2021). The codes and themes were reviewed and refined to accurately reflect the views of respondents, while maintaining their anonymity.

The interview data were compared with quantitative data obtained through surveys and primary observations to identify points of convergence and divergence. These datasets were then comprehensively synthesised to analyse low-carbon energy transition within the study communities. To support the empirical findings, excerpts from a few interviewees' responses were quoted using pseudonyms – herein, common local names – to ensure confidentiality and to give the study a more familiar and local feel. To produce a scholarly report of the analysis, the findings were compared to other literature, as further presented in Chapters 5, 6 and 7. Some images were also used to graphically explain the energy situation of the rural communities. Unless otherwise stated, credit of the images used in this research goes to the author.

3.10 Researcher's role in the study

The position of the researcher within a study can significantly influence the results of the study and how the data are interpreted (Clarke and Braun 2013). That is, even though I am familiar with the relevant literature on the subject matter, my position as a student researcher and belief system could influence the outcome of the study. As a student who has reviewed scholarly works on the subject matter in a rural context, I possess general 'on-the-ground' knowledge of the energy situation of rural households in Ghana. This knowledge had the potential to influence the research outcome.

Furthermore, my affiliation with a foreign institution could lead participants to have preconceptions about me, even before engaging them in the research. Given that I have lived most of my life in urban communities, I also had some potential blind spots regarding my perception of the energy situation or access in rural communities, which could also influence certain aspects of the data collection process.

As an international student, my background and experiences could predispose me to prioritise formal knowledge, leading to the marginalisation of local knowledge. More so, as the research involved people of diverse gender identities, I recognised the potential to be unconsciously biased towards other gender identities. Such biases, if not addressed, could influence the research process and its outcomes.

According to Giametta (2018), the language used by researchers and the context in which they situate these words can significantly influence their perspective as investigators. The role of the researcher in influencing research outcomes has sparked scholarly debates regarding the part researchers have to play in a study, particularly whether they should adopt the position of an outsider or an insider (Day 2012).

Assuming the role as an insider is a situation where a researcher studies an institution or group in which he/she belongs. While this position enables the researcher to bring all sorts of contextual understandings to the data that an outsider researcher might lack, some scholars have challenged this role of researchers, arguing that such insights could potentially bias the research findings, a concept referred to as ‘guilty knowledge’ (Williams 2009). Moreover, insider status can also cause interference, particularly in the data collection exercise where respondents attempt to take control of the process, by asking researchers questions themselves (Adu-Ampong and Adams 2020; Bukamal 2022).

Assuming the role as an outsider researcher on the other hand, involves studying an institution or group to which a researcher does not belong to. Some scholars argue that assuming this position enables researcher to gain sensitive information, since participants may feel more comfortable confiding in someone they do not know while also, permitting fairness in data reportage as researchers can distant themselves from the context (Gasman and Payton-Stewart 2006).

However, other researchers state otherwise, contending that this role can negatively influence the quality of research. They argue that it creates a situation where researchers perceive themselves as studying ‘others’ through their own lenses. This disconnect can make it difficult for researchers to contextualise some of the findings of their research (Al-Makhamreh and Lewando-Hundt 2008; Clarke and Braun 2013).

It is from this backdrop that I adopted a middle line in this research, assuming the role of an insider/outsider. This position enabled me to leverage the advantages of both roles, compensating one with the other (Bourke 2014; Htong Kham 2024). To mitigate potential biases and address the potential blind spots, I engaged with scholarly works that challenged my existing understanding on the subject matter. That is, I did not conveniently review research works that aligned with my prior knowledge. Additionally, I sought for feedback from colleagues with diverse backgrounds and perspectives, which was particularly useful in drafting appropriate questions for data collection (Temple and Young 2004).

To ensure that personal opinions did not influence the findings of the study, I focused on asking questions on the interview schedule and accurately reporting participants' responses, as recorded during data collection. Although I am a graduate student who happened to be working in rural communities with low literacy levels, the role as an insider with households was adopted due to my shared experiences regarding energy access issues. More so, my status as a Ghanaian who speaks the local dialect in the study communities, further helped to establish rapport with respondents. This common bond facilitated a deeper connection with the respondents.

Dressing appropriately to fit and blend into the rural setting also contributed to enhancing my connection with respondents (Gair 2012; Bukamal 2022). This insider role rendered me very approachable and thereby, made it easy and safe for households to disclose information and engage in discussions with me, without feeling any sense of judgement (Mayorga-Gallo and Hordge-Freeman 2017). The insider approach proved advantageous in the study, especially in a Ghanaian context where research often relies on social connections (Moser 2008; Adu-Ampong and Adams 2020).

Despite assuming the role of an insider in the field, no participant ended up taking control of the data collection process by asking me questions. To earn credibility with research participants, I provided them with a Participant Information Sheet and a Consent Form, which detailed the purpose of the research and ensured them of their anonymity. This fostered trust in participants and encouraged them to dedicate time for the research, while giving objective responses (Adu-Ampong and Adams 2020).

During data collection, I remained conscious of potential gender biases, by employing a reflexive approach throughout the research to promote inclusivity. I refrained from interfering with respondents' answers. I also created an interactive atmosphere which encouraged participants to provide genuine responses, giving recognition to the local culture. I did this by not making the data collection exercise end up feeling more like a 'job-interview' session.

For this research, I was primarily responsible for data analysis and interpretation, and my role as an insider facilitated efficient data interpretation (Easterby-Smith and Malina 1999). However, this position had the potential to influence the findings of the study, especially the qualitative part of the research. To minimise this effect, I tried to remain very objective, ensuring independence from the data collected and avoiding any influence of the results by assuming the role as an outsider at some point (Bryman 2016).

By assuming the role of an outsider in the analysis, I ensured that quality and objective output was produced. This approach minimised the risk of bias and allowed me to document the results comprehensively. The outsider role enhanced a detached and impartial viewpoint, which was essential for rigorous data analysis and ensured that I did not miss crucial details recorded at the field sites.

Overall, balancing the insider and outsider positions in the research ensured that the interests of both the respondents and researcher are served. I was therefore able to gather high-quality data and objectively interpret them, thereby enhancing the credibility and validity of the findings (Clarke and Braun 2013; Bourke 2014).

3.11 Challenges in the field

Distance posed a significant challenge to the research. The remote location of some study communities made them exceedingly difficult to access. At times, the researcher had to travel long distances to the homes of potential participants only to find nobody present. To overcome this obstacle, the researcher visited the working sites of some household heads to conduct surveys. This ensured the collection of data despite the absence of participants in their homes.

The lack of precise information on the number of households in the study communities made it challenging to mathematically, determine the sample size of the study. To address this, the researcher used population size at the district level, obtained from the 2021 Population and Housing Census data, to estimate the sample size. This estimated sample size was increased to ensure the inclusion of many households within the study communities.

Because issues of energy have been heavily politicised in the study communities, a few households were initially reluctant to participate in the survey. These individuals expressed frustration, citing numerous unfulfilled promises by actors in the past that their communities would be connected to the national electricity grid. As a result of this, they were unwilling to engage in any discussion related to energy, particularly electricity. The researcher, however, took the time to explain the purpose of the research to them and emphasised their voluntary involvement in the study. This action helped to address their concerns and enhanced household participation.

Since the data collection exercise was undertaken in the period of the Russia-Ukraine war, it was challenging for motorcycle riders to get access and purchase fuel. Consequently, the researcher could not visit the study communities as frequently as planned. This posed a challenge for the researcher to meet the targeted sample size within the predicted timeframe. The researcher overcame this challenge by extending the length of stay in the study communities, allowing more time to gather necessary information.

Many of the respondents who engaged in the interviews were reluctant to have the interview sessions audio-recorded, despite being assured of anonymity. The researcher therefore had to manually hand-record all the responses which presented a significant challenge for the researcher. To manage this, the researcher quickly noted relevant quotes, while concisely and promptly documenting the responses of interviewees. Longer notes were then transcribed as soon as possible.

3.12 Research methodology workflow

The materials and methods deployed in the research were rigorous and hence, the findings of the study reflect the energy situation of households in the study communities. This research methodology workflow visually presents the key methods used in addressing the research questions. It highlights the systematic steps that were taken during the research, from the design of the research to the analysis of the data collected (Fig. 3.2).

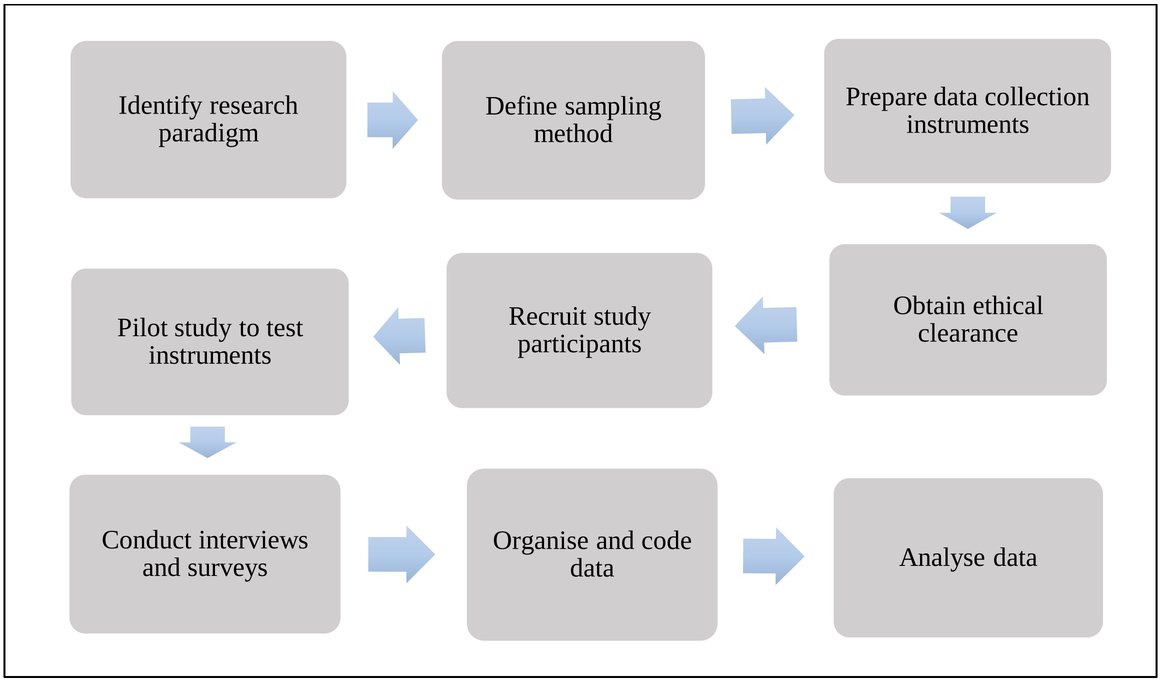

Fig. 3.2: Research methodology workflow

(Source: Author’s construct).

4. PROFILE OF THE KWAHU AFRAM PLAINS NORTH AND SOUTH DISTRICTS

This chapter provides an overview of the energy profile of Ghana as well as the case study area, the KAPN and KAPS districts. For the purposes of the research (based on the working definition), the chapter focuses on the electricity and cooking fuel demand in Ghana. Additionally, the chapter delves into the socio-demographic characteristics, environmental factors and socio-economic dynamics of households within the districts.

The data presented in this chapter are largely based on secondary data sources, including data from the Energy Commission of Ghana, the authoritative body mandated to provide comprehensive data on energy for national decision making. Furthermore, the analytical reports of the 2010 Population and Housing Census, and some preliminary findings of the 2021 Population and Housing Census[4], are used to enrich the understanding of the case study districts. Collectively, these secondary sources contribute to the robust analysis of the energy consumption patterns, demographic trends and livelihood dynamics within the context of the study areas.

This chapter is integral for the research as it enhances the contextual understanding of the findings by providing insights into the cultural, social, and economic characteristics of the districts. Knowledge on this is essential in designing appropriate interventions that meet the specific needs of the districts. It also helps in assessing how the research would be applicable in other geographical areas with similar or different profiles. This information is crucial for actors as it fosters partnerships and provides strategic means to allocate available resources based on the identified needs, strengths and weaknesses of households in the districts.

4.1 Energy situation of Ghana

The transition to low-carbon energy in Ghana has received limited investment in recent years, leading to increasing calls for greater financial commitment to renewable energy development (Ankrah and Lin 2020; Agyekum *et al*. 2021; Ali *et al*. 2021). In response, the government, through

[4] Only population sizes of districts in the 2021 Population and Housing Census had been published at the time this research was conducted. The detailed profiles of districts had not yet been published and hence, a lot of materials used in this chapter were based on the 2010 Population and Housing Census.

the Renewable Energy Master Plan (REMP) and the National Energy Transition (NET) Framework, has outlined plans to invest in renewable energy to enhance access to clean energy sources (Ministry of Energy 2022a; Energy Commission of Ghana 2022b). However, several challenges – such as institutional weaknesses, lack of commitment to policy implementation and limited financial accessibility – continue to hinder the achievement of the country's renewable energy targets (Sakah *et al*. 2017; Obeng-Darko 2019; Sefa-Nyarko 2024). Sefa-Nyarko (2024) notes that Ghana will be unable to meet its national energy transition goals unless the government takes decisive action to accelerate the shift toward renewables.

Political decision-making plays a crucial role in Ghana's energy transition (Tettey *et al*. 2025; Tyce *et al*. 2025). According to (Sefa-Nyarko 2024, p. 9), the discourse surrounding energy transition in the country is inherently political, as "decision-making around energy transition is significantly influenced by geopolitical and external thrusts as much as it is by domestic political considerations". This perspective highlights how Ghana, like many other SSA countries, perceives energy transition as a process characterised by global inequalities. For instance, disparities in access to clean technologies and financial resources place certain countries at an advantage in achieving energy transition, while others, including Ghana, face systemic barriers (Sefa-Nyarko 2024).

Beyond national politics, local-level political dynamics also play a significant role in shaping energy access and distribution (Amankwaa and Gough 2022). Despite Ghana's decentralised system of governance, which is intended to empower marginalised groups by ensuring their representation in governance through local government structures, several structural challenges undermine its effectiveness. Political interference, inadequate funding, and the inability to mobilise financial resources have rendered local governments largely ineffective (Forkuor and Adjei 2016; Mensah *et al*. 2024). Analysing decentralisation through Schneider's (2003) core dimensions, Crawford (2009), Ayee (2013) and Mohammed *et al*. (2024) highlighted that decentralisation in Ghana is 'centralised' as the central government retains fiscal control (i.e. no fiscal decentralisation), has not fully devolved financial power to local authorities (i.e. no administrative decentralisation), and exerts political control on local authorities.

At the household level, (Amankwaa and Gough 2022) illustrate how individuals with political influence or strong family ties are able to secure access to energy infrastructure. Their study highlights how political affiliations and personal networks determine who gains access to electricity, often disadvantaging marginalised communities. This politicisation of energy access, lack of effective decentralisation and household dynamics can pose a challenge to equitable access to clean energy.

4.1.1 Electricity

Ghana has a notable achievement in electricity access in comparison to other African countries, with about 85% (in 2019) of its population connected to the national electricity grid. This notwithstanding, communities with access to electricity are mostly urban, and are not guaranteed reliable supply (see for instance, Amankwaa and Gough (2022) and Shah *et al*. (2022)). Ghana's energy mix (as of 2021) consists of hydroelectricity (29%), conventional thermal plants (69%) and renewables (2%). Electricity consumption, specifically residential, has shown consistent growth in the country. For instance, the total consumption increased from 13,700 GWh (2016) to 21,466 GWh (2021) – an annual growth rate of 8% (Agyekum 2020; Energy Commission of Ghana 2022a; IEA 2022b).

The increase in electricity demand has been accompanied by an increase in supply. Over the last decade, there has been an increase in the electricity generation capacity of the country, resulting from the annual improvement in capacity of thermal and renewable sources. Specifically, installed electricity generation capacity witnessed an increase from 3,795 MW (2016) to 5,449 MW (2021). Moreover, the country trades electricity with other African countries like Togo, Benin, Burkina Faso and Cote d'Ivoire (Energy Commission of Ghana 2022a; IEA 2022b).

Electricity in Ghana is primarily generated by the Volta River Authority and Independent Power Producers (IPP). Ghana also imports electricity to complement the quantities domestically produced. The rate of import fluctuates based on the country's ability to generate sufficient power to meet the energy demands of citizens. Consequently, the volume of import is not fixed. All the generated and/or imported electricity are dispatched by the Ghana Grid Company (GRIDCo). GRIDCo is responsible for transmitting electricity from wholesale suppliers to bulk consumers such as the Electricity Company of Ghana (ECG), Northern Electricity Distribution Company (NEDCo) and the mining sector (Ghana Grid Company 2024).

The ECG and NEDCo function as retail points, distributing electricity to end-users. ECG and NEDCo are both state-owned limited liability companies under the Ministry of Energy. ECG is the largest distributor of electricity in Ghana, distributing electricity to regions such as the Ashanti, Central, Eastern, Greater Accra, Volta and Western Regions, serving about 80% of the Ghanaian population. The remainder of the population are served by NEDCo, mainly supplying electricity to the northern parts of the country (Electricity Company of Ghana 2024) – Fig. 4.1.

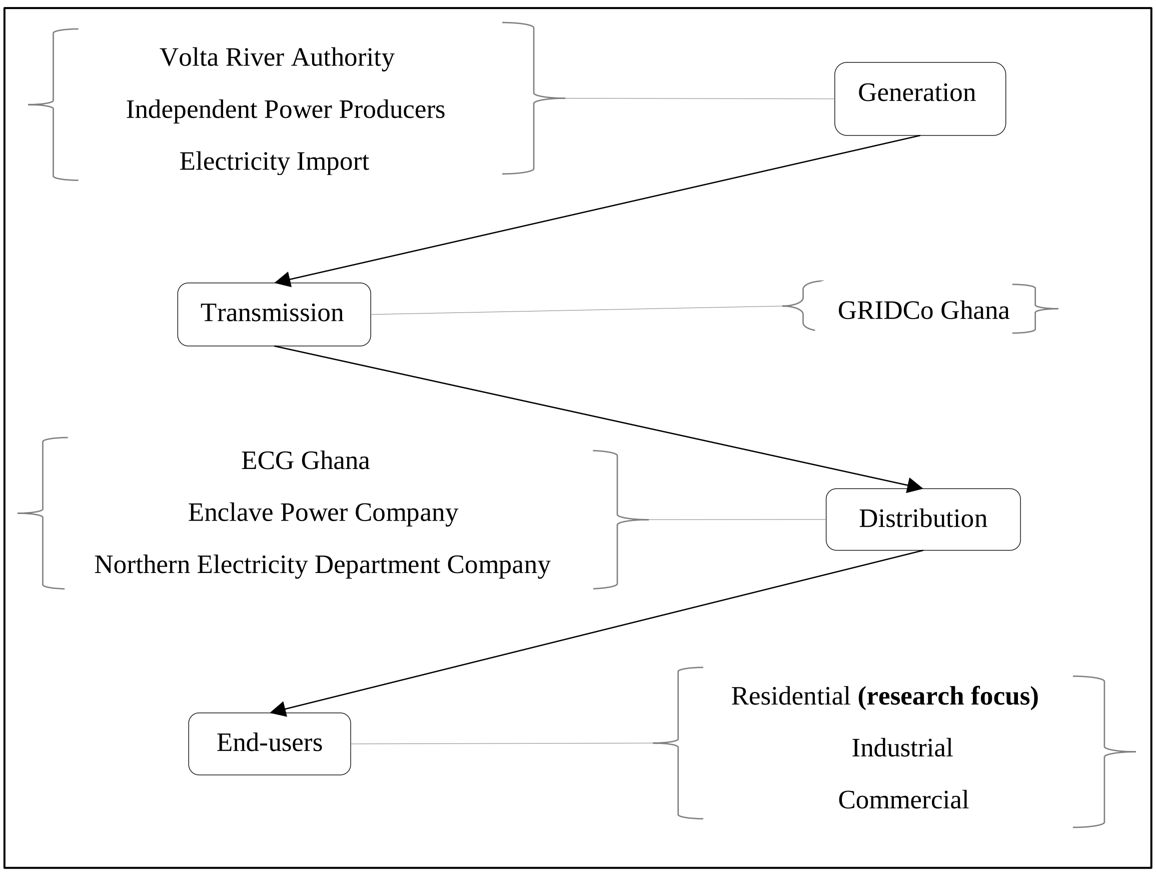

Fig. 4.1: Structure of the electricity sector in Ghana

(Source: Author's construct).

Despite the increased electricity generation capacity over the years, Ghana continues to face significant supply challenges mainly caused by transmission losses, mismanagement by consumers and non-diversification of sources. These challenges result in intermittent power outages which are witnessed in various parts of the country, locally termed ‘dumsor’ – which literally means ‘on and off power supply’. As the population of the country is projected to rise to 40 million by 2030, electricity consumption and access could further deteriorate (Kumi 2017; Agyekum 2020; Murshed and Ozturk 2023).

This situation has led to the call for actors to step up efforts to enhance electricity supply and also, connect more people to the national electricity grid. In response to this, there has been the introduction of prepaid metering systems to reduce thefts, make bill collection more efficient, and remove bad debts. The primary target of these meters has been residential electricity users. However, the benefits associated with the use of prepaid metering have yielded mixed results among households, with some households satisfied with the prepaid metering system, while others express dissatisfaction (MIDA 2015; Kumi 2017; Kambule *et al*. 2018; Tuffour *et al*. 2018; Mensah and Birch 2021; Bloomer and Boateng 2024).

4.1.2 Cooking fuels

In the specific context of cooking fuels, Ghana, like many countries in the Global South, relies on a mix of woodfuels (including firewood and charcoal), LPG, kerosene, and harvested crop residues. Although access to LPG has been increasing in Ghana, woodfuels remain the traditional source of energy and the dominant source of cooking energy. Woodfuels, comprising firewood (33%) and charcoal (34%), account for a substantial portion of the country’s total energy use (Asante *et al*. 2018; Energy Commission of Ghana 2019a; Ghana Statistical Service 2019).

Woodfuels are woody biomass that can be used in its natural form or processed into forms such as charcoal and briquettes. When used in its raw form, it is referred to as firewood or fuel wood. Woodfuels are sourced from forest and/or farmlands. Charcoal is the most widely used processed biomass used in Ghana. The primary source of wood for making charcoal is sourced from forest in the transition zones. The main charcoal producing hotspots in Ghana are Kintampo in the Kintampo North District, Bole in the Bole District and Atebubu in the Atebubu Amantin District (Energy Commission of Ghana 2019b).

Woodfuels are the only energy source where cooking appliances and most production equipment are locally sourced, significantly contributing to the Ghanaian economy and as such, supports the livelihoods of many Ghanaians (Brobbey *et al*. 2019; Ghana Statistical Service 2019;

Bawakyillenuo *et al*. 2021). Yet, the production of charcoal decreased from 2,807 Ktoe in 2020 to 2,225 Ktoe in 2021, which could be attributable to regulations against deforestation. However, production is expected to rise in the coming years due to increasing demand, while firewood production is anticipated to decline (Energy Commission of Ghana 2022a).

Charcoal production and sale are a major source of income and livelihood for households involved in the business, particularly for women who play vital roles like collecting and burning wood, handpicking and packing of charcoal. Charcoal is typically packed in mini (39 kg) and maxi (50kg) bags. The price of charcoal varies from place to place, with prices being generally higher in urban areas. In 2021, the national mean price for a maxi charcoal bag was GH¢62 [5]. The price of charcoal is directly related to the national inflation rate and hence increases with rising inflation (Bawakyillenuo *et al*. 2021; Energy Commission of Ghana 2022a).

In Ghana, biomass fuels, including woodfuels, account for approximately 16,600 deaths annually and are a significant contributor to ambient air pollution. Although efforts have been made through initiatives, such as the LPG for Development (LPG4D) Programme to increase the use of LPG in the country, its uptake remains higher in urban areas compared with their rural counterparts. Even so, some users of LPG fail to exclusively use LPG for cooking (Ghana Statistical Service 2014c, 2019; Inkoom and Crentsil 2015; Karimu *et al*. 2016; Wiedinmyer *et al*. 2017; Bawakyillenuo *et al*. 2021).

4.1.3 Renewable energy resources

Ghana is endowed with many river bodies and has historically been reliant on hydropower for electricity. Until 2016, hydropower was the predominant source of electricity but has since been surpassed by thermal generation sources. By 2019, 6017 GWh of electricity was generated from hydropower with the majority of the remaining electricity generated from thermal sources (Energy Commission of Ghana 2019b). Solar and wind energy have been less deployed in Ghana, despite the country having a favourable landscape and being geographically well positioned to deploy such energy alternatives (Lin and Ankrah 2019; Sun *et al*. 2020).

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[5] 1 Ghana cedi (GH¢) is equivalent to 10 US Dollars, as at January 2023

Traditionally, solar energy has been used for domestic purposes, such as drying and heating. However, Ghana is recently making more use of the abundant solar resource by harnessing it in electricity generation. As of 2019, the total installed capacity of solar PV systems in the country reached 67,218 kW[2]. Over the years, there has been several renewable energy programmes aimed at enhancing the use of solar energy, such as National Rooftop Solar Programme and Solar Lanterns Promotion Programme. Yet, the general adoption and investment in renewable energy has been very slow despite efforts by the Government of Ghana to promote the use of renewables (Bawakyillenuo 2017; Aboagye *et al*. 2021).

There is a disconnect in Ghana's SDG 7 aims of achieving clean cooking fuels and electricity-based technologies[6]. Using a political economy approach, Newell and Daley (2022) highlight intervention points for accelerating the adoption of electricity-based cooking. They emphasise the need to realign governance and enhance policy responses to tackle the issue and they note: "this should be focussed less on individual behaviours and more on wider social and cultural settings and the gendered and other power dynamics that structure them" (Newell and Daley 2022, p. 8).

The feasibility of cooking with electricity in Ghana is higher in urban areas due to the connection of such communities to a regular electricity supply. However, it will be more challenging in rural areas, given their low-income levels and in some cases, their non-connection to the national grid. As of 2017, less than 1% of Ghanaian households used electricity as their primary source of cooking fuel (Ghana Statistical Service 2019).

Biofuels (biogas, biodiesel and bioethanol) have also been introduced in the country as renewable energy alternatives. Among all the biofuels, biogas have garnered attention in the country because of its diverse application. The generation of biogas can serve as sources of energy for cooking, electricity, and transportation. Feedstock such as sewage sludge, crop and agricultural residues can be converted into biogas through anaerobic digestion in a biodigester. To generate electricity through biogas, large volumes of feedstocks and a large biodigester are required. The by-product

[6] E-cooking here refers to cooking with electricity and the goal of this transition is to "increase the electrification of cooking using mainly solar powered batteries and microgrids to power … stoves and hobs for cooking" (Newell and Daley 2022, p. 1)

of this process can be used as fertiliser which farmers can apply on their farms (Bensah and Brew-Hammond 2010; Awafo and Agyeman 2020).

Despite the development of largescale biogas offering the potential for Ghana to address its energy needs, while providing fertilisers to boost the agricultural sector, it is yet to gain significant traction in the country. Consequently, biotechnologies in Ghana are typically small to medium-scale sizes, even though some actors regard it as having the potential to contribute to multiple sectors of the economy including agriculture, waste management, energy and climate change, health and social benefits, such as job creation and improved well-being (Awafo and Agyeman 2020). At the household level, there has been a steady, albeit slow, increase in the use of biogas technologies.

Factors such as gender, age, occupation of household heads, household size, type of energy currently used for cooking, household expenditure on energy for cooking, income and prior knowledge influence households' willingness to adopt these technologies (Oduro *et al*. 2023). Furthermore, cultural and religious factors inhibit households' adoption of certain clean energy solutions, specifically biogas systems that entail the use of human excreta. In response to these challenges, Osei-Marfo *et al*. (2022) highlighted the crucial roles of religious leaders and the government can play in promoting the uptake of biogas technologies.

4.1.4 The case of off-grid rural communities

It is estimated that SSA will hold 30% of the global off-grid population by 2030 (Sturm *et al*. 2017; IEA 2022b). There is hence, the need to step up efforts toward electrification in the quest to attaining SDG 7. Consequently, the Energy Commission of Ghana aims to increase investment in renewable energy in rural areas through the REMP, which aims to achieve a 10% contribution of renewable energy to the country's electricity generation mix by 2030 (Energy Commission of Ghana 2022b).

As many of the communities without access to electricity in Ghana are in isolated rural districts, the REMP prioritises deploying mini-grids in some rural communities. So far, five mini-grids have been established by the Government of Ghana in the off-grid communities of Atigagome, Wayokope, Aglakope, Kudorkope and Pediatorkope. Following the abundance of solar resources in the country, all five mini-grids heavily rely on solar resources (Bukari *et al*. 2021a).

Thus, electrification efforts through the REMP, have yet reached all off-grid rural communities in Ghana. Consequently, many off-grid rural communities have seen the introduction of simpler/smaller low-carbon technologies, such as solar PV lanterns, SHS and solar torchlights, particularly for lighting.

In an effort to mitigate the overreliance on woodfuels in rural communities, the Government of Ghana, along with other actors, have been rolling out programmes targeting the use of cleaner cooking fuels (Asante *et al*. 2018). One notable initiative is the Rural LPG Promotion (RLP) program which aimed to improve LPG access in rural areas from 3% (in 2012) to 15% (by 2016). The RLP program was introduced to specifically target rural communities to enhance the use of LPG for cooking. Launched in 2013, the programme sought to contribute to the nation's goal of expanding LPG coverage to about 50% of the population by 2020.

Under the RLP program, beneficiaries were provided with free 6 kilogramme cylinders, single-burner stoves, hoses and regulators. The RLP was coordinated by the Ministry of Energy, with beneficiaries selected based on their ability to make an initial payment of GH¢ 22.00 (5 U.S dollars then) to fill the cylinder. This selection process was conducted by the District Assembly officers and focal persons in the beneficiary communities (ENERGIA 2015; GhanaWeb 2016).

However, the RLP program did not meet its intended goal as beneficiaries failed to exclusively adopt or sustain the use of LPG (Energy Commission of Ghana 2016; Asante *et al*. 2018; Carrión *et al*. 2020; Adjei-Mantey and Takeuchi 2021). Some households could not afford the cost of filling their cylinders after gas depletion, while others, could not bear the expense of transporting their cylinders to gas stations to have them refilled. As a result, a significant number of rural dwellers, similar to findings of other African countries, failed to shift to LPG and continued to rely on the use of woodfuels (Wiedinmyer *et al*. 2017; Makonese *et al*. 2018; Njenga *et al*. 2019).

This dependence on traditional biomass poses a challenge towards meeting the nationally determined contributions to the SDGs. Currently, all interventions to promote LPG use in Ghana (both rural and urban) have been revised and consolidated under the LPG4D programme. This programme aspires to achieve 50% access to LPG by 2030 (Ahunu 2015; Ministry of Energy 2022b). It remains to be seen how successful the LPG4D programme will be in shifting rural fuel use to LPG.

4.2 Profile of the study districts

The ten rural communities that constituted the study communities (Ayebeng, Aduonum, Adukrom, Asimpanyin, Mmradan, Kwasi Addae, Apesika, Sawua, Sodzikope and Abotanso 1) are situated in the KAPN and KAPS districts of the Eastern Region of Ghana. The Eastern Region of Ghana shares a boundary to the north with Brong Ahafo and Ashanti Regions, to the east with the Volta Region, to the west with the Central Region, and to the south with the Greater Accra Region. The region is known for its extensive tropical forest and the presence of the Lake Volta and Akosombo Dam, which serves as a source of hydroelectric power for the country (Fig. 4.2).

Fig. 4.2: Map of Ghana showing the study districts and communities; based on ESRI shapefiles using ArcGIS 10.6

The study districts, KAPN and KAPS districts, form part of the 33 municipalities and districts in the Eastern Region of Ghana. Across every district of the country, governance has been decentralised and there are elected councils and officials who constitute the District Assembly. These assemblies act as government representatives at the local level.

According to the Constitution of the Republic of Ghana (1992), a District Assembly consists of: one person from each electoral area; Member(s) of Parliament (MP) from the district, the District Chief Executive (DCE) and other members appointed by the President, in consultation with traditional authorities and interest groups in the district. This structure is to ensure representation at the local level to enhance responsiveness to the needs and interests of communities within every district.

4.2.1 Kwahu Afram Plains North (KAPN) District

4.2.1.1 Physical and natural environment

The KAPN district has a land area of 2,341.3 km^2 and is geographically bounded by Kwahu Afram Plains in the south, the Volta River in the east, Sekyere East and Asante-Akim districts in the west, and the Sene and Atebubu districts in the north. The terrain of the district is generally undulating, rising about 60 - 120 meters above mean sea level.

The district's capital is Donkorkrom and its landscape is predominantly drained by the Afram, Obosom and Volta rivers throughout the year, which are also used by residents as a source of water for agricultural purposes. The district lies in the savannah vegetation zone, which has an abundance of short semi-deciduous trees and ground flora. There are a few forest reserves with trees such as *Milicia excelsa* (Odum), *Sterculia rhinopetala* (Wawa), *Terminalia superba* (Ofram), *Khaya ivoriensis* (African mahogany) and *Antiaris toxicaria* (Kyenkyen).

The KAPN district has a vast amount of fertile soils suitable for cultivating food crops (e.g. cassava, plantain, yam, maize) as well as cash crops (e.g. cashew, oil palm, citrus). However, the soils are prone to erosion if left bare without vegetation cover. The agricultural potential of the KAPN district underscores its significance as a hub for subsistence and commercial farming activities (Ghana Statistical Service 2014b).

4.2.1.2 Population distribution and economic status

According to the 2021 Population and Housing Census conducted by the Ghana Statistical Service (2021), the KAPN district has a population of 66,555 people with 35,567 being males and 30,988 females. The district is predominantly rural as about 52,151 of its population live in rural areas. The demographic profile of the district shows a youthful population with 17% of them within the 0-4 years age group. The average household size is 5 people and about 90% of households are located in rural areas. Many households are nuclear, consisting of spouses and children – with males serving as household heads.

The district has an economically active population, as 86% of residents are engaged in various forms of employment. Both males (86%) and females (82%), irrespective of their roles in the homes, are engaged in employment. The private informal sector notably employs about 94% of the people of the employable age (15 years and above). The demographic and economic distributions highlight the importance of the informal sector in supporting the livelihoods of households within the district (Ghana Statistical Service 2014b).

4.2.1.3 Economy and occupation

As a result of the rich soils, farming is the main occupation in the KAPN district. The manufacturing sector is subdued, and it is dominated by agro-processing units predominantly located in the district's capital. The district, although having a substantial amount of potential tourist attractions (e.g. Dwarf Island), has not yet harnessed these resources to promote its development.

The workforce in the district predominantly consists of skilled agricultural, forestry and fishery workers (71%), craft and related trades workers (15%) and service and sales workers (7%). The high percentage of individuals in the agricultural sector results from the presence of abundant fertile lands and major rivers within the district. In particular, a larger proportion of males (82%) are engaged in agricultural activities, while females are mostly engaged in the service and sales sector.

Agricultural practices in the KAPN district predominate 75% of rural households compared to their urban counterparts (56%). Crop farming, comprising 89% of agricultural activities, is the dominant agricultural activity in the district. Interestingly, in both rural and urban communities of the district, tree planting is not a popular agricultural activity, indicating potential areas for sustainable agricultural practices (Ghana Statistical Service 2014b).

4.2.1.4 Access to utilities for lighting and cooking

In the KAPN district, flashlights/torches (42%), kerosene lamps (28%) and the main electricity grid (27%) are the principal sources of lighting for residents. Many urban households (70%) in the district are connected to the main electricity grid compared to rural areas (18%). Alternative sources such as candles, solar technologies and gas lamp are used by less than 2% of households.

Regarding cooking fuels, firewood is the principal source in the district and many rural areas (85%) rely on it. Few households in the district use LPG (14%) and electricity (0.3%) for cooking purposes. This pattern of energy usage highlights the disparity in access to modern energy access between rural and urban areas in the district (Ghana Statistical Service 2014b).

4.2.2 Kwahu Afram Plains South (KAPS) District

4.2.2.1 Physical and natural environment

The KAPS district, with a land mass of 3,095 km^2, is located at the north-western corner of the Eastern Region of Ghana. It is bordered in the north by the Kwahu Afram Plains North, in the south by Kwahu South, in the east by the Volta River, and in the west by Sekyere East and Ashanti-Akim districts. The administrative capital of the district is Tease. The KAPS district generally, has undulating lands rising about 60 -120 metres above mean sea level. It is primarily drained by the Afram and Volta rivers, which are mostly used by residents for domestic purposes. These rivers also serve as a vital water source for households in the district who use it for irrigation.

The KAPS district is in the savannah vegetation zone, characterised by abundant fire-resistant trees and ground flora. It has a few forest reserves which contain trees such as *Milicia excelsa* (Odum), *Sterculia rhinopetala* (Wawa), *Terminalia superba* (Ofram), *Khaya ivoriensis* (African mahogany) and *Antiaris toxicaria* (Kyenkyen). The district has fertile soils making it suitable for cultivating both food crops and cash crops. Farmers in the district grow a variety of cash crops, such as cocoa, coffee, oil palm, citrus and cola. However, the district’s lands are prone to wind erosion if uncovered by vegetation (Ghana Statistical Service 2014a).

4.2.2.2 Population distribution and economic status

According to the 2021 Population and Housing Census by the Ghana Statistical Service (2021), the KAPS district has a population of 74,002 people, comprising of 39,423 male and 34,579 females. The district is predominantly rural as about 47,255 of its population reside in rural areas. It has a very youthful population with many in the 0-4 years age group. The average household size of the district is 4 people, and a substantial number of households are in rural areas, reflecting the district's rural character.

Following the availability of arable lands and drainage of the district, agriculture is the main driver of the KAPS district's economy. The dominant agricultural activity in the district is crop farming (90%). Animal husbandry (5%) and fishing (4%) also contribute to the agricultural sector, albeit in a small proportion. The industrial sector of the district is characterised by micro agro-processing enterprises. Processing cassava into 'gari' (a coarse granular flour) is a significant income-generating activity, particularly among women in the industrial sector (Ghana Statistical Service 2014a).

4.2.2.3 Economy and occupation

In the KAPS district, 77% of the working population are employed in the skilled agricultural, forestry and fishery work. This is followed by the manufacturing sector, employing 8% of the labour force. A gender disparity exists within these sectors as a significant majority of males (86%) are engaged in agricultural, forestry and fisheries work, while females (18%) are mostly engaged in the craft and related trade work, compared to males (4%).

KAPS district has diverse agricultural activities, encompassing crop farming, tree growing, livestock rearing and fish farming. However, only a few engage in tree planting. A sizeable number of the labour force in the district are in the private informal sector (96%), indicating the role of the sector in the district's economy (Ghana Statistical Service 2014a).

4.2.2.4 Access to utilities for lighting and cooking

In the KAPS district, flashlights/torches (46%), kerosene lamps (27%) and electricity mains (24%) are the primary sources of light for people. The connection to the main electricity grid is higher in urban areas (68%) compared to rural areas (9%). As many rural communities are not connected to the national electricity grid, the use of flashlights/torches is more predominant in rural areas (56%), than in urban areas (17%).

For cooking purposes, firewood (71%) and charcoal (24%) are the dominant cooking fuels used in the district. There are also pockets of households that utilise other sources such as LPG, electricity, kerosene, charcoal, crop residue and saw dust. The reliance on firewood is common in rural communities, where 88% of residents use firewood, compared to residents in urban communities (12%). This underscores the differences between rural and urban communities regarding their access to modern energy technologies for both lighting and cooking (Ghana Statistical Service 2014a).

5. UNDERSTANDING HOUSEHOLD ENERGY DECISIONS IN OFF-GRID RURAL GHANA

Like other countries in the SSA region, not all Ghanaians have access to cleaner energy, with access being particularly problematic in many rural communities. Despite efforts to transition to cleaner energy, there is little evidence of a decline in the reliance on unclean energy sources in rural Ghana. This chapter reflects the energy situation in rural SSA and considers how low-carbon transitions can include universal accessibility. It presents the socio-demographic characteristics of the study participants, household energy sources and the criteria used by households in selecting energy sources for lighting and cooking. It details the energy needs of households and the reliability of their energy sources. A portion of this chapter has already been published as a book chapter, while another has been submitted for consideration in a peer-reviewed journal.

The findings revealed that to meet their residential energy demands, rural dwellers have a range of energy sources to choose from – both clean and unclean sources. Availability, cost, and reliability are some factors households consider important in choosing their primary energy sources. Although households are gradually shifting to the use of clean energy for lighting, the narrative is entirely different with regards to cooking fuels, as households still rely primarily on unclean fuels.

While a transition to cleaner technologies in rural communities is imperative from an emissions reduction point of view, the findings suggest that the provision of cleaner technologies does not guarantee utilisation, specifically in the interim. This chapter therefore builds and expands on research on energy transitions and provides a valuable Global South perspective on energy access.

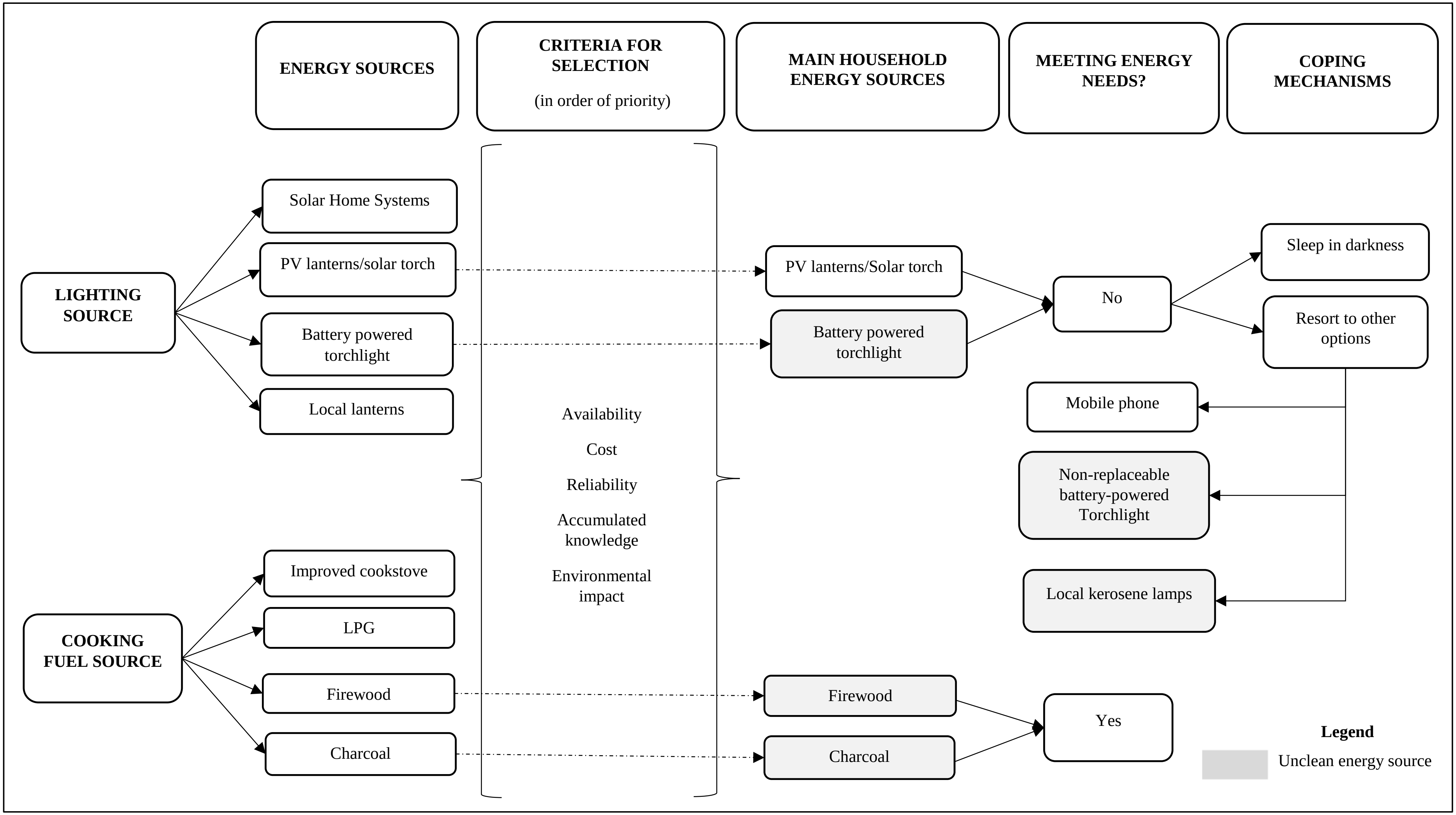

Fig. 5.1: Graphical summary of the chapter

(Source: Author's construct).

5.1 Electrification as a political tool in off-grid rural communities

The presence of electric lights is argued to cause changes in the culture of traditional communities (e.g. distorting sleep patterns and the outdoor lifestyle of traditional communities). These cultural changes, coupled with the attraction of mosquitoes by electric lights, may make rural communities more prone to malaria if connected to electricity (De La Iglesia *et al*. 2015; Pellegrini and Tasciotti 2016; Tasciotti 2017).

On the contrary, Sultana *et al*. (2017) argue that malaria was more prevalent among rural children and children of households without access to electricity. This could result from their inability to use fans to drive mosquitoes away which often make them leave windows open for ventilation. Again, the lack of electricity makes households spend more time outdoors in the evening, which also increases their exposure to mosquitoes.

Despite the differing opinions on electricity access and health, the benefits associated with rural electrification cannot be downplayed (Pandiyan *et al*. 2022). Recognising the benefits associated with rural electrification, particularly in off-grid communities, efforts have been made by the Government of Ghana to connect some of the study communities to the main electricity grid. However, these efforts have been futile.

Some members of these communities attributed the futility of such efforts to political factors - accentuating the role political factors play in the electrification of rural communities (Goddard and Farrelly 2018; Axon and Morrissey 2020; Lo and Kibalya 2023; Shyu 2023; Wibisono *et al*. 2023). In some communities, utility poles were erected but they had remained disconnected after years of waiting by community members. Some communities had also seen wired utility poles bypass their communities to supply electricity to other communities (for example, see Image 1 and Image 2).

Image 1: A rural community being used as a channel to provide electricity to another community

Image 2: A rural community with an erected electric pole waiting to be connected to the national grid

Many households voiced concerns about perceived power dynamics in the electrification of their communities explaining that promises of 'connection to the main electricity grid' was used as a campaign message by politicians to lure them into voting for them in elections. According to them, politicians will have no political message once the communities are connected to the grid and so, they were no longer expectant of seeing a connection to the main electricity grid soon. They expressed their displeasure over this and vowed not to vote in the next elections if their respective communities are not provided with electricity. In an interview with a traditional leader of a community, she remarked:

> *"Members of this community have been repeatedly deceived by politicians. If they fail to deliver on their promise of providing electricity, I will ensure that no politician is allowed to campaign in this community during the next elections"* – (Yaa, October 2022).

The findings contravene the assertion that access to energy is a fundamental right, particularly from the political lens of Ghana. Thus, even though some governments of SSA countries may officially acknowledge that energy is a right, in practice, this is largely nominal. Political interests in Africa are known to hinder the development objectives in the region (Ajulor 2018; Agbor *et al*. 2024). Madumo (2016) therefore suggested the concept of 'de-politicisation', an administration devoid of political bias, as a strategy to enhance access to basic services, such as electricity. There is hence, the pressing need for governments of Africa to have robust policies that are development oriented and apolitical, and domesticate SDGs through decentralised systems (Adenle 2020; Mthembu and Nhamo 2021).

Lack of electricity supply and/or non-connection to the main electricity grid, has led to low level of industrial operations in the communities. No industrial activity was observed in the study communities and therefore, community members heavily relied on fishing and farming as a source of livelihood. In an interview with some District Assembly officials in the KAPN and KAPS districts, they admitted that the electrification of rural communities would expand the local economy by for instance, diversifying income streams which would in the long run, improve rural livelihoods (Kirubi *et al*. 2009; Bos *et al*. 2018; Thomas *et al*. 2020). Accordingly, access to energy, specifically electricity, is captured as a key element in the District Assemblies' rural development strategies.

Access to cooking energy was commonly not a problem for members of the study communities as both districts had a variety of sources – electricity, firewood charcoal, crop residue, LPG, etc. Hence, the attention of actors is shifted towards electricity when the issue of energy is raised. A careful examination of the KAPN District's *Medium-Term Energy Sector Plan* for instance, highlights this one-sided approach as emphasis is placed on issues relating to electricity access, with less focus on cooking fuels (Ministry of Local Government and Rural Development and Kwahu Afram Pains North District Assembly 2019). In interviews with officials of District Assemblies in both districts, they emphasised this fact. One District Assembly officer, for instance, stated that:

> *"Access to cooking energy is less problematic for people in the district. The challenge regarding energy access mainly relates to electricity, as many communities are not connected to the national electricity grid"*— (December, 2022).

It is therefore important for actors to focus on rural electrification to ensure that electricity is made available in communities (potential access). The KAPN and KAPS District's *Medium-Term Energy Sector Plan* recommends: connection to the national grid for mainland and lakeside communities with a projected population of 500 by 2030; mini-grids for island communities with similar characteristics; and SHS and solar lanterns for both island and mainland communities with scattered and low population densities (Ministry of Local Government and Rural Development and Kwahu Afram Pains North District Assembly 2019).

Despite the study communities not connected to the national grid, there are other alternative sources of electricity available in the districts which members can use – examples include, flashlight/torches, kerosene lamps, candles, private generators and SHS (Ghana Statistical Service 2014a, 2014b). Simply put, there are energy sources available in the districts, aside the main electricity grid, which households in the study communities can use, particularly for lighting. However, since availability does not necessarily lead to utilisation, it would be wrong to conclude that households in the study communities have access to energy for lighting.

Additionally, it is important to pay critical attention to the strategies deployed in improving access to energy since the way it is "undertaken has not always warranted a sustained livelihood in rural areas" (Dyner *et al*. 2005, p. 17). This affirms the need to not only limit the definition of energy access to mere provision (availability or potential access), but to broaden it to encompass factors like affordability, quality, adequacy, reliability, capacity, formality (bills paid to utility providers) and safety (IEA 2020; World Bank 2022a).

Tesfamichael *et al*. (2020) expound that rural households are eager to connect to an energy source but are cautious to consume, implying that energy 'access' should be seen as a combination of 'potential access' (availability) and 'realised access' (utilisation). The rest of this chapter thus, broadens the basic binary means of examining household/residential energy access that views access as the mere connection or non-connection to an energy source.

5.2 Illuminating the path: exploring household energy access

Studies have shown that certain socio-demographic characteristics of households influence their choice of energy sources (Adeyemi and Adereleye 2016; Mashhoodi 2018; Guta 2020; Xu *et al*. 2020; Twumasi *et al*. 2021; Sharma and Dash 2022). Some socio-demographic characteristics of households were therefore collected to assess how they are linked to a household's energy sources. The background information of respondents involved in the study covered variables such as sex, age, educational level, status in the community and household size (Table 5.1).

Table 5.1: Socio-demographic characteristics of respondents

Variable	Category	Name of communities and frequencies										Total	%
		Ayebeng	Aduonum	Adukrom	Asimpanyin,	Mmradan	Kwasi Addae	Apesika	Sawua	Sodzikope	Abotanso1		
Sex	Male	3	18	18	17	36	38	15	14	47	39	245	58.5
	Female	1	10	10	10	21	17	22	4	29	50	174	41.5
	Total	*4*	*28*	*28*	*27*	*57*	*55*	*37*	*18*	*76*	*89*	*419*	*100*
Age	18-20	0	0	0	0	0	1	1	2	3	5	12	2.9
	21-30	1	2	7	7	11	4	7	0	16	14	69	16.5
	31-40	2	6	4	8	19	6	9	1	15	13	83	19.8
	41-50	1	9	6	3	9	14	8	4	26	21	101	24.1
	51-60	0	7	6	4	13	18	4	6	12	19	89	21.2
	>61 years	0	4	5	5	5	12	8	5	4	17	65	15.5
	Total	*4*	*28*	*28*	*27*	*57*	*55*	*37*	*18*	*76*	*89*	*419*	*100*
Status	Native	3	11	13	18	41	40	24	13	57	58	278	66.3
	Migrant	1	17	15	9	16	15	13	5	19	31	141	33.7
	Total	*4*	*28*	*28*	*27*	*57*	*55*	*37*	*18*	*76*	*89*	*419*	*100*
Household size	<3	0	6	8	2	7	12	6	2	12	16	71	16.9
	3-5	3	10	9	17	31	24	19	9	34	28	184	43.9
	6-8	1	11	10	6	13	15	6	6	20	36	124	29.6
	>9	0	1	1	2	6	4	6	1	10	9	40	9.5
	Total	*4*	*28*	*28*	*27*	*57*	*55*	*37*	*18*	*76*	*89*	*419*	*100*
Educational level	No School	2	15	3	8	14	21	12	6	23	12	116	27.7
	Basic	2	11	23	14	34	30	23	11	51	70	269	64.2
	Secondary	0	2	0	5	4	4	2	0	1	7	25	6.0
	Tertiary	0	0	2	0	5	0	0	1	1	0	9	2.1
	Total	*4*	*28*	*28*	*27*	*57*	*55*	*37*	*18*	*76*	*89*	*419*	*100*

5.2.1 Socio-demographic characteristics of households

Out of the total sample of 419 respondents, more than half (59%) were males. This gender distribution is not surprising since the study targeted household heads. In a traditional Ghanaian society, similar to many developing countries, men act as household heads. As household heads, men are responsible for the livelihoods of household members, making decisions for households and in some cases, owning household assets (Posel 2001; Bookwalter *et al*. 2006; Ali *et al*. 2019).

Even though some women may have some level of control behind the scenes, it is only in an event of death, not in the absence of a man, that a woman can take on the family-head role, especially the decision-making authority. In rural Bangladesh, for instance, Fakir and Abedin (2021) found no improvement in women's decision-making authority even when men migrated away from the communities. They however, recounted that women are more likely to own assets in households with male migrants.

On the contrary, migration in rural Ghana is feminine, what Apatinga *et al.* (2022, p. 83) term "feminisation of migration" – females independently migrating to other communities in search for better prospects. Like most cases of migration in rural Ghana, the destination of people leaving rural communities has been urban areas (Pickbourn 2020). Rural-urban migration has been on the rise in Ghana, and this is because of the mobility paradox[7], fuelled by increased transportation, improved communication and inequalities (Kleist and Thorsen 2017).

This mobility paradox, coupled with future aspirations of young rural people, tends to make them migrate from rural communities to the cities (Yeboah 2021). As a result, Ghana, despite having a young and growing population, has an unevenly spread young population across its rural and urban divide – there are relatively few young people (15-35 years) in rural areas (39.5%), in comparison with urban areas (60.5%) (Ghana Statistical Service 2024). Similar trends were recorded in the study communities as the empirical results showed that about 60% of the participants were above 40 years – 41- 50 years (24%), 51-60 years (21%) and above 60

[7] A situation where an improvement in conditions in rural communities reduces out-migration on one hand and on the other, promotes out-migration.

years (16%). A few of the participants (39%) were within 18-40 years bracket – 12-20 years (3%), 21-30 years (17%) 31-40 years (20%).

The reduced young population in the rural communities can also be attributed to the communities' non-connection to the national electricity grid which makes the local economy unattractive. As evidenced in Ethiopia, rural electrification boosts the local economy which eventually, decreases emigration (Fried and Lagakos 2021). This aside, agriculture is viewed with distain by many youth in rural Ghana, who often regard agriculture as the reserve of illiterates. Eissler and Brennan (2015, p. 7) term this "deskilling of the youth" – a situation where the youth see agricultural activities as not lucrative enough.

In a period where the Government of Ghana is implementing a Free Senior High School Programme, it is feared that the situation will lead to further flows of youth out of rural communities, especially as agriculture is often on a small scale. In an interview with a traditional leader, he stated:

> *"The community is losing a lot of its young and abled population. These young people are leaving the aged behind. Some have even moved to nearby rural communities that have access to electricity"*— (Kwadwo, October 2022).

As some rural migrants are also likely to move to other rural communities, it is pertinent to widen the migration discourse to embrace 'rural-rural migration', as reflected in the works of Wineman and Jayne (2017) and Arthur-Holmes and Busia (2022). In the study communities, the results showed that some household heads were migrants (34%), mostly from other rural communities who have resided in their new-found communities for economic purposes. That is, migration due to agricultural activities in the study areas was predominant as it was observed that many of these migrants were either engaged in fishing and/or farming.

Between 2010 and 2021, the average size of households in rural Ghana decreased from 5 to 4 people (Ghana Statistical Service 2022), aligning with the empirical results which showed that many households in the study communities have household sizes of 3-5 people (44%). A significant number of households had 6-8 people (30%). Moreover, 17% of households had less than 3 people, whereas a few households (10%) had 9 and more people. Some scholars, for example Utomo *et al*. (2021), link the size of household to the educational level of households, predicting that highly educated households prefer larger families.

Quite the opposite, the relatively larger family sizes of rural dwellers in the study communities did not reflect their educational status. The empirical results showed that 116 household heads (28%) in the study communities had never been schooled, while 269 people (64%) had attained no more than basic education. A few of the respondents had attained secondary (6%) and tertiary (2%) education. This results is in conformity with the Ghana Statistical Service (2022) findings that education in Ghana is an urban phenomenon with urban population (18 years and above) having thrice the number of people who have either attended school or attained tertiary education in rural Ghana.

5.2.2 Household energy sources and uses

Energy in the study communities is used for residential purposes. A similar trend is observed in other rural parts of SSA, where energy is widely used in meeting the basic needs of households (Muhumuza *et al*. 2018). The predominant use of energy for residential purposes in the study communities, indicates the limited industrial activities in the KAPN and KAPS districts.

5.2.2.1 Electricity

Electricity in households was used mainly for lighting and powering smaller items like mobile phones, and in a few homes, televisions and radios, as found in other rural communities in the Global South (Shahi *et al*. 2020; Twerefou and Abeney 2020). This reflects the vital role electricity plays in rural communities and the limited rural access to electrical appliances – see for example, Image 3.

Image 3: Solar-powered appliances being charged by some community members

Saim and Khan (2021) identified that electricity in remote and rural communities is mainly used for lighting in the evening. Similarly, the findings indicated that electricity for lighting in the study communities was primarily crucial for households in the evenings. Ghana enjoys bright and elevated sunshine levels throughout most of the year, guaranteeing communities bright and sunny days (Schillings *et al*. 2004). Households of the study communities therefore had a powerful desire for electricity in the 'dark' evenings.

Compounding this is the lack of streetlights resulting from the communities' non-connection to the national electricity grid. Rogers *et al*. (2010), George (2013) and Naah (2015), for instance, acknowledged the essential role electricity plays in the evening periods of rural Ghana – such as for studying by children, lighting homes and extending productive hours. The frustration of households in the study communities, therefore, stemmed from their inability to engage in certain activities in the evening (Boamah and Rothfuß 2020).

In rural Africa, battery-powered LEDs, generators, PV lanterns and SHS are common energy sources used at the household level for lighting. Grimm *et al*. (2020) highlight the need for a total shift to cleaner energy sources, urging solar technologies to be deployed and prioritised in the electrification of rural communities. High capacity and sophisticated solar technologies can power high wattage appliances like stoves, ovens, fans, microwaves and refrigerators, which can improve the lives of rural dwellers (Goldemberg 2000; Batchelor *et al*. 2018).

However, the low-income levels of households in the study communities, means many of them are unable to afford such high-capacity solar technologies, just as they are unable to afford sophisticated electrical appliances. Lahimer *et al*. (2013) therefore argued that “affordability is the key parameter to achieve 100% universal access to modern reliable electricity services” (Lahimer *et al*. 2013, p. 316), since it prevents households from meeting their energy needs.

Thus, even though solar technologies can meet the electricity demands of households in the study communities, these households are restricted in the use of high-capacity ones and instead, have to rely on low wattage appliances (Hassan *et al*. 2020; Bharadwaj *et al*. 2023). Bharadwaj *et al*. (2023) further recommended that policies should move beyond electricity provisioning that offers basic access to one that can support high wattage appliances – which is unpopular in off-grid communities.

High wattage appliances like air conditioners (or more sustainable alternatives) are essential, particularly in the advent of climate change. Ghana, located in the tropics, has elevated temperatures and hence, the residential need of electricity for cooling purposes (Luerssen *et al*. 2020). The mean temperatures of Ghana are expected to rise by 1.0°C to 3.0°C (2050) and by 2.3°C to 5.3°C (2100) as a result of climate change (USDA 2023). However, because of their proximity to forested areas, temperatures in rural communities are cooler than communities in the urban mainland.

Accordingly, research works on extreme heat have focused primarily on urban areas which are characterised by rapid urbanisation, leading to the creation of Urban Heat Islands (UHIs). UHIs, metropolitan areas which warm faster than surrounding areas, are created by substituting natural land cover with artificial heat absorbent structures like concrete buildings and tarred roads. This makes urban communities more prone to extreme heat events (Meyers *et al*. 2020; Halder *et al*. 2021; Masson-Delmotte *et al*. 2021; Park *et al*. 2021; Sun *et al*. 2021).

Although the proximity to forested areas reduces the threat of extreme heat events and the dire need of electricity for cooling purposes in rural communities, it makes rural communities extremely dark in the evenings – emphasising the study communities’ need of electricity in the evenings for lighting purposes. In an interview with a traditional leader, who is also a household head, he stated:

"Certainly, I would like to use electricity for several purposes. However, I cannot afford larger solar technologies. What my household really needs now is an electricity source for lighting, especially after sunset" – (Akwasi, November 2022).

For lighting purposes, the study found that simple low-carbon energy technologies, such as SHS, PV lanterns and solar torchlights, were used in the study communities – as observed in other rural parts of Africa (Barrie and Cruickshank 2017; Cross and Neumark 2021). Despite their small capacity, these simple solar technologies can impact the quality of lives of rural and off-grid communities, by providing comfort and improving living standards of users (Kabir *et al*. 2017; Lemaire 2018).

Yet, the empirical results showed that a significant number of households (53%) used non-rechargeable battery-powered torchlights for lighting, while almost one-third (33%) used PV lanterns and solar torchlights. Few households used SHS (12%), specifically low capacity/simple ones, and a few used local lanterns (1%). Only one household did not use any lighting source (Table 5.2).

Table 5.2: Rural household energy sources

Variable	Energy sources	Occurrences (N=419) [a]	Percent of cases
Lighting	Non-rechargeable battery-powered torchlight	329	53.15%
	Local lantern	9	1.45%
	Nothing	1	0.16
	Solar Home Systems	76	12.28%
	PV lanterns/solar torchlights	204	32.97%
	Total	*619*	*100%*
Cooking Fuel	Firewood	403	56.76%
	Charcoal	303	42.68%
	Cookstove	2	0.28%
	LPG	2	0.28%
	Total	*710*	*100%*

N, is the total number of households that answered the question

[a] Multiple responses were allowed.

The results, in line with the World Bank (2020), suggest that some households are being left behind in the transition process as they are unable to take advantage of the availability of clean energy sources and thereby, continue to resort to unclean sources. However, the limited number of households using local lanterns, and none using candles, demonstrates rural households' willingness to transition from traditional energy sources to other alternatives, if the opportunity allows.

Unfortunately, the empirical results indicated that this shift from traditional energy sources is not to a cleaner option but rather, to another unclean source – non-rechargeable battery-powered torchlights. This corroborates the assertion that people without electricity access in rural Africa transition from the use of kerosene and candles to LED lamps powered by non-rechargeable batteries (Bensch *et al*. 2017) – giving rise to concerns regarding provision of proper waste facilities and the responsible disposal of batteries.

The decision of households in the study communities to use multiple lighting sources, amidst the introduction of simple solar technologies, casts doubt about the efficiency of decentralised renewable energy technologies in transitioning rural dwellers to clean energy. In recent years, decentralised renewable mini-grids have been recommended and implemented in rural African communities to enhance access to electricity and to reduce the use of unclean fuels, such as non-rechargeable batteries (Peters *et al*. 2019; Abada *et al*. 2021).

However, it must be noted that the electrification of rural communities only provides potential access by making electricity available to rural dwellers. As evidenced in the work of Thom (2000), most electrified households fail to exclusively use the electricity provided but rather, they use the provided electricity to complement a range of available options.

5.2.2.2 Cooking fuels

Regarding cooking fuels, a range of options are available for rural households in the Global South to choose from, for example, woodfuels, animal dung, LPG, electricity and harvested crop residue (Ali *et al*. 2019). However, the empirical results indicated that only four cooking energy sources are used by rural households – firewood (57%), charcoal (43%), improved cookstove (0.3%) and LPG (0.3%) (refer to Table 5.2). The limited cooking energy sources for households in the study communities depicts the comparatively constrained access to cooking fuels in rural compared to urban Ghana, as highlighted by Bawakyillenuo *et al*. (2021).

The empirical results further indicated that the use of electricity and biogas for cooking is unpopular in rural communities since no household utilised any of them (Bawakyillenuo *et al*. 2021; Kojima 2021; Newell and Daley 2022). The restricted use of electricity for cooking indicates a disconnect in Ghana's SDG aims in achieving clean cooking fuels and electricity-based technologies, as asserted by Newell and Daley (2022).

The use of electricity for cooking is regarded as clean since it reduces energy consumption and carbon emissions (Aemro *et al*. 2021). However, the decision of households not to use electricity for cooking, could be as a result of their low-income levels and/or their non-connection to the main electricity grid, which has enough capacity to be used for cooking. As identified in a part of South Africa, high-income rural households used electricity for cooking and valued cooking with electricity (Thom 2000).

The role of rural electrification can therefore be considered relevant in promoting electric cooking, a point underscored by Kofi, during an interview:

> *"I recognise the convenience of using electrical appliances like microwave and electric stove for cooking. However, I have not considered using them because I lack sufficient electrical capacity to power them"* — (October, 2022).

The findings confirm that many rural dwellers in Ghana are reliant on the use of firewood for cooking (Ghana Statistical Service 2019; Bawakyillenuo *et al*. 2021), emphasising the popularity of the use of unclean fuels for cooking in rural parts of SSA. Many households used a combination of firewood and charcoal – the two dominant sources of cooking fuel in rural Ghana (Karakara and Osabuohien 2021). This indicates how critical it is to pay attention to cooking fuel sources in rural SSA.

These woodfuels (charcoal and firewood) were mostly sourced from forested areas that were unregulated by authorities (fallow lands and farms) and hence, made it easy for households to secure access rights. As observed elsewhere in rural communities in SSA, the decision of households to choose either of the two for cooking was mainly dependent on the weather (Olugbire *et al*. 2016).

In Ghana, there are two main seasons, the rainy season (wet) and the dry season. In the dry season, households rely on firewood since they could easily go the forested areas to collect dry firewood. The wet season occurs when the regular annual and inter-annual pattern of moisture-laden air moves with the Intertropical Convergence Zone across the region (Maloney and

Shaman 2008). During this period, households are unable to get access to dry firewood, either because of unavailability or due to inaccessible footpaths to forested areas.

The inability of households to get access to firewood during the rainy season prompts them to store firewood in the dry season for use in the rainy season (Mulenga and Roos 2021; van Hove and Johnson 2021). Changing rainfall and temperature patterns over the past few decades has, however, made it more difficult to predict the once very consistent weather patterns (Addaney *et al*. 2021; Asante *et al*. 2021).

The climate variability, alongside the limited storage space of households, makes it challenging for households to stockpile enough firewood in the dry season for later use. This made households use charcoal as a substitute cooking fuel, especially in the rainy season. In an interview with a community leader who is also a household head, she stated:

> *"I heavily rely on firewood for cooking food. While it is available most of the time, I am unable to walk to the forest to get it during rainy periods. So, I use charcoal as an alternative"* – (Abena, September 2022).

As has already been stated, households in the study area had multiple energy sources to choose from, for both lighting and for cooking. Because households use energy for a few basic services, such as cooking and lighting, it might be considered that their energy needs/demands are being met. The study therefore sought to find out if the energy sources used in households were sufficient to meet their energy needs.

5.2.3 Meeting the energy needs/demands of households

Although a plethora of energy sources are used by households for lighting, the results showed that few households (19%) were content with their energy sources and agreed that their lighting needs were being met, explaining that their lighting sources were bright enough for them to carry out activities in the evening. Out of the 339 households (81%) that indicated that their lighting needs are not being met, many (49%) were concerned about the reliability of the source and the quality of batteries (21%), particularly for the users of renewables and battery-powered torchlights (Table 5.3).

Table 5.3: Households' ability to meet their energy needs

Variable	Energy needs being met?	Freq	%	Reasons	Freq	%
Lighting	Yes	80	19.1%	I can perform every activity	80	100%
	No	339	80.9%	Cannot afford batteries	22	6.4%
				Source is unreliable	169	49.4%
				Battery dies quickly	71	20.8%
				Cannot light up all rooms well	71	20.8%
				Goes off quickly	7	2.0%
				Product quality	2	0.6%
Cooking	Yes	399	95.2%	Source is always available	399	100%
	No	20	4.8%	Inaccessible during rainy periods	17	85.0%
				Difficult to cross river	3	15.0%

The empirical results suggest that despite using lighting sources like non-rechargeable battery powered torchlights and PV/solar torchlights, which are regarded as providing a high-quality light, many households are unable to meet their energy needs (Mahajan *et al*. 2020; Munro *et al*. 2020; Wassie and Adaramola 2021). It corroborates the findings of Numminen *et al*. (2018) in which reliability and technical efficiency of renewables were raised as pertinent issues in meeting the energy demands of users.

The empirical results also showed that meeting the cooking energy needs was not a problem for households as many (95%) admitted that they are able to meet their cooking energy needs, supporting the report on the profile of the Kwahu Afram Plains North and South Districts (Ghana Statistical Service 2014a, 2014b). In an interview with a District Assembly Officer, he reiterated that:

"*Meeting the cooking energy needs of households is less problematic in terms or access. All communities in the district can easily access one or more cooking energy sources*" – (September 2022).

The fact that many households were able to meet their cooking energy needs, attributing this to the source (woodfuels) being consistently available, supports Matavel *et al.* (2023a) findings that 'availability' is the most important factor households consider in the selection of a cooking energy source. With a growing population in SSA, actors and researchers have amplified the call for rethinking energy poverty in the region, especially when households are unable to afford clean energy sources for cooking.

This call remains complex as an increase in wealth in the region does not necessarily reflect a shift to cleaner cooking fuels (Matavel *et al*. 2023a). That is, a rise in the income levels of rural households does not automatically lead to a transition away from traditional fuels. The preference for traditional fuels could be as a result of the cost element of clean alternatives. Since traditional fuels are relatively free, households prefer this option to paying for other alternative sources.

The few households (5%) that stated that they were unable to meet their cooking energy needs, in line with Mulenga and Roos (2021) and van Hove and Johnson (2021), clarified that it was difficult to gain access during rainy periods (85%). A few other households (15%) also had challenges crossing a river that linked communities to the forested areas. These geographical and environmental factors made it challenging for households to gather traditional biomass for cooking purposes (Table 5.3).

In a situation where households have multiple sources of energy to choose from, it was the responsibility of household heads to determine the households' main energy source, based on a set of criteria. The study therefore explored the criteria households used and factors they considered as relevant in selecting the main type of energy to be used. This was to understand the decision-making processes of households.

5.2.4 Household criteria for energy selection

On a Likert Scale, with 1 being the highest importance and 5 being the lowest importance, the empirical results showed that many households ranked availability (52%), and cost (42%), as the most important factors they consider in selecting the type of energy source to be used in their homes. A few households, however, ranked environmental impact (4%) and accumulated knowledge (1%) as the most crucial factors they consider in selecting the household energy source[8] (Table 5.4).

[8] 'Availability' refers to the existence of an energy source, 'cost' is the financial burden associated with the use of energy source, 'reliability' refers to the dependability and durability of the energy source, 'environmental impact' is how an energy source positively/negatively affects the environment and, 'accumulated knowledge' is the traditional knowledge people have on an energy source.

Table 5.4: Ranks of households' criteria for selecting energy sources

Criteria	Scale	Frequency (N=418)	Percent of cases
Availability	Highest importance	217	51.8%
	High importance	178	42.5%
	Moderate importance	21	5.0%
	Low importance	2	0.5%
	Lowest importance	1	0.2%
Cost	Highest importance	177	42.2%
	High importance	129	30.8%
	Moderate importance	75	17.9%
	Low importance	27	6.4%
	Lowest importance	11	2.6%
Reliability	Highest importance	15	3.6%
	High importance	106	25.3%
	Moderate importance	221	52.7%
	Low importance	69	16.5%
	Lowest importance	8	1.9%
Accumulated Knowledge	Highest importance	6	1.4%
	High importance	3	0.7%
	Moderate importance	32	7.6%
	Low importance	145	34.6%
	Lowest importance	233	55.6%
Environmental Impact	Highest importance	2	0.5%
	High importance	4	1.0%
	Moderate importance	73	17.4%
	Low importance	173	41.3%
	Lowest importance	167	39.9%

The empirical results indicated that availability of energy sources is the foremost criterion households consider when selecting an energy source. It is therefore right for scholars (e.g. (Azimoh *et al*. 2016; Hansen and Xydis 2020) to focus on the electrification of rural communities as a means of rural development. Thus, for a successful transition to cleaner energy technologies in rural communities, it is necessary for these technologies to be available.

In rural Ghana, particularly isolated communities, this is done through the REMP and NET Framework (Energy Commission of Ghana 2022b; Ministry of Energy 2022a). Acharya and Marhold (2019), in their work, emphasised the role of energy access (hereafter availability) in the transition process. They however, found that access to a renewable energy source did not automatically lead to a transition to clean energy, indicating that households considered other factors as well in determining their choice of energy.

Cost emerged the second most important factor for households in choosing an energy source. Given their economic constraints, households in rural communities prefer energy sources that are affordable – as mostly provided by traditional fuels. This situation makes it particularly challenging for rural dwellers to transition to renewable technologies, which often comes at a cost – affirming the need to make modern energy sources affordable for rural dwellers (Acharya and Marhold 2019). This is particularly important as the poor rural economy, and resultant low-income levels of households, makes it difficult for households to get access to credit.

An increase in household income levels, as well as access to credit facilities and subsidies, are generally known to enhance the adoption of modern energy technologies, since cost is a major factor households consider in selecting the type of energy source to use (Guta 2020; Twumasi *et al*. 2021; Wassie *et al*. 2021). For instance, the few households that used SHS in the study communities were relatively better-off households. Even within this group, not all were able to make a lump-sum payment for the technologies. Some households paid for the cost of the product in instalments. In an interview with a household head who used SHS, he stated that:

> "*It is very expensive to own a solar home system. I purchased mine on credit and still paying off the cost. It would have been less costly to make a one-time payment rather than paying in instalments*" – (Kwabena, November 2022).

Making households pay more in instalments for modern technologies is perhaps a reason why households do not opt for higher capacity ones, particular as a source of electricity. This finding therefore expands the narrative that access to credit facilities enhances households' adoption of modern energy as households are very much concerned about the associated interest rates and payment plans. As rural households have the 'luxury' of deciding the energy source to use from multiple options, they are unlikely to pick one that would bring an undue financial burden on them, something that getting solar technologies on credit is associated with (Baye *et al*. 2021a; Ibrahim *et al.* 2021; Twumasi *et al*. 2021).

The third factor households consider when selecting an energy source is reliability. Many households however, scored this factor as moderately or weakly important, despite the recognition by Adenle (2020) and Wassie *et al*. (2021) of its significance in energy access. In rural India for instance, a substantial number of households, despite having access to electricity, failed to solely rely on it because of issues regarding reliability. Accordingly, these households, like those in the study communities, used multiple energy sources for lighting (Blenkinsopp *et al*. 2013).

Considering reliability concerns, Aklin *et al*. (2016) underscored the need to move from quantity of grid connections in the rural electrification discourse to the reliability of electricity provided. A household head who viewed reliability as important, stated in an interview that:

> *"My household's choice of an energy source is largely dependent on reliability. Although we can afford to use LPG as a household, we cannot depend on it as our principal source of cooking energy. There are no gas stations in the community and hence, our choice of firewood for cooking*"– (Kwame, September 2022).

Since agriculture is the primary source of livelihoods for most households in the communities, it is predicted that households have been and/or will be negatively impacted by climate change and hence, have knowledge on climate change and adaptation (File and Derbile 2020; Kom *et al*. 2022). Although indigenous knowledge plays a vital role in climate change adaptation, the study found out that it was considered a less important factor by households in selecting an energy source.

This finding can be looked at from two perspectives in the same manner as culture, which is regarded as "double-edged sword", because depending on the context, it promotes and/or obstructs the adoption of renewable technologies (Ojong 2021, p. 9). Firstly, if households are not reliant on indigenous knowledge in selecting an energy source, then it implies that they are willing and can easily be convinced to shift from the use of traditional fuels. Thus, regardless of the number of years households have been exposed to a particular type of energy source, they factor that as less important in choosing an energy source. This openness can enhance their uptake of modern technologies.

Secondly, the lack of emphasis on indigenous knowledge might indicate that households are unable to link their indigenous knowledge on the environment to the choice of fuel they use. Hence, even though they can apply their indigenous knowledge in climate change adaptation practices, they are unable to do the same in their choice of energy source. This situation will, therefore, make it difficult to transition rural households to the use of clean energy – prompting the need for awareness raising on clean energy and the environment.

The findings also support the need for awareness raising on the environment as the environmental impacts of energy sources was considered as a factor of less importance to households in choosing an energy source. This tendency, in line with Hassan *et al.* (2014) may stem from a limited understanding of renewable energy and the benefits therewith. They attributed this to a lack of environmental awareness and technical information.

The levels of awareness and conceptions local people have about an energy source are linked to their adoption. As identified by Mfune and Boon (2008), the lack of household awareness on the benefits of renewable energy, be it social or economic, is a barrier towards the adoption of renewable energy. This necessitates the need to educate households on the benefits associated with the use of renewable energy.

Educating households on renewable technologies can promote their participation in renewable energy projects which eventually, could enhance their adoption of renewable and clean technologies (Baxter *et al*. 2020; Duran and Sahinyazan 2021; Sovacool 2021a; Boateng *et al*. 2023a). This is particularly vital as there have been recent calls for a bottom-up approach through the creation of Energy Communities or Community Energy, a model that emphasises co-operation between citizens, civil societies, social entrepreneurs, public authorities and community organisations (Walsh *et al*. 2020; Interreg Europe 2022).

Thus, if rural households are to play key roles in the creation of energy communities, then it is relevant for their knowledge on clean energy technologies and the environment to be improved. With an improved knowledge, rural households will likely pay keen attention to environmental impacts as a key factor in choosing an energy source.

5.2.4.1 *Statistical analysis of households' rankings*

Using a one sample Kolmogorov-Smirnov test with Lilliefors correction to assess the distribution of households' rankings of the factors – Availability, Cost, Reliability, Accumulated Knowledge and Environmental Impact –, the results revealed that the distribution of households' rankings deviated from a normal distribution for ranks of availability (Mean = 1.55, n = 419, z = .32, $p < .05$), cost (Mean = 1.96, n = 419, z = .24, $p < .05$), environmental impact (Mean = 4.19, n = 419, z = .25, $p < .05$), reliability (Mean = 2.88, n = 419, z = .27, $p < .05$) and accumulated knowledge (Mean = 4.42, n = 419, z = .33, $p < .05$) (Table 5.5).

Table 5.5: Variation in households' criteria of energy selection

Hypotheses	Test statistic	Mean	Standard deviation	P-value [a]
The distribution of rank of availability is normal	.323	1.55	.63725.	<.001
The distribution of rank of cost is normal	.244	1.96	1.04728	<.001
The distribution of rank of environmental impact is normal	.247	4.19	.78674.	<.001
The distribution of rank of reliability is normal	.272	2.88	.78988	<.001
The distribution of rank of accumulated knowledge is normal	.326	4.42	.78294	<.001

a. Lilliefors Corrected.

The empirical results suggest that households differ significantly in how they prioritise several factors when choosing an energy source. Thus, the importance placed on a specific criterion can vary widely from one household to another. For instance, while some households prioritise availability as the most critical factor in their decision-making process, viewing it as the top criterion, others may assign it a lower priority, perhaps considering other factors – such as environmental impact or reliability – as more important. This divergence in ranking highlights the complex and individualised nature of decision-making in energy source selection, as noted by Guta *et al*. (2022).

5.2.5 Household main energy sources

Following the intricate nature of household energy decision-making, the empirical results showed that each household relied on a primary source of energy from a range of available options which may differ from those used by other households. Out of the 418 households that had access to an energy source for lighting, 44% mainly relied on PV lanterns/solar torchlights, while 42% used non- rechargeable battery-powered torchlights (Image 4).

Image 4: Solar torchlights being charged by rural households

Few households used SHS (13%) and only one household used a local lantern (0.2%). For cooking purposes, the findings indicated that the majority of households' primary source was firewood (93%), with a few using charcoal (6%), LPG (0.2%) and improved cookstove (0.2%) (Table 5.6).

Table 5.6: Main source of energy for households

Variable	Energy sources	Frequency (N=418)	Percent of cases
Lighting	PV lanterns/solar torchlights	185	44.2%
	Battery-powered torchlight	177	42.2%
	Solar Home Systems	55	13.1%
	Local lantern	1	0.2%
	Total	*418*	*100%*
Cooking	Firewood	390	93.1%
	Charcoal	27	6.4%
	Cookstove	1	0.2%
	LPG	1	0.2%
	Total	*419*	*100%*

N is the total number of households that answered the question.

The empirical results, in line with Ghana Statistical Service (2014a, 2014b) and Wallach *et al.* (2022), indicate that households are gradually moving away from the principal use of traditional fuels like local kerosene lamps and candles, which were predominantly used in times past as the main sources of energy for lighting, to newer and cleaner technologies. This contravenes the notion that low-carbon energy technologies are burdensome and less beneficial for rural households and hence, resulting in low uptake (Saim and Khan 2021).

Even though many households use clean energy sources (PV lanterns/solar torchlights and SHS) as their primary energy source for lighting, the fact that a significant number had access to non-rechargeable battery-powered torchlights reflects the inability of households to completely rely on them. This corroborates the findings of Arraiz and Calero (2015) that some households fail to exclusively use cleaner technologies even when they have access to them.

Such a situation can be attributed to the 'sufficiency' of solar technologies – the inability of households to acquire solar technologies sufficiently powerful enough to light up many locations in the homes, specifically the kitchen, in the case of rural households (Komatsu *et al*. 2011; Stojanovski *et al*. 2017). Traditional kitchens in SSA are mostly detached from the main house, have open access and are poorly ventilated (Ochieng *et al*. 2020; Dida *et al*. 2022) – see Image 5 for an example.

Image 5: A traditional rural kitchen in the study communities

The structure of these kitchens makes it difficult for users of solar technologies, particularly SHS, to mount the technologies there. As a result, it was observed in the study that few households, particularly solar technology users, had light bulbs mounted in their kitchens, corroborating the findings of Stojanovski *et al*. (2017) and Wallach *et al*. (2022).

Inside the kitchen, the findings revealed that households predominantly rely on firewood and charcoal for their cooking needs, even though cleaner options like improved cookstoves and LPG are available. This validates Amoah *et al*. (2015) and Bawakyillenuo *et al*.'s (2021) assertion that firewood consumption is higher in rural Ghana.

According to Amoah *et al*. (2015), the geographical location of rural dwellers is a determinant of firewood consumption, with the semi-deciduous zones, recording higher numbers of firewood consumption. Although not in the semi-deciduous zone of Ghana, the study communities fall within the savannah vegetation zone which is also typified by deciduous trees, making it easy for dwellers to access firewood (Ghana Statistical Service 2014a, 2014b).

As a major driver of deforestation in SSA, felling of trees for fuel causes biodiversity loss, reduces GHG sinks and contributes to soil erosion (Bennett 2017; Kumar *et al*. 2022). The increased rate of firewood consumption in rural Ghana raises concerns about the sustainability of firewood consumption, making some scholars (e.g. Amoah *et al*. 2015) encourage policies aimed at encouraging rural dwellers to plant more trees.

During interviews, however, rural dwellers who engaged in the felling of trees for fuels did not practice reforestation, despite being reliant on trees for cooking fuel. Failure to plant more trees, while felling existing ones for firewood is linked to fuel scarcity, a situation which can cause rural dwellers to either reduce their daily number of meals or increase their walking distance to collect firewood (Mendum and Njenga 2018; Waswa *et al*. 2020; Matavel *et al*. 2023a).

5.2.5.1 Effects of socio-demographic characteristics on households' energy choices

Chi-square statistics were used to examine the association between socio-demographic characteristics of household heads and the main household energy source (clean and unclean energy sources). The results showed no significant association, at a 5% significance level, between the main cooking energy source and sex, x^2 (1, N = 419) = 1.43, p > .05., age, x^2 (5, N = 419) = 3.31, p > .05., status of households, x^2 (1, N = 419) = 1.02, p > .05., household size, x^2 (3, N = 419) = 4.95, p > .05, and educational level, x^2 (3, N = 419) = 1.12, p > .05.

Regarding households' choice of main energy source for lighting, the empirical results showed a significant association between households' main source of lighting and age, x^2 (5, N = 418) = 13.21, p < .05., as well as household size, x^2 (3, N = 418) = 8.35, p < .05. However, an insignificant association was recorded between households' main lighting source and sex, x^2 (1, N=418) = 0.61, p > .05., status of households, x^2 (1, N = 418) = 0.84, p > .05, and educational status, x^2 (3, N = 418) = 3.92, p > .05 (Table 5.7).

Table 5.7: Association between socio-demographic characteristics and households' choice of energy sources (clean and unclean)

Variable	Category	Counts	Lighting			Cooking		
			Clean	Unclean	P-value	Clean	Unclean	(P-value)
Sex	Male	Count	144	100		2	243	
		Expected count	140.1	103.9		1.2	243.8	
	Female	Count	96	78		0	174	
		Expected count	99.9	74.1	0.433	.8	173.2	0.513
Age	18-20	Count	11	1		0	12	
		Expected count	6.9	5.1		.1	11.9	
	21-30	Count	34	35		0	69	
		Expected count	39.6	29.4		.3	68.7	
	31-40	Count	39	44		0	83	
		Expected count	47.7	35.3		.4	82.6	
	41-50	Count	63	37		1	100	
		Expected count	57.4	42.6		.5	100.5	
	51-60	Count	53	36		0	89	
		Expected count	51.1	37.9		.4	88.6	
	>61 years	Count	40	25		1	64	
		Expected count	37.3	27.7	0.021	.3	64.7	0.638
Status	Native	Count	164	114		2	276	
		Expected count	159.6	118.4		1.3	276.7	
	Migrant	Count	76	64		0	141	
		Expected count	80.4	59.6	0.358	.7	140.3	0.552
Household size	<3	Count	34	37		0	71	
		Expected count	40.8	30.2		.3	70.7	
	3-5	Count	99	85		0	184	
		Expected count	105.6	78.4		.9	183.1	
	6-8	Count	82	41		1	123	
		Expected count	70.6	52.4		.6	123.4	
	>9	Count	25	15		1	39	
		Expected count	23.0	17.0	0.039	.2	39.8	0.126
Educational status	No School	Count	61	54		0	116	
		Expected count	66.0	49.0		.6	115.4	
	Basic	Count	162	107		2	267	
		Expected count	154.4	114.6		1.3	267.7	
	Secondary	Count	11	14		0	25	
		Expected count	14.4	10.6		.1	24.9	
	Tertiary	Count	6	3		0	9	
		Expected count	5.2	3.8	0.270	.0	9.0	1.000

The empirical results imply that the age of household heads and household sizes significantly determine households' choice of lighting source (Danlami *et al.* 2017; Giri and Goswami 2017). While Sharma and Dash (2022) argue that larger households are more likely to use woodfuels, the findings indicate that neither household size nor age, sex and educational level of household heads significantly affects the current choice of cooking energy source for households. This suggests that the socio-demographic characteristics of household heads to a larger extent, have little to no significant influence on the current choice of primary household energy source, whether for lighting or cooking purposes.

In the study communities, access to clean energy sources is generally limited, when compared with the availability of such sources in urban communities of the country. This makes it challenging for rural households to use cleaner energy sources even when they have the will. The peculiar situation of the study communities, being remote, off-grid and with inadequate access to clean energy sources, could explain the insignificant association between household heads' socio-demographic characteristics and their choice between clean or unclean energy sources as a primary household energy source.

5.3 Sufficiency of main energy sources

To examine households' ability to meet energy needs with their principal energy sources, a cross-tabulation analysis showed that a significant number of households (81%) are unable to meet their lighting needs. However, out of the few households that indicated that their lighting needs are being met, more than half (64%) used clean energy sources – PV lanterns/solar torchlight and SHS. Similarly, all households (100%) that used clean cooking fuels, such as LPG and improved cookstoves, reported being able to adequately meet their energy needs (Table 5.8).

Table 5.8: Cross tabulation of main energy sources households' ability to meet energy needs

Variable	Energy sources	Household's energy needs met?				Total	
		Yes	*%*	*No*	*%*		*%*
Main light source	Battery-powered torchlight	29	16.4%	148	83.6%	177	100.0%
	Local lantern	0	0.0%	1	100.0%	1	100.0%
	PV lanterns/solar torchlight	44	23.8%	141	76.2%	185	100.0%
	Solar Home Systems	7	12.7%	48	87.3%	55	100.0%
Total		80	19.1%	338	80.9%	418	100.0%
Main cooking energy source	Firewood	374	95.9%	16	4.1%	390	100.0%
	Cookstove	1	100.0%	0	0.0%	1	100.0%
	Liquified Petroleum Gas	1	100.0%	0	0.0%	1	100.0%
	Charcoal	23	85.2%	4	14.8%	27	100.0%
Total		399	95.2%	20	4.8%	419	100.0%

The inability of households using battery-powered torchlights to meet their lighting needs can be attributed to the small sizes of these torchlights, which make them unable to light up their homes properly. To reduce a households' use and overdependence on battery-powered torchlights in homes, Stojanovski *et al*. (2017) recommended the development of rechargeable flashlights for rural communities.

In the study communities however, a significant number of households that used such rechargeable flashlights, in the forms of PV lanterns/solar torchlight as their main lighting source, indicated that they are unable to meet their lighting needs. Thus, for a sustained transition to happen, renewable technologies with larger capacities, such as SHS, would be a reliable solution.

Yet, households that utilised SHS also indicated their inability to meet their energy needs as they could not afford larger capacity solar technologies. Baurzhan and Jenkins (2016) therefore have argued that solar technologies can only meet the needs of off-grid rural households of SSA if subsidies are provided, emphasising the need for a market framework that aligns with the local economy of rural communities.

The empirical results further showed that the few households that used clean cooking fuels (i.e. LPG and clean/improved cookstoves) are able to meet their energy needs. It is hence understandable for efforts aimed at achieving SDG 7 (regarding cooking fuels) in rural SSA to focus on cleaner cooking technologies. A switch to cleaner technologies in rural Ghana is beneficial for meeting national and global emission targets, while addressing the energy needs of households and reducing deforestation.

5.3.1 Reliability of households' main energy source

Households' inability to meet their energy demands necessitates the examination of the reliability of primary energy sources used in off-grid rural households in SSA. However, the headlines on energy reliability in the region is urban biased. For example, discourse on reliability of lighting sources has largely focused on blackouts in on-grid urban communities, with less attention on off-grid rural communities (Oyuke *et al*. 2016).

As shown in this study, households rank reliability as the third most important factor they consider, after availability and cost, in selecting an energy source. It is therefore important to examine the reliability of the primary energy sources of households because even when affordable energy sources are made available to households but are unreliable, they are likely not going to use them.

Examining the reliability of the main energy sources of households on a Likert Scale, many households ranked their main source of lighting as 'unreliable' (72%) with a few households ranking it as reliable (11%) and very reliable (1%). Households that ranked their lighting sources as unreliable attributed it to accessibility, technical and weather dependent factors (Numminen *et al*. 2018; Saraji *et al*. 2023). Specifically, some households that used solar technologies raised concerns about how dependent the technologies were on the unpredictable weather and the inability of the charged technologies (even when fully charged) to take them through the night (Table 5.9).

Table 5.9: Reliability of households' energy sources

Variable	Main Criteria	Sub- criteria	Freq	%	Reasons
Lighting	*Reliable*	Very reliable	4	1.0%	Available to hire Enough capacity
		Reliable	44	10.5%	
		Total	*48*	*11.5%*	
	Somewhat reliable		54	12.9%	
	Unreliable	Unreliable	302	72.2%	Weather-dependent Battery dies faster Difficult to get batteries Poor product quality
		Very unreliable	14	3.3%	
		Total	*316*	*75.5%*	
Cooking	*Reliable*	Very reliable	112	26.7%	Very dependable and available
		Reliable	270	64.4%	
		Total	*382*	*91.1%*	
	Somewhat reliable		20	4.8%	
	Unreliable	Unreliable	17	4.1%	Burn out quickly Take time to light up when wet
		Very unreliable	0	0%	
		Total	*17*	*4.1%*	

This finding suggests that the lighting sources of people in the study communities, like many rural SSA communities, are generally unreliable (Lee *et al*. 2022). The Independent Evaluation Group (2016) therefore advocates for solutions geared towards electrification to put people first (i.e. consider among other things, reliability of sources). By so doing, it is important that research on electrification transcend technological developments, despite their importance. Some households, who rated their source of lighting as reliable, attributed this reliability to the sources having enough capacity to meet their lighting needs and their ability to get easy access to the source, highlighting the need for technological advancement.

In some of the study communities, there were social enterprises and individuals who rented out solar torchlights to rural households at a fee of 0.50 Ghana cedis (50 pesewas) per night. Some households that rented these units, regarded them as reliable as they were guaranteed a fully charged solar torchlight for lighting all the time. Others also claimed that at times, the fully charged solar torchlights did not last long and were unable to sustain households throughout the night (Image 6).

Image 6: A solar rechargeable unit, owned by a social enterprise, used for renting out solar torches to rural households

In an interview with a female household head who rents these technologies, she stated:

"We are not guaranteed light throughout the night from the rented solar torchlights. In some instances, they only last for few hours. When this happens, we are forced to sleep in darkness, and we are not entitled to a refund or a discount the following day" — (Akosua, December 2022).

Since the study communities have a lot of sunshine, the inability of fully charged solar technologies to take households through the night is likely, a technological issue. A similar issue was highlighted by other households as they raised concerns about the product quality of their light source. This finding suggests that the quality of renewable technologies matters to users. Although solar technologies are recommended as a solution for mass rural electrification in off-grid communities, it is unlikely to yield the intended results if quality is not assured (Grimm *et al*. 2020).

Some users of non-rechargeable battery-powered torchlights that ranked this lighting source as unreliable, reported difficulties in getting access to batteries to power the torchlights, while others stated that some of the products had a short lifespan. In an interview with a household head who used non-rechargeable battery-powered torchlights, he expressed that:

"It is difficult to obtain batteries to power the torchlights. The new and affordable non-rechargeable battery-powered torchlights available on the market are also of inferior quality. I have had to replace mine several times this year" – (Kwame, December 2022).

Concerning access to energy for cooking, the empirical results showed that many households (91%) were satisfied with their cooking fuel source and thus classed it as reliable – ascribing this mainly to its availability and dependability. The few (4%) that viewed their cooking energy source as unreliable, also largely attributed this to the undependable nature of the cooking energy sources – burning out quickly and difficulty to light up, especially when wet (Table 5.9).

Given that access to energy remains an indispensable part of quality of life, households are likely to use alternative energy sources when their main energy sources are unreliable and unable to meet the energy demands (UNDP 2018; Twumasi *et al*. 2021). Since access to electricity, specifically for lighting, was something households deemed problematic, they put some mechanisms in place to cope with the unreliability of their main lighting sources.

5.3.2 Households' coping mechanism for unreliable lighting

Out of the households who stated that their lighting source was unreliable, the empirical results showed that many did nothing but sleep in darkness (59%). A few households had coping mechanisms by managing consumption via either reducing the quantity of energy they consumed (0.2%) or resorting to other sources (41%). Those who resorted to other sources mainly used alternatives such as battery powered torchlights (74%) and mobile phones (19%) (Table 5.10).

Table 5.10: Households' coping mechanisms

Coping mechanisms	Others (alternatives)	Frequency	Percent of cases
Resort to others	Mobile phone	25	19.2%
	Battery-powered torchlight	96	73.8%
	Local lantern	2	1.5%
	Solar torch/PV lantern	7	5.4%
	Total	130	41.1%
Reduce quantity consumed		1	0.3%
Nothing (sleep in darkness)		185	58.5%
Total		316	100.0%

The results corroborate the findings of Gafa and Egbendewe (2021), who reported that mobile phones are used in certain parts of rural West Africa for lighting. The study found that some households that used mobile phones had to travel to nearby electrified communities to charge their phones at a fee of 1-2 Ghana cedis. In interviews with two household heads, they shared the following experiences:

"I use a small mobile phone for lighting when my solar torchlight goes off. Because I have no access to electricity to charge the phone, I take it with me whenever I go to the market to have it charged for a fee" — (Afua, January 2023).

"At times, the batteries of my non-rechargeable torchlight die. When this happens and I have no replacements, I am forced to travel to the town the next day to purchase new batteries. As a result, I have to sleep in darkness until the day I can make this trip" — (Yaw, December 2022).

The study found that the few households who ranked their cooking energy source as unreliable, despite having options in LPG and cleaner cookstoves, did not opt for these options. Consequently, these households overcame all barriers preventing access by, for example, walking longer distances and/or crossing a river to get access to woodfuels. This warrants the debate as to whether indeed the provision of clean fuels will lead to its adoption in rural areas, as has been extensively discussed in the works of Saraji *et al*. (2023). In an interview with a male community leader and a household head, he stated:

"My household has several options to choose from with regards to cooking fuels. LPG and improved cookstoves are available for use. However, we find woodfuels to be the most comfortable option" – (Kwame, November 2022).

As rural households tend to be excessively dependent on woodfuels, the research, through interviews, investigated the reasons behind this reliance and the reluctance of households to use other alternatives like clean/improved cookstoves and LPG. This was to provide an in-depth understanding of the factors that inhibit and influence the cooking energy choices of households, as well as identify strategies that can be deployed to enhance the adoption of available alternatives for cooking.

5.3.3 Why woodfuels?

Rural communities have historically been known for the use of woodfuels and hence, residents are familiar with their use. Since the kind of fuels rural dwellers were exposed to at an early stage of life, influences the type of cooking fuel they use presently, it is not surprising that many households are reliant on woodfuel (Sovacool and Griffiths 2020; Boateng *et al*. 2023b). Some rural dwellers preferred to use woodfuels because of the longer periods it took to prepare staple food. Even in urban households where LPG is mostly used, some households use charcoal when cooking certain stable foods to reduce LPG consumption (Wiedinmyer *et al*. 2017).

The special taste of food cooked by woodfuels also made it favourable to some rural dwellers. Just as wood-fired ovens are regarded as superior for baking Neapolitan pizzas and wooden barrels add flavour to the liquids they contain (Ciarmiello and Morrone 2016; Cisar-Erlach 2019), so do some rural dwellers appreciate the value of woodfuels for cooking flavoured staple local meals. Consequently, many rural dwellers have a sense of cultural attachment to wood and have cultivated the habit of using woodfuels, even when other alternatives are available. A 50-year resident of one of the communities stated:

> *"I have since my childhood been using woodfuel for cooking. I know about other alternatives, but I do not think I am ever going to try them. I find it comfortable using woodfuel."* – (Adwoa, November 2022).

Regardless of the time-cost associated with accessing woodfuels, these fuels were favoured by poor rural dwellers, partly as these groups found it difficult to afford the price of LPG (Karimu 2015; Karakara and Dasmani 2019). Although acknowledging the time benefits of using LPG, rural dwellers preferred to use woodfuels because their usage came with a much lower comparative economic price. The initial capital needed to get LPG – from purchasing a cylinder, then a stove and then the gas – prevented most rural dwellers from resorting to this energy source, despite widespread acknowledgement of the positive aspects associated with it.

Woodfuels were also preferred by households because they are readily available, compared to alternatives like LPG and improved cookstoves (Karimu 2015; Adjei-Mantey and Takeuchi 2023). In the study communities for instance, there was no gas station and dwellers who preferred to use LPG had to travel long distances to fill their cylinders. To escape this inconvenience and the initial capital outlay involved in acquiring LPG, many rural dwellers resorted to woodfuels. This sentiment was echoed by a household head:

> *"I can afford LPG, but there are no gas stations nearby to fill the cylinder once it is empty. I would have to travel to the city to get LPG, which for me, is not economical"*— (Kwame, November 2022).

Even when available, explosions associated with LPG in urban areas posed risks to its adoption in rural Ghana as people were fearful of adopting it in their homes (Adjei-Mantey and Takeuchi 2023). Notable among such incidents was an explosion in Ghana's capital, Accra, in 2017 where seven lives were lost and 130 people sustained injuries (The Guardian 2017). News of this event and of several other comparable accidents in urban communities make some rural dwellers concerned about potential risk from the use of LPG. Hence, some rural dwellers are risk-averse and remain committed to not using LPG.

To sum things up, the decision of households to commit to woodfuels emanates from woodfuels' availability/accessibility, affordability, perceived 'risk-freeness' and traditions and customs of the local people (Fig. 5.2).

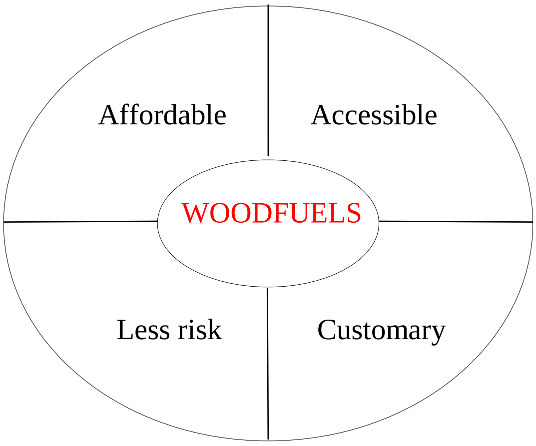

Fig. 5.2: Households' reasons for predominantly using woodfuels

(Source: Author's construct).

In line with this, two female household heads, in an interview, stated that:

"Meeting the cooking energy needs of my household, as well as those of other households in this community, is not problematic because we have an affordable, accessible, comfortable and risk-free source in woodfuels" — (Ama, December 2022).

"It is very easy to get access to cooking energy for my household, namely, firewood and charcoal. Access to electricity, particularly for lighting, is the real challenge we have as a household" — (Adwoa, January 2023).

5.3.4 Gender dynamics in energy use and access

The decision-making power of households in the study communities were in the hands of men who acted as family heads. There were at times, the delegation of power by men who assigned specific roles to women, particularly cooking for members of the family (Ojong 2021). Even though some women assumed the responsibility of providing energy, specifically for cooking, men retained the decision-making power in determining the households' choice of energy source.

In certain parts of rural SSA, the roles of women are culturally restricted to cooking (Robson 2006). Limiting the role of women to the kitchen, specifically in rural SSA, has been extensively studied by feminist scholars and some findings suggest that women are increasingly resisting this cultural requirement (Williams-Forson 2010; Ojong and Ndlovu 2016). Similarly, it was found that the roles of women in households in the study communities were not limited to the kitchen as they assisted men in fishing and farming related activities. In support of this, some male household heads stated that:

"My wife handles the cooking in our house. This is however, not the only work she does to support the household. She assists me in the fishing business by drying and smoking fish for sale" — (Kwabena, November 2022).

"I work alongside my wife on the farm. We undertake all tasks together, from tilling the land to harvesting the crops. Although she does most of the cooking in the house, I try to support her whenever I am available" — (Kwaku, January 2023).

Despite this development, cooking and collection of firewood for households in the study communities, as observed in Kenya and Uganda, was mainly done by females (wives and/or girl child) (Bamwesigye *et al*. 2020; Waswa *et al*. 2020). From the 419 households involved in the survey, the empirical results showed that females (wives: 76%; girl child: 15%) were responsible for cooking with a few households having males (husbands: 6%; boy child: 3%) do the cooking (Table 5.11).

Table 5.11: Household cooking responsibilities

Variable	Category	Sub-category	Frequency	Percent of cases
Household cooking responsibility	Males	Husband	26	6.2%
		Boy child	12	2.9%
	Females	Wife	319	76.1%
		Girl child	62	14.8%
Total			419	100.0%

A lot of time was spent by females collecting firewood, as well as cooking traditional food. Households preferred to cook single meals instead of composite meals and cooking was done mostly in traditional kitchens. In the house, females cooked twice a day (mornings [before work] and evenings [after work]), while a few cooked three times, particularly wives who worked on the farms with their husbands. These women cooked on the farms in the afternoon. Each household cooked its own meals and members of a household ate together. Household meals and cooking utensils were served and washed by females (especially, the girl child).

Collection of firewood and cooking for households are known to prevent females from investing time in other activities (e.g. civic engagements, employment, and education) and expose them and their children to health hazards associated with the combustion of fuels, especially air pollution. Yet, the knowledge of women on the effects of their exposure to smoke from firewood was limited to 'irritation of the eyes'.

This notwithstanding, studies show that the health effects can extend to respiratory diseases and affect the health of unborn children (Bede-Ojimadu and Orisakwe 2020; Hussein *et al.* 2020; Weber *et al*. 2020; Adjei-Mantey and Takeuchi 2021; IEA 2022c; Sharma and Dash 2022). Some men, on the other hand, despite cooking at times and frequenting the kitchen, trivialised the effects of exposure to smoke from woodfuels, as they are not direct victims.

In a situation where households fail to replace trees that were felled by planting new ones and where cleaner cooking fuels are not used, women in the study communities are likely to be affected the most if there is fuel scarcity, since they would have to walk longer distances in search of fuelwood. In an interview with a female household head, she stated that:

> *"I am responsible for cooking for the members of my household. I use firewood for cooking and I collect the firewood with my children. Fortunately, we live very close to forested areas and do not have to walk longer distances like other households. However, going to the forest poses a risk of snake attacks"* — (Adwoa, November 2022).

The empirical results also showed that children played key roles in cooking as some (18%) assumed the responsibility of cooking for household members. Since the use of unclean cooking fuels is predominant in the study communities, this puts the health of children who cook for households and those who are with their mothers while cooking at increased risk. As it has been identified by Amadu *et al*. (2021), children from rural households that are dependent on unclean cooking fuels are more likely to be anaemic, compared to those in urban households using clean cooking fuels.

Being the groups that find themselves in the kitchen more often, deaths associated with ambient air pollution in rural communities are higher among women and children (Smith 2012; Inkoom and Crentsil 2015; Bede-Ojimadu and Orisakwe 2020). Although the place of cooking matters, with lower incidence of respiratory infection associated with outdoor cooking compared to indoor, the negative health impacts associated with the use of unclean cooking fuels on women and children cannot be lessened.

Women and children spend a lot of time in the house. Hence, a household's choice of energy source is likely to impact them the most. If households are guaranteed access to light, particularly in the evening, women and children can have flexibility in deciding the time to cook and learn (Winther *et al*. 2018). Women and children are, therefore, likely to benefit more from a transition to cleaner technologies. However, men wield the power to decide the type of energy to use and which area to light up in homes.

Because men do not use the kitchen often, they perhaps find it less important to place light bulbs there, as indicated in this study. The trend of households having no light bulbs and using less light in kitchens is observed in other rural SSA countries as well (Stojanovski *et al*. 2017; Ojong 2021). Mensah and Adu (2015) also identified that male-headed households are more likely to use firewood, and this can again, be attributed to the fact that men spend less time in the kitchen and hence, find it less relevant to transition to clean fuels.

These findings propose that there are gender issues that have to be considered in the transition to cleaner technologies in rural Ghana. This is because women in particular, face a lot of energy injustices. As described in the study, women and children are more exposed to the negative effects associated with the use of unclean fuels. This notwithstanding, men (who are less exposed to the direct impacts of exposure to unclean fuels) have the decision-making authority in households and thus, decide where to use an energy source and what type of energy source a household must use.

Thus, a decision to transition to cleaner cooking fuels is dependent on the household heads, who are mostly men. This necessitates the need to give women a voice in decision-making since in households where women have the decision-making power (female-headed households), modern and improved energy sources are more likely to be used (Meried 2021). Consequently, it is critical to consider gender as a justice issue in the energy transition discourse, as recommended by Moniruzzaman and Day (2020).

As a transition to clean energy alternatives for cooking has not yet been achieved and appears to be a distant goal, particularly in the rural Ghanaian context, it is important to take steps to mitigate the negative health impacts of woodfuels combustion on women and children. It is therefore recommended that poor rural households resort to outdoor burning in the meantime, and the promotion of the use of clean cooking fuels in an indoor and well-ventilated kitchen in the longer term (Barnes *et al*. 2006; Geremew *et al*. 2020; Amadu *et al*. 2021).

Conclusion

The chapter indicates that energy access is shaped by a complex interplay of economic choices, indigenous knowledge and political influences. For instance, economic factors influence households' ability to adopt clean energy solutions. Indigenous knowledge on the other hand, plays a crucial role in shaping local energy preferences, particularly regarding energy sources for cooking. Additionally, power dynamics, including political influences, affect the availability and distribution of energy resources. As shown in the study, decision-making in the energy sector is at times shaped by political interests, with resource allocation sometimes favouring communities with stronger political representation or influence. Thus, political affiliations can determine which areas receive energy infrastructure investments, resulting in disparities in energy access in rural areas.

The chapter identified instances of procedural injustices within the energy transition process, where certain households were bypassed by key actors, particularly in rural electrification. Distributive injustices were also evident, as some households lacked sufficient access to energy resources to meet their demands, with some receiving less than their entitled share. Furthermore, instances of exclusion in energy consumption were identified, as some households were unable to rely exclusively on clean energy solutions for lighting and cooking.

As knowledge is recognised for playing a significant role in the adoption of clean energy technologies, the next chapter of the research examines households' knowledge on energy and the environment. Additionally, it explores clean energy access in the study communities and the factors inhibiting households' adoption of clean energy technologies, as well as households' expectations of a clean/low carbon energy transition.

6. EXPLORING HOUSEHOLDS' PERSPECTIVES ON THE ENERGY-ENVIRONMENT-LIVELIHOODS NEXUS IN OFF-GRID RURAL GHANA

Rural areas of SSA face peculiar challenges that inhibit the successful transition to clean energy solutions, such as limited access to financial resources and information, inadequate infrastructure, and the lack of political will or institutional support. These challenges are further exacerbated by economic dependencies on traditional energy sources, which can create resistance to change or cause a reverse transition – a situation where households fail to sustain the use of clean energy solutions.

This chapter, therefore, examines the barriers that obscure the uptake of clean technologies among rural households. It highlights the knowledge of households on the environment and clean energy technologies, as it is regarded as essential in transitioning people from the use of unclean fuels. The chapter further identifies the potential impacts of clean energy transition on rural households, and their economic ties with unclean energy sources. A section of this chapter has been submitted published in a peer-reviewed journal (see Boateng *et al*. 2025).

The findings of the chapter revealed that there is a gap in household knowledge on clean energy technologies and the environment, as 34% of households could not associate energy sources with environmental impact and hence, disagreed that energy sources can have an impact on the environment. Factors such as availability (82%), cost (87%) and inadequate information (23%) were identified as barriers to a smooth transition to cleaner energy technologies. Although a transition to clean energy technologies is critical to sustainable development, the findings showed that an abrupt transition would negatively impact rural households, especially as the livelihoods of many households are tied to the production and sale of charcoal (49%).

6.1 Clean energy interventions

Growing electricity demand has led to increased generation capacity in Ghana. Yet, challenges such as intermittent power outages persist in areas connected to the national grid. With regards to cooking energy, woodfuels remain the dominant source despite increased LPG access. The reliance on biomass fuels and unclean lighting sources contributes to air pollution and health risks, highlighting the need for more effective clean energy transition strategies. The REMP, NET Framework and LPG4D program aim to increase investment in renewable energy (Ankrah and Lin 2020; Agyekum *et al.* 2021; Ali *et al*. 2021; Ministry of Energy 2022a; Energy Commission of Ghana 2022b).

However, there are spatial inequalities in the distribution of these interventions. For example, many of the country's clean energy interventions (e.g. the rural LPG Programme, Rural Electrification Project and Sustainable Energy for All Programme) have specifically targeted rural communities, since they are noted for their reliance on unclean fuels for lighting and cooking purposes, as highlighted in the Ghana Renewable Energy Master Plan (2019). This notwithstanding, electrification and clean cooking initiatives have yet to reach all rural areas, leading to the introduction of smaller low-carbon technologies, such as solar PV lanterns SHS and improved cookstoves (Boateng *et al*. 2025).

The study, therefore, highlighted the clean energy interventions available in the survey communities, specifically in the past decade. When asked about the types of interventions observed over the past decade and the actors who implemented such interventions, households stated that they have observed clean energy interventions targeting the supply of LPG technologies (14%), solar technologies (62%) and improved cookstoves (10%). Many households admitted to seeing such interventions being undertaken by actors such as private clean technology providers/companies (38%) and NGOs (28%). Although the government is primarily responsible for enhancing access to clean energy in rural communities, few households had witnessed an intervention from the government (19%) (Table 6.1).

Table 6.1: Interventions available in rural communities and key actors

Variable	Interventions and actors	Number of occurrences	Percent of cases
Kind of intervention	LPG	56	13.4%
	Cookstove	43	10.3%
	Solar	260	62.1%
By whom?	State / Government	79	18.8%
	Private clean technology providers	158	37.7%
	NGOs	117	27.9%
	Faith Based Organisation	4	1.0%

Multiple responses were allowed.

The empirical results showed that interventions to provide rural communities with clean cooking fuels, for example LPG and improved cookstoves, have been relatively scarce. This trend may be due to households not viewing access to cooking fuel as a significant challenge. Nsafon *et al*. (2023) highlight the need for decision-making processes to reflect the experiences of individuals and communities. In the study communities, access to energy for cooking appeared to be of lower concern compared to energy for lighting. Consequently, many interventions focused on providing energy for lighting, particularly through solar technologies.

Generally, the results indicate that actors are taking steps to deploy clean energy technologies in off-grid rural communities of Ghana, with private clean technology providers playing a significant role (Gunda 2020; Aboagye *et al*. 2021; Mungai *et al*. 2022). Evidence suggests that this commitment may be driven by economic gain associated with the investment in clean energy (Goddard and Farrelly 2018; Nduka 2021; Sovacool 2021b). Yet, there still remains room for improvement by other actors, such as government/state.

To achieve the ambitious targets for renewable energy set by the government and ensure equitable energy distribution, Gboney (2009), Asante *et al*. (2020) and Asante *et al*. (2022), for instance, underscore the need to address technical, financial and institutional barriers. While the government has partnered with international agencies, such as the World Bank, to implement mini-grid projects in some rural communities (see for example, Bukari *et al.* (2021a)), a significant number off-grid communities, including some of the study communities, still lack governmental clean energy interventions. Consequently, rural households continue to disproportionately face exclusion from energy resources, reinforcing spatial and socio-economic inequalities.

As evident from the findings, the prioritisation of lighting over clean cooking fuels by actors suggests that interventions are shaped by community-defined needs, rather than solely the agenda of actors. The distribution and accessibility of clean energy technologies in rural Ghana, as the findings indicate, reflect institutional imbalances. The dominance of private clean technology providers and NGOs further underscores the neoliberalisation of energy access, enabling new forms of investment (Newell and Phillips 2016).

The lack of Community-Based Organisations' involvement, despite their potential to drive context-specific solutions, further reflects the marginalisation of local organisations. This can make it difficult for rural communities to empower themselves, thereby limiting their ability to resist people with power in the transition process (Avelino 2017). Community-Based Organisations have been widely recognised for their role in supporting the adoption of renewable energy technologies, particularly in rural communities (Mittal *et al*. 2019; Joshi and Yenneti 2020; Sovacool and Griffiths 2020; Butu *et al*. 2021).Household insights on energy-environment issues and clean energy options.

Residents of rural communities had access to traditional fuels for cooking and lighting prior to the introduction of low-carbon technologies. Consequently, it is necessary for a clean energy transition to not only target the distribution of technologies but also, aim to bridge the knowledge gap of potential users. As rural dwellers have developed a cultural attachment to traditional energy sources following years of usage, there is a need to step-up efforts in educating them on 'newer' low-carbon energy technologies, albeit in a gradual process.

Awareness of the social, economic and environmental benefits of cleaner energy technologies is recommended as a way of promoting the use of clean energy and its acceptance (Irfan *et al.* 2021; Ibegbulam *et al*. 2023). From this background, the study found out the knowledge that rural households have on clean energy and the environment.

6.2.1 Households' energy-environment knowledge

Household heads involved in the study were asked to rank their understanding on the linkages between energy sources and the environment. On a Likert Scale, with 1 being strongly agree and 5 being strongly disagree, the results showed that more than half (51%) of the household heads knew energy sources, in general, can impact the environment with 3% strongly agreeing and 48% agreeing to the statement that 'energy sources can affect the environment'. Conversely, some household heads (34%), disagreed that energy sources can impact the environment.

Regarding the main energy sources used in households, half (50%) of the household heads were able to connect their main energy source to the environment. Specifically, 47% of households agreed and 3% strongly agreed that their main energy source can have an impact on the environment. Some households however, held different views as 26% disagreed and 10% strongly disagreed, that their main energy source can have an impact on the environment (Table 6.2).

Table 6.2: Households' energy-environment knowledge and level of agreement

Variable	Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Energy source can affect the environment	12	2.9	203	48.4	60	14.3	114	27.2	30	7.2
Main energy source can impact the environment	12	2.9	198	47.3	59	14.1	107	25.5	43	10.3
Awareness of plans by actors	34	8.1	99	23.6	140	33.4	136	32.5	10	2.4

The empirical results indicate that a significant number of households are able to link energy used for cooking and lighting purposes to the environment. That is, these households recognise the environmental impacts of their choices of energy. This indicates that there is the growing conscience among energy consumers on the impacts of energy on the environment. The ability of households to link their domestic energy sources to the environment is likely to positively influence the adoption of clean energy technologies (Irfan *et al*. 2021; Ibegbulam *et al*. 2023). As highlighted by Adams *et al*. (2023), limited awareness of clean technologies, including their environmental benefits, is a significant factor inhibiting their adoption in Ghana.

6.2.2 Household awareness of clean energy transition plans

In the study districts, there are medium and long-term energy sector policies aimed at promoting energy access. These plans outline strategies to guide the provision of energy for people in the districts, including those in off-grid rural communities. However, for a more sustained development, there is a need for community engagement in the process (Sanga *et al*. 2022). Following this, the study sought to find households' awareness of plans to transition their communities to clean energy.

A sizeable number of households (35%) stated that they were unaware of plans by some actors, specifically private providers, to provide the communities with clean energy. Some household heads (32%), however, stated that they were aware of plans by actors, particularly the local government, to provide communities with cleaner energy. These households mentioned being pre-informed before implementation of clean energy projects (Table 6.2). In interviews with a member of one of the District Assemblies and a household head, they expressed that:

> *"I am unaware of all plans to provide the community with cleaner energy. Many of the interventions here are by private companies and individuals who just enter the communities to sell low-carbon technologies"*— (Kwadwo, January 2023).

> *"In the local government's planning processes, we involve the communities through their representatives. However, some actors, before implementing clean energy interventions in the rural communities, fail to pass through the District Assembly. When this happens, we are unable to pre-inform community members or involve them in the implementation process"* — (District Assembly Officer, October 2022).

From the key informant interviews, it was revealed that households were primarily involved in the transition process during the project implementation stage and were often disregarded, or not consulted with, during the development of innovations. In many instances, households were surprised by the introduction of some low-carbon technologies into their communities, as they had not been involved in any consultation activities prior to the implementation of projects or sale of the technologies. This situation, where households are treated as mere consumers, has been deemed unsustainable, thereby leading scholars like Campos and Marín-González (2020) and Campos *et al*. (2024) to advocate for the need for citizens to be prosumers – both producers and consumers.

6.2.3 Diverse insights on energy's environmental impact and transition awareness

A Kolmogorov-Smirnov test with Lilliefors correction was employed to assess the distribution of households' rankings for the three statements: "Energy sources in general can affect the environment", "Main household energy source can impact the environment" and "Household is aware of transition plans by actors". The results indicated deviations from normality in the distribution of households' ranks for the statement "Energy sources in general, can affect the environment" (Mean = 2.87, n = 419, z = .31, $p < .05$) and for "Main household energy source can impact the environment" (Mean = 2.93, n = 419, z = .30, $p < .05$). Likewise, the results showed no normal distribution regarding households' awareness of transition plans (Mean = 2.97, n = 419), z = .20, $p < .05$) (Table 6.3).

Table 6.3: Variation in household awareness and opinions on environmental impact of energy sources

Hypotheses	Test statistic	Mean	Standard deviation	P-value [a,b]
The distribution of fuels can have an effect on environment is normal	.306	2.87	1.070	<.001
The distribution of main fuel source can affect environment is normal	.299	2.93	1.11856	<.001
The distribution of awareness of plans to migrate to clean energy is normal	.198	2.97	.99124	<.001

[a] The significance level is .050.

[b] Lilliefors Corrected. Asymptotic significance is displayed.

The empirical results highlight that not every household is knowledgeable about the relationship between energy sources and the environment. Similarly, not all households are informed about plans to transition them to cleaner technologies. The findings suggest that households' awareness of the environmental impacts of energy sources and plans to transition to cleaner energy is not uniform. This implies that, while some households, for instance, might be aware of transition plans, others might be unaware.

The variation in households' opinions and awareness on these topics indicates a broad spectrum of understanding and awareness. That is, while some households rank these statements very highly, indicating strong awareness or agreement, others rank them lower, reflecting less awareness or concern. Consistent with the findings of Otlhogile and Shirley (2023), these findings underscore the need for actors to tailor communication strategies that address the diverse needs and knowledge levels of different segments of the rural population.

6.2.4 A path to clean energy

To assess the impact of households' knowledge of the environmental effects of energy sources and their awareness of energy transition plans on their choice of energy sources (clean vs. unclean), a multiple regression analysis, with robust standard errors, was performed. This method was adopted to mitigate potential heteroscedasticity in the dataset.

The model included the following independent variables: households' knowledge about the environmental effects of energy sources (HKEE), households' knowledge of the main energy source's environmental impact (HKMEE), and households' awareness of energy transition plans (HATP). The dependent variables were the choice of energy source for lighting (CEL) and the choice of energy source for cooking (CEC).

The results revealed that the model accounted for only 0.5% of the variance in households' choice of energy for both lighting and cooking. This suggests that HKEE, HKMEE, and HATP are not significant predictors of CEL ($R^2 = .005$, $F(3, 418) = .676$, $p > .05$) or CEC ($R^2 = .005$, $F(3, 419) = .733$, $p > .05$). Thus, the independent variables do not provide a strong explanatory basis for the dependent variables in this context (Table 6.4).

Table 6.4: Household environmental and transition awareness and choice of energy sources

Variable	Predictor	Beta coefficient	Robust Standard errors[a]	T-value	P-value
Lighting	HKEE – CEL	-.053	.043	-1.230	.220
	HKMEE – CEL	.032	.041	.773	.440
	HATP – CEL	-.010	.025	-.402	.688
Cooking	HKEE – CEC	-.001	.002	-.314	.754
	HKMEE – CEC	.001	.001	.866	.387
	HATP – CEC	-.005	.005	-1.099	.273

[a]HC3 method.

Educating households about energy-environment issues and disseminating information about clean energy transitions are recognised strategies for enhancing the uptake of clean energy technologies (Lindgren 2020; Wu *et al*. 2022). However, the empirical results suggest that variations in households' knowledge of environmental impacts and energy transitions do not significantly influence their energy choices, whether clean or unclean. This finding partially aligns with Irfan *et al*. (2021) who reported that environmental concerns do not significantly influence intentions to use renewable energy.

The findings affirm that although environmental consciousness and knowledge of energy transition are important in households' adoption of clean energy technologies, other factors, such as price, accessibility, and cultural preferences, may have a more significant influence (Guta 2020; Amoah and Addoah 2021; Irfan *et al*. 2021; Wu *et al*. 2022; Boateng *et al*. 2023a).

6.2.5 Household fuel preferences based on awareness of primary energy sources' environmental impact

The empirical results showed noteworthy insights into the relationship between households' knowledge of their main energy source's impact on the environment and their choice of energy, both for lighting and cooking. The findings indicated that households who strongly agreed that their main energy source can impact the environment are more likely to use clean energy for lighting. More specifically, 75% of households in this grouping used a clean energy source for lighting. Fifty-six percent of households, who agreed that their main energy source can have an impact on the environment, also used clean energy as their main source of lighting.

The findings demonstrate that increased understanding of the connections between energy sources and the environment has a positive impact on the uptake of clean lighting technologies. This emphasises the importance of educating households about energy-environment issues. Nevertheless, a chi-square analysis looking at the relationship between the choice of households' energy source for lighting (clean vs. unclean energy sources) and knowledge on its impact on the environment, showed no significant association, at a 5% significance level, x^2 (4, N = 418) = 5.06, p > .05.

Regarding energy for cooking, the empirical results showed minimal adoption rates among households (0.5%) that strongly agreed and agreed that their main energy source has an impact on the environment used a clean cooking energy source. Despite the seeming disconnect between households' choice of energy source for cooking (clean and unclean energy sources) and knowledge on its impact on the environment, a chi-square test, x^2 (4, N = 419) = 2.64, p > .05, at 5% significance level, showed no significant association (Table 6.5).

Table 6.5: Households main energy-environment knowledge and choice of energy sources (clean or unclean fuels)

Variable	Category	Lighting					Cooking				
		Clean		Unclean		P value	Clean		Unclean		P value
		N	%	N	%		N	%	N	%	
Main energy source can impact the environment	Strongly agree	9	3.8%	3	1.7%		0	0.0%	12	2.9%	
	Agree	111	46.3%	87	48.9%		1	50.0%	197	47.2%	
	Neutral	31	12.9%	28	15.7%		0	0.0%	59	14.1%	
	Disagree	59	24.6%	47	26.4%		1	50.0%	106	25.4%	
	Strongly disagree	30	12.5%	13	7.3%		0	0.0%	43	10.3%	
	Total	240	100%	178	100%	0.282	2	100%	417	100%	1.000

The findings suggest that households are unable to reflect their knowledge on energy and environment onto their choice of energy, particularly for cooking. That is, households indiscriminately choose an energy source based on other criteria with less emphasis on the environment, as their choice of energy source for cooking did not necessarily reflect their understanding of the energy-environment relationship.

The results further demonstrate the variety of factors affecting household choices of energy for cooking and lighting purposes. Although environmental consciousness is important in households' adoption of clean energy technologies, other factors like price, accessibility, and cultural preferences, probably have more significant influence. As a result, policymakers and institutions supporting clean energy transition need to acknowledge the complexity of household energy decisions.

6.2.6 Household specific energy choices based on environmental awareness

An in-depth analysis of the specific energy sources that households used based on their awareness of how their main energy source can impact the environment was conducted. According to the empirical results, 51% (90 out of 177) of households using non-rechargeable battery-powered torchlights agreed that the environment could be impacted by their primary energy source. Similarly, 52% of households (96 out of 185) that utilise PV or solar torchlights concurred that the environment can be impacted by their primary energy source.

Regarding cooking fuels, the only household that used LPG agreed that their main energy source can affect the environment. Conversely, the household using an improved cookstove disagreed that their main energy source can impact the environment. Half of households (50%, 196 out of 390) that used firewood as their main cooking fuel agreed that it can have an impact the environment (Table 6.6).

Table 6.6: Households main energy-environment knowledge and main choice of energy sources

Variable	Category	Main lighting source									
		Torch		Local Lantern	PV lantern / solar torchlight		Solar Home System			Total	
		N	%	N	%	N	%	N	%	N	%
Main energy source can impact the environment	Strongly agree	3	1.7%	0	0.0%	8	4.3%	1	1.8%	12	2.9%
	Agree	87	49.2%	0	0.0%	88	47.6%	23	41.8%	198	47.4%
	Neutral	28	15.8%	0	0.0%	16	8.6%	15	27.3%	59	14.1%
	Disagree	46	26.0%	1	100%	49	26.5%	10	18.2%	106	25.4%
	Strongly disagree	13	7.3%	0	0.0%	24	13.0%	6	10.9%	43	10.3%
Total		177	100%	1	100%	185	100%	55	100%	418	100%
Variable	Category	Main cooking energy source									
		Firewood		Cookstove	LPG		Charcoal			Total	
		N	%	N	%	N	%	N	%	N	%
Main energy source can impact the environment	Strongly agree	12	3.1%	0	0.0%	0	0.0%	0	0.0%	12	2.9%
	Agree	184	47.2%	0	0.0%	1	100%	13	48.1%	198	47.3%
	Neutral	56	14.4%	0	0.0%	0	0.0%	3	11.1%	59	14.1%
	Disagree	98	25.1%	1	100%	0	0.0%	8	29.6%	107	25.5%
	Strongly disagree	40	10.3%	0	0.0%	0	0.0%	3	11.1%	43	10.3%
Total		390	100%	1	100%	1	100%	27	100%	419	100%

The findings provide valuable insights on households' energy choices and their awareness of environmental impacts. Households held differing opinions on the impacts of their energy sources on environment. The results further suggest a lack of awareness among certain households, especially those that use firewood, who are not aware of the detrimental effects that their energy choices can have on the environment. Thus, even though households (based on local knowledge) are knowledgeable about trees suitable for woodfuels for cooking, they are unable to link their act of felling trees for woodfuels to the broader environmental consequences (Adam 2014).

In light of the findings, it is imperative to provide households with comprehensive education on the impact of their choice of energy on the environment. Bridging households' knowledge gap on energy-environment issues can help them make informed decisions on their energy sources which would in effect, contribute to wider environmentally focused conservation and reduction of GHG emissions. However, it is important not to limit transition strategies to the provision of knowledge as there are other factors that households consider more relevant, even when they are knowledgeable on energy-environment issues.

6.2.7 Household knowledge on clean energy sources

To find their level of awareness of clean energy technologies, households were asked to identify the clean energy sources they are familiar with. The empirical results showed that households generally possess knowledge of clean energy sources. Regarding lighting, households were knowledgeable of sources such as wind, PV lanterns/solar torch, SHS and hydropower. Specifically, a considerable number of households were familiar with PV lanterns/solar torch (90%), SHS (86%) and hydropower (59%).

This awareness can be attributed to the abundance of PV lanterns/solar torch and SHS in the communities, and the prominence of hydropower as a major source of electricity in the country. Although the country has excellent wind conditions to generate power, efforts to generate power from wind have been slow (Kemausuor *et al*. 2011; Sun *et al*. 2020). It is therefore not surprising that a few households (7%) were knowledgeable about utilising wind to generate electricity for lighting.

Concerning cooking energy sources, many households were aware of improved cookstoves (94%) and LPG (97%) as cleaner cooking energy sources. This demonstrates the rigorous efforts of actors to provide households with knowledge about clean cooking technologies, in order to transition them from their predominant reliance on woodfuels. For example, initiatives such as the country's LPG Promotion Programme have played a critical role in enhancing the knowledge of rural households on LPG, consequently increasing the likelihood of shifting people from the use of woodfuels to LPG for cooking purposes (Adjei-Mantey *et al*. 2021).

Again, there is an alliance by some actors, e.g. Ghana Alliance for Clean Cookstoves and Fuels (GHACCO), who are championing the distribution of clean cookstoves and fuels, particularly in rural Ghana. This collective action contributes to the profusion of knowledge on LPG and improved cookstoves among households (Table 6.7).

Table 6.7: Households knowledge on the clean energy sources

Energy source	**Energy sources**	**Frequency, N = 419**	**Percent**
Lighting	PV lanterns / Solar torch	377	90%
	Mini-grids	186	44.4%
	Wind	29	6.9%
	Solar Home Systems	362	86.4%
	Hydropower	247	58.9%
Cooking	Improved cookstove	393	93.8%
	LPG	406	96.9%

Multiple responses allowed.

The empirical results indicate significant levels of awareness of clean energy technologies, both for cooking and for lighting, among rural households. Solar technologies for lighting are widely known by households because their distribution has been heavily invested in by actors (Nuru *et al*. 2021; Ojong 2021).

The use of electricity for cooking, despite being considered the cleanest cooking option, was not known as a clean energy source by households as their knowledge about clean cooking technologies was limited to the use of improved cookstoves and LPG. This lack of awareness could be as a result of inadequate promotion of electric cooking in the country, compounded by communities' non-connection to the electricity grid (Bawakyillenuo *et al*. 2021).

The reluctance of actors to promote electric cooking may also be because of the broader challenges that persist in the electricity sector of the country. Even in urban communities that have been connected to the national electricity grid, some urban households complain about challenges such as availability (power outages) and cost, leading to dissatisfaction among users (Bloomer and Boateng 2024).

The findings in general, suggest that actors have made strides in energy transition, particularly by making clean energy technologies known to potential users, herein, rural households. If households have knowledge of all these clean energy technologies for cooking and lighting, what factors hinder their adoption by rural households?

6.2 Barriers preventing the adoption of clean energy sources

After assessing the barriers preventing households from adopting clean energy technologies, the findings indicated that the cost (87%) of clean technologies is a major barrier preventing their use. This was closely followed by availability (82%), as many households stated that the clean technologies that they wish to use are completely unavailable. Some households had concerns about the inadequate information on clean energy technologies (22%) and their lack of involvement in the transition process (17%), stating that they hindered the adoption of clean energy technologies. Few households stated being change averse (4%) and the unreliability of clean energy technologies (3%) as barriers that prevent their adoption (Table 6.8).

Table 6.8: Factors preventing the adoption of clean energy technologies

Factors	Frequency, N= 419	Percent
Availability	345	82.3%
Cost	363	86.6%
Inadequate information	94	22.4%
Change averse	16	3.8%
Unreliability	13	3.1%
Lack of technical support	48	11.5%
Lack of inclusion in the process	70	16.8%

Multiple responses were allowed.

The empirical results, consistent with Acharya and Marhold (2019), Guta (2020), Twumasi *et al*. (2021) and Wassie *et al*. (2021), demonstrate that the cost of clean energy technologies is a major barrier that hinders households' adoption of technologies. Many households expressed concerns about the high cost of energy technologies like SHS, improved cookstoves and LPG.

Although the kind of technologies deployed in the study communities are typically simple in design, the associated prices were high for rural households, who often face the challenge of making lump sum payments for these products or, alternatively, paying more through instalment plans. Consequently, even when households have the will to transition from the use of unclean fuels to cleaner ones, they are unable to do so because of the price element.

This situation is compounded by the presence of available alternatives which are relatively cheaper. In the study communities for instance, the cost of filling a 7kg LPG cylinder is 120 Ghana cedis. This 7kg cylinder, when used by a household of 3 people, can last for 3-4 weeks, depending on usage. This price element makes households resort to the use of woodfuels because their usage comes with a comparatively, low economic cost. The high cost of the simple low-carbon technologies has made some households lose interest in the adoption of these technologies, as echoed during interviews:

"I am unaware of the prices of the new solar technologies. Although I often see the sellers of these technologies in the community, I have not inquired about the prices. This is because, regardless of the price, I am certain that I cannot afford"— (Kwabena, November 2022).

"The prices of clean technologies are significantly higher compared to traditional fuels. I do not believe a transition to cleaner fuels is feasible if nothing is done about the cost" — (Akwasi, January 2023).

Availability of cleaner energy technologies is another factor that households identified as hindering their adoption of low-carbon technologies, as highlighted by Blenkinsopp *et al*. (2013) and Acharya and Marhold (2019). If clean energy technologies are not available, then they cannot be used by households, even when they are willing to transition from the use of unclean fuels.

For example, some households expressed a desire to transition to the use of LPG, admitting that LPG makes cooking easier. However, these households could not shift from the use of woodfuels to LPG because there were no gas filling stations in the communities. This absence means, the use of LPG can put undue financial burden on potential users as they would have to travel to other communities to fill their gas cylinders.

Aligning with Mfune and Boon (2008), inadequate information on clean energy technologies is another barrier that households raised as impeding their adoption. Notably, Irfan *et al*. (2021) and Ibegbulam *et al*. (2023) highlight that if households are made aware of the benefits accompanying the use of clean energy – particularly social, economic and environmental impacts – they are more likely to embrace clean technologies.

Since the communities are agrarian, if many households are able to link their choices of energy to the negative environmental impacts, then they are more likely to adopt clean energy technologies. This is because their livelihoods are dependent on agriculture, which is reliant on climate. However, the knowledge many households had about clean technologies was limited to meeting their energy needs.

Thus, many households viewed energy transition or the introduction of clean energy technologies as a solution to energy poverty. This perspective was shared by a community leader in an interview:

"The solar technologies available in the communities are intended to help us meet our energy needs since the community is not connected to the main electricity grid" – (Kwame, November 2022).

Despite the crucial role of community involvement in the adoption of clean energy technologies (Cloke *et al*. 2017; Baxter *et al.* 2020; Sovacool 2021a; Boateng *et al*. 2023a), a few households perceived the lack of this as a barrier that impedes their adoption of clean technologies. This suggests that many households, regardless of their level of involvement in the transition process, are willing to transition to the use of cleaner energy technologies.

Hellmuth *et al*. (2019) and Ukoba *et al*. (2024) suggest that a successful energy transition must include technical support and capacity building. Technical support involves helping households in the installation of solar panels, repairing the panels and training them on how to fix and repair technologies themselves. Because many rural households are illiterate, they are unable to make meaning out of the manuals that are mostly attached to the products they buy. Hence, they would need technical support to install clean technologies, which they typically receive (Kishore *et al*. 2014).

However, households raised concerns about the unavailability of technicians to help fix technical issues that arise after the installation of solar technologies. For these reasons, Ukoba *et al*. (2024) specifically suggested a need for building the capacity of people in the transition process, particularly on how to install and maintain clean technologies. For instance, households can be trained on how to install solar technologies and fix the technologies when defective. Clean energy technology providers can also have a support centre that is readily available to assist households in the event of any malfunctions.

Nonetheless, a household head stated in an interview:

> *"The providers of low-carbon technologies are primarily concerned about making profits. Once the technologies are purchased, it becomes difficult to contact them when there are technical challenges"* – (Kwame, November 2022).

Very few households identified unreliability of clean energy technologies and being change averse as factors that hindered their adoption. This suggests that some households perceive clean energy technologies as reliable. As the IEA (2020) considers reliability of energy sources a key determinant of energy access, households' awareness of the dependability of clean energy technologies is likely to enhance their adoption, if all other factors are held constant.

The small numbers of households stating that being change averse impeded their transition to cleaner technologies suggests that the majority of households are susceptible to change – a quality that is likely to enhance a smooth transition to clean energy technologies. That is, all other things being equal, households are likely to change from the use of traditional fuels which they have been exposed to for a prolonged period. This contravenes the assertion of Goswami *et al*. (2017) and Khandelwal *et al*. (2017) that rural households reject new clean energy technologies because of their familiarity with traditional fuels.

The empirical results indicate that the cost of low-carbon technologies and their availability are significant factors that inhibit their successful adoption by rural households. Although the involvement of rural dwellers in the transition process is documented to enhance the uptake of clean technologies, few households view their non-involvement in the process, and a lack of participatory planning, as factors that hinder their adoption. The findings also suggest that households are keen to transition to the use of clean technologies because they know how reliable clean energy technologies are, and they are not opposed to a change from traditional fuels.

6.3 Potential (dis)possessions associated with low-carbon transition

Without careful reflection, the broad expectations of low-carbon transition, may obscure the specific expectations of households at the local level. As noted by Sovacool (2021a), a transition to clean energy technologies can disproportionately impact the livelihoods of vulnerable households. The study therefore investigated, at the residential level, rural households' expectations of a transition to clean energy technologies – recognising the importance of harmonising the energy transition and safeguarding livelihoods.

6.4.1 Expected positive impacts of embracing low-carbon transition

When rural households were asked about the potential benefits of a complete transition[9] to clean energy on their livelihoods, wellbeing and the environment, the empirical results showed several positive expectations. A significant number of households anticipated that a complete transition to clean energy would improve their health (54%) and increase their income (44%). Others also expected this transition to enhance food security (24%), while a few anticipated reduced vulnerability (13%) and more sustainable use of natural resources (4%). Consequently, these people expressed a general expectation for the implementation of clean energy solutions in their households and the districts (Table 6.9).

[9] A complete transition implies the change to a clean energy system that is readily available, reliable and affordable.

Table 6.9: Potential positive impacts associated with a complete transition to clean energy system

Positive impacts	Number of occurrences	Percent of count	Reasons
Increase income	186	44.4%	Reduce money spent on unclean fuels
			Provide more economic opportunities
			Extend trade hours
Reduce harm	56	13.4%	Will not be exposed to predators
Improve health	227	54.2%	Little exposure to smoke
			Enhance satisfaction through access to technologies
Improve food security	101	24.1%	Can cook and eat well
			Reduce cook times
			Easily preserve food
Enhance sustainable use of natural resources	18	4.3%	Reduce the rate of deforestation for firewood

Multiple responses were allowed.

The findings suggest that households have substantial expectations concerning the impacts of a clean energy transition on their livelihoods, wellbeing, and the environment. These expectations are well-founded as the transition to cleaner energy is associated with multiple benefits (Diallo and Moussa 2020; Aemro *et al*. 2021). Previous scholarly works on the impacts of clean energy adoption highlight improvements in health as a primary outcome.

The adoption of clean energy technologies, specifically for cooking, is associated with significant health benefits, including the reduction of exposure to smoke and improvements in mental health of users (Chillrud *et al*. 2021; Liu *et al*. 2022). Furthermore, access to clean energy for electricity enables off-grid households to utilise appliances such as mobile phones, televisions, and radios, which play a vital role in health communication within SSA (Iacoella *et al*. 2022).

Consistent with these findings, many households anticipated that a complete transition to clean energy would have a significant positive impact on their health, as one household head stated in an interview:

"I am exposed to a lot of smoke whenever I cook with firewood. I have eye irritation anytime I am exposed to the smoke from firewood. A shift to LPG will alleviate this problem for me" – (Akosua, December 2022).

In line with Liao *et al.* (2021), improvement in household income was identified as the second most expected impact of a complete transition to a clean energy system. Indeed, transitioning to clean energy systems is known to bolster the economies of rural communities (Mugisha *et al*. 2021). Households, therefore, expected more economic opportunities to be created in the communities following a successful transition to cleaner technologies. Moreover, they expected improvements in productivity, resulting from increased productive hours, which would lead to higher household incomes. A household head expressed:

"I am forced to halt my selling activities after sunset since it gets extremely dark here. With the presence of light in the community, I can extend my trading hours and generate more income to support my household" — (Adwoa, January 2023).

Some households also expected a transition to clean technologies to reduce the money they spend on energy (Aemro *et al*. 2021). These households mentioned that using SHS, for instance, would alleviate the financial burden of a monthly electricity bill payment on them. In the case of urban communities connected to the national electricity grid, payment of monthly electricity bills has been challenging for many poor households, especially in the current global geopolitical crises and associated economic impacts (Bloomer and Boateng 2024).

Given that off-grid rural communities have similar economic features as their urban-poor counterparts, the monthly electricity bill payments associated with connection to the national electricity grid, are likely to be financially burdensome for some poor households in off-grid rural communities.

However, there are some financial benefits associated with the use of clean fuels. Notably, Bawakyillenuo *et al*. (2021), in their research on cooking energy sources in Ghana, found that a transition of households to fully electric cooking with energy-efficient appliances could save 30-40% of their fuel costs. Supporting this, a household head stated that:

"The durability of woodfuels, specifically charcoal, has declined. This is due to the scarcity of suitable tree species for charcoal production. As a result, I now spend more on charcoal than I did in times past" – (Kwabena, January 2023).

In the study communities, many households used traditional means of food preservation, such as heating and drying. Conversely, only a few households used refrigerators in their homes for food preservation. This limited adoption of refrigerators makes it challenging for households to maintain food safety and quality, and limits their ability to use canned foods to a degree (Miller *et al*. 2021).

The decision of many households to forego refrigerators could be a result of the lack of an energy source that has the capacity to power refrigerators and their income levels, since refrigerators are often among the first assets households acquire with an increase in wealth (Wolfram *et al*. 2012). Some households therefore admitted that a complete transition to cleaner energy will improve food safety by simplifying food preservation processes.

Consistent with the findings of Troncoso *et al.* (2019) and Miller *et al*. (2021), other households anticipated a reduction in cooking time and an enhancement in cooking comfort upon a transition to cleaner cooking technologies. For example, one household head expressed that:

"It takes a considerable amount of time to light up woodfuels for cooking, especially when the wood is not dry enough. A shift to LPG and an improved cookstove will make it easy for me to cook, allowing me to invest my time in other productive activities" – (Afua, January 2023).

As households primarily rely on very simple solar technologies and non-rechargeable battery-powered torchlights which often provide dimmer lights, a complete transition to a clean energy system can significantly benefit them through the provision of brighter lights, as they would be able to afford more advanced technologies for lighting. In line with the findings of Hellmuth *et al*. (2019), Ulsrud (2020) and Saim and Khan (2021), some households anticipated that a low-carbon transition would reduce their exposure to harm, particularly in the evenings when there is a need for adequate lighting for safety and security. Some household heads remarked that:

"Although it is safe to walk about at night in the community, I am always in fear of being attacked by criminals as I hear in other communities. I am therefore, always indoors after sunset. It would be much safer if households had access to brighter lights" – (Yaa, October 2022).

"I try to do all my activities in the day and stay indoors at night. In the evening, we are exposed to predators, such as scorpions and snakes, since we live close to the forest. That aside, the District Health Centre is distant from the community, so it is better to protect oneself, which means staying indoors" – (Kofi, January 2023).

Few households anticipated that a complete transition to cleaner technologies would minimise environmental impacts by promoting sustainable use of natural resources. This indicates households' limited knowledge on the nexus of energy-environment issues and their inability to link their choice of energy to the environment.

Among the few households that expected a transition to clean energy to positively affect the environment, their reasoning centred on the notion that a transition to clean cooking fuels would reduce reliance on woodfuels, thereby reducing deforestation. No household however, expected a clean energy transition to cause a reduction in GHG emissions, despite a clean transition being noted for the capacity to reduce GHG emissions. In an interview, a household head stated:

"A transition to clean energy, particularly for cooking, will help reduce my household's reliance on woodfuels. This will reduce the quantity of trees being cut for woodfuels everyday" – (Kofi, January 2023).

6.4.2 Expected negative impacts of embracing a low-carbon transition

Empirical evidence suggests that energy accessibility does not positively impact all facets of livelihood and wellbeing (Acheampong *et al*. 2021). The empirical results of this study reinforce this assertion, as some households expressed concerns about certain components of their wellbeing that would potentially be negatively impacted, in the event of a clean energy transition.

Specifically, some households (40%) expressed worries that a complete transition would lead to a reduction in their gross incomes and discretionary incomes, due to increased expenses from the payment of clean energy bills. A few households were also anxious that a transition to clean energy would expose them to dangers (4%). However, no household expected that a transition to clean energy would negatively impact their food security and sustainable use of natural resources (Table 6.10).

Table 6.10: Potential negative impacts associated with a complete transition to clean energy system

Negative impacts	Number of occurrences	Percent of count	Some reasons
Reduce income and increase expenditure	167	39.9%	I trade in charcoal
			I have to pay bills and buy gas
Increase exposure to harm leading to health deterioration	18	4.3%	LPG can cause fire outbreak

Multiple responses were allowed.

Certainly, the use of clean energy technologies comes at a cost that can be burdensome for some households. For instance, if households are shifting to the use of LPG, then it implies that aside from the one-off payment to get a cylinder, hose and burner, they have to fill the cylinders from time to time when the gas runs out. The intermittent purchase of gas and/or bill payment associated with a clean energy transition can put an undue financial strain on households.

In certain communities, where mini-grids have been deployed, some households have found it challenging to pay the associated tariffs, even at subsidised rates (Hellmuth *et al*. 2019). The socio-economic conditions of households in these mini-grid communities are similar to households involved in this study – poor, traditional and rural. Knowing these circumstances, some households were particular about the type of clean energy intervention for lighting that would be introduced in the communities. A traditional leader in one of the study communities stated that:

"When provided with options, we (community members) prefer solar home systems for individual households as an intervention. This will allow owners to make a one-off payment to access electricity. Although we may be able to afford bill payment when a mini-grid is introduced, that will mean an increase in our monthly expenditure" – (Kwabena, January 2023).

The findings further showed that some households are concerned about potential employment losses or income reduction upon a complete transition to clean technologies. In the study communities, some householders are involved in the trade of unclean energy sources such as charcoal, battery-powered torchlights and batteries. For such households, a shift to clean energy sources would reduce their income or even, collapse their businesses, which are heavily reliant on unclean fuels. As noted by Kiruki *et al*. (2020), the production and sale of charcoal significantly serves as a source of income for households in SSA, particularly rural households.

Activities related to the production and sale of charcoal are known to contribute substantially towards the livelihood of rural households in the SSA region (FAO 2017). Therefore, a reduction or a cessation in the production and sale of charcoal, following a transition to clean cooking technologies, may negatively impact rural livelihoods. Just as a ban in charcoal production in Kenya is noted for inconveniencing producers (Wekesa *et al*. 2023), so could a transition to clean cooking fuels have similar effects on households in rural Ghana. A household head noted that:

> *"I am a producer and seller of charcoal. A transition to LPG will cause me to lose my job, impacting my income and the wellbeing of my household as I am the primary breadwinner"* – (Kwadwo, November 2022).

A few households also stated that a complete transition to clean technologies will expose them to harm. These households explained that the use of LPG for cooking would for instance, expose them to burns, as have been recorded in some urban parts of the country (The Guardian 2017). Some of these households lacked kitchens or did not have well-ventilated kitchens. They therefore expressed how impossible it was for them to use LPG, given their current economic situation. To use LPG, the households with poorly-ventilated kitchens would have to cook indoors, which can easily expose them to smoke and fires (Dida *et al*. 2022). In an interview with a household head, he stated that:

> *"It is not advisable for me to use LPG as I do not have a kitchen and hence, cannot cook inside my room with LPG. That aside, my house, which is mainly a hut, is highly susceptible to fires"* – (Kwaku, January 2023).

6.4.3 Influence of anticipated impacts on household energy preferences

The study further examined the influence of anticipated positive (API) and anticipated negative impacts (ANI) of a clean energy transition (independent variables) on households' current adoption of energy sources (CAE), whether clean or unclean (dependent variables), using multiple regression analysis with robust standard errors. The regression model showed that only 1% of the variance in the choice of energy is explained by households' expectations regarding energy transition, suggesting that these expectations have minimal explanatory power.

More specifically, the results indicated that neither the positive expectations ($R^2 = .01$, $F(1, 418) = 2.24$, $p > .05$) nor the negative expectations ($R^2 = .01$, $F(1, 418) = 2.24$, $p > .05$) regarding the effects of a clean energy transition, significantly influence households' choice of energy for lighting. Concerning cooking energy choices, the empirical results indicated that households' expectations of a clean energy transition, whether positive ($R^2 = .01$, $F(1, 419) = 2.46$) or negative ($R^2 = .01$, $F(1, 419) = 2.46$), have no significant influence on their choice of energy for cooking (Table 6.11).

Table 6.11: Association between expected impacts of a complete clean energy transition and households' choice of energy sources

Variable	Predictor	Beta coefficient	Robust Standard errors[a]	T-value	P-value
Lighting	API – CAE	-.081	.078	-1.039	.299
	ANI – CAE	-.090	.049	-1.845	.066
Cooking	API – CAE	-.020	.023	-.872	.384
	ANI – CAE	-.009	.006	-1.403	.161

[a]HC3 method.

The findings indicate that some households, despite perceiving a transition to clean technologies as potentially detrimental to their wellbeing, continue to use clean energy. This may result from either the inability of some households to critically evaluate the potential impact of a clean energy transition on their wellbeing or households' willingness to make sacrifices (herein, endure the negative impacts on their wellbeing) to promote clean energy transition (Adjakloe *et al*. 2021).

Some households on the other hand, despite being aware of the positive impacts associated with a clean energy transition, fail to adopt clean energy technologies. This contravenes the findings of Elahi *et al*. (2022), who argue that increased knowledge of the socio-economic and environmental benefits of clean technologies will enhance the uptake of clean technologies. This could possibly mean that while households are aware of the benefits of clean energy transitions, these benefits have not yet been experienced directly and therefore, do not consider it relevant in their current energy decisions.

Generally, the findings give credence to Irfan *et al*. (2021), who identified that the beliefs of people on the benefits of clean energy and its environmental impacts do not significantly influence consumption patterns. Whereas the study found no statistically significant association between the impacts which households expect from clean energy transition and their choice of clean or unclean energy, the findings underline the need to educate households on the benefits associated with clean energy transition, particularly its impacts on the environment.

For households to reap the expected positive impacts from a transition to cleaner energy, "its implementation will need to be fully supported by robust technology, adequate maintenance, flexible financing strategies, and social institutions in the diverse, vast, and remote rural areas" (Liao *et al*. 2021, p. 6). This emphasises that while a clean energy transition is capable of improving livelihoods and the environment, its execution can negatively impact households, if not properly implemented.

6.4 Household livelihood and ties to unclean energy sources

To understand how the livelihoods of household members are linked to unclean fuels, households were asked which unclean energy source(s) their livelihoods are tied in with. The empirical results showed that the livelihoods of many households are tied to traditional cooking fuels such as charcoal (49%) and firewood (5%). Additionally, the sale of non-rechargeable battery-powered torchlights was identified as a source of income for some households (7%).

Specifically, households involved in the sale of non-rechargeable battery-powered torchlights were engaged in selling these products and batteries within off-grid rural communities. On the other hand, the majority of households whose livelihoods were linked to charcoal, were involved in its production and/or sale, both within and outside the off-grid rural communities (Table 6.12).

Table 6.12: Households' livelihoods and ties to unclean energy sources

Energy sources	**Number of occurrences**	**Percent of cases**
Charcoal	205	48.9%
Firewood	21	5.0%
Torchlight	27	6.5%

Multiple responses were allowed.

The results suggest that a substantial number of households' livelihoods are directly and/or indirectly dependent on the production and/or sale of unclean energy sources such as charcoal, firewood and non-rechargeable battery-powered torchlights. This implies that although the livelihoods of some households are tied to the production and/or sale of charcoal, not all households in this category possibly realise that a transition to the use of clean energy may potentially affect their income. This may explain the relatively fewer number of households who expect a complete transition to clean energy to cause a reduction in their income.

As the findings affirm that charcoal production is a major source of income for rural dwellers in Ghana (Nketiah and Asante 2018; Ablo *et al*. 2022; Asare *et al.* 2022), the study further assessed its specific contribution towards the livelihoods of rural households, particularly when agriculture is known to be the predominant income source for rural households.

6.5.1 Charcoal contribution to rural livelihoods

Despite farming and fishing being their primary occupations, some rural dwellers in the study communities were involved in the production of charcoal as a coping mechanism to deal with economic shocks, particularly caused by climate change (Brobbey *et al*. 2019). Although heavily involved in the production of charcoal, these rural dwellers used significantly less charcoal (Ghana Statistical Service 2019).

A lot of the charcoal produced in the rural communities is transported to nearby cities, such as Koforidua and Accra, to be sold. Charcoal production thereby creates employment opportunities for not only people in rural communities but also, urban dwellers who are engaged in commodity chain of charcoal production and consumption (Jones *et al*. 2016) – see Image 7, for an example.

Image 7: Bags of charcoal ready to be transported to cities

While of insufficient scale to meaningfully contribute to the eradication of poverty in rural communities, charcoal production remains an important poverty alleviation strategy (Kiruki *et al*. 2020). Charcoal production and sale provided additional income for rural dwellers, particularly women, who performed roles such as fetching and burning of firewood, packing charcoal into bags and trading of charcoal.

Not only women benefitted from the charcoal production activity but also, men who were involved in the loading and transportation of charcoal to the cities. Aside from being critical to the energy needs, income from woodfuels (firewood and charcoal), supports the livelihoods of rural dwellers (Nketiah and Asante 2018; Ablo *et al*. 2022).

Out of the 419 households who were involved in the study, 32% obtained 0-40% of their monthly incomes from trading in charcoal. Four percent and 1% of households had 61-80% and 81-100% of their monthly income, respectively, sourced from trading in charcoal (Table 6.13).

Table 6.13: Percent of households' incomes generated from trading in charcoal

Percent of monthly income	Number of occurrences	Percent of cases
0-20%	65	15.5%
21-40%	67	16.0%
41-60%	51	12.2%
61-80%	18	4.3%
81-100%	4	1.0%

The empirical findings suggest that although the incomes of many households are tied to charcoal production, only a few households (5%) had it contributing more than 60% of their household incomes. Corroborating Kiruki *et al*. (2020), the findings indicate that many households do not solely rely on charcoal production for their livelihoods. Rather, they engaged in the activity to complement their main economic activity (Brobbey *et al*. 2019; Paul Jr 2023). Since households have a considerable economic stake in the use of unclean energy, specifically charcoal production, it is essential for actors to involve them in transition process, while ensuring that the process is a friendly one. In the case of cooking fuels, improved cookstoves can offer a viable option (see for example, Ackah *et al.* (2021) and Boateng *et al*. (2023b)).

6.5.2 The case of improved cookstoves

The benefits of a global clean cooking are considerable: "reducing premature deaths by about 500,000 a year by 2030, drastically cutting time spent gathering fuel and cooking, and allowing millions of women to pursue education, employment and civic involvement" (IEA 2022a, p. 16). While a rapid shift to rolling out clean cooking technologies is demanded by the pace of action required to adapt to global climate change, a swift transition to LPG in rural SSA is likely to backfire as rural dwellers prefer fuels that are more readily available, cheaper and perceived as safer to use.

Improved cookstoves are innovations that aim to address the clean cooking energy needs of low-income earners who cannot afford LPG and are excluded from its benefits (Lambe *et al*. 2020; Gill-Wiehl *et al*. 2021; Matavel *et al*. 2023b). In Ghana, these technologies are typically, locally produced and readily available for purchase in all parts of the country. Improved cookstoves could be used as an alternative where LPG uptake and/or use has been unsatisfactory (see Image 8, for an example).

Image 8: An improved cookstove deployed in rural Ghana

(Credit: Clean cookstove Ghana Limited 2023).

Improved cookstoves are cheaper than LPG. The cost incurred in adopting LPG (i.e. to purchase a cylinder, stove, and gas) can be used to purchase two or more units of improved cookstoves. If the cost of cookstoves is problematic for rural households, then it would be extremely difficult for them to shift to and sustain the use of LPG in their homes, given its higher cost.

Additionally, improved cookstoves allow for more efficient use of woodfuels (firewood and charcoal). Applied as an interim 'stepping-stone' technology, improved cookstoves might help to avoid an abrupt disconnect from traditional practices of many rural dwellers, closely associated with the use of woodfuels. Since improved cookstoves use fewer woodfuels, the emissions from the fuels can be significantly reduced (Lambe *et al*. 2020; Gill-Wiehl *et al*. 2021).

Rural dwellers are more comfortable with the use of woodfuels, stemming from their historic and traditional use of the resources in their homes. Consequently, a rapid transition to LPG may be resisted and hence, not yield the intended results. A shift from woodfuels to improved cookstoves on the other hand, indicates a steady change in the custom of rural dwellers, which can likely increase uptake and sustain the adoption of the technology.

Unlike a direct transition to LPG which can collapse charcoal production activities, an improved cookstove stopgap allows the activities to continue – albeit at a slower pace. A move to improved cookstoves implies that rural dwellers engaged in the production of charcoal would still be in business and, therefore, be earning an income from charcoal production to support their livelihoods.

Thus, a 'friendly' approach to transition to cleaner cooking fuels that considers disparities and inequalities within societies (for example, educational levels, income levels, customs and traditions), namely an improved/clean cooking fuel pathway, is encouraged (Jasanoff 2018) (Fig. 6.1).

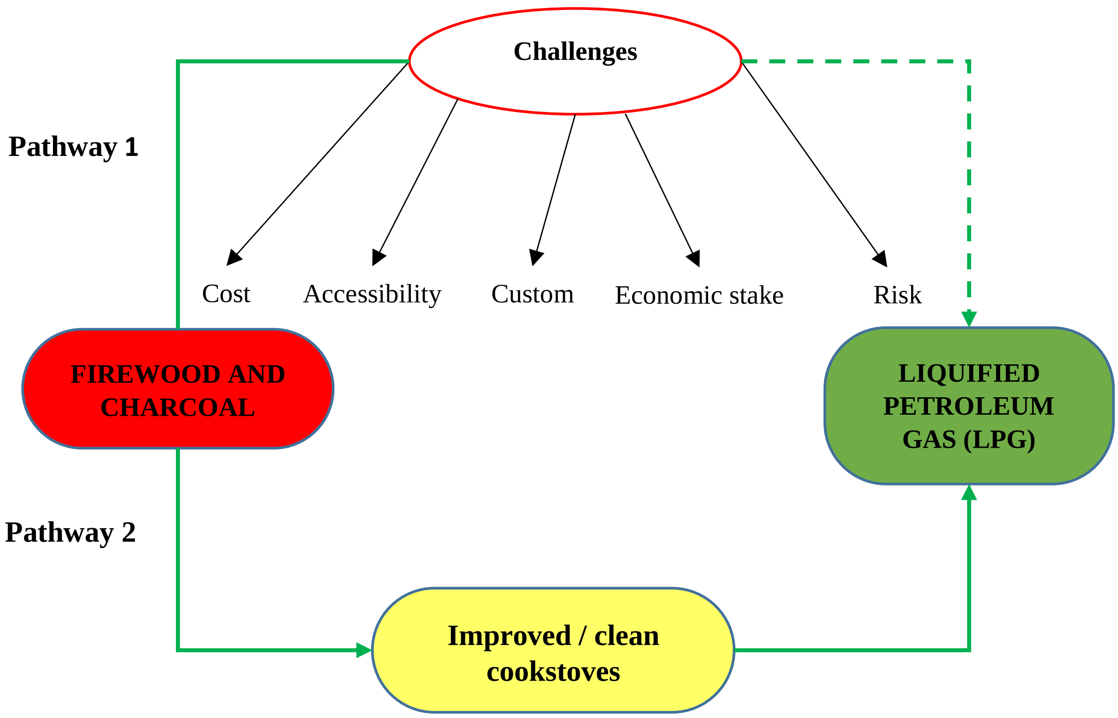

Fig. 6.1: A proposed pathway to transitioning to LPG via improved cookstove

(Source: Author's construct).

As illustrated in Fig. 6.1, a direct transition to cleaner cooking fuels (such as LPG) is fraught with many challenges (for example, cost, accessibility, impacts on local custom, and disruption of income-generating activities), as already discussed in this research. These factors make it challenging to attain the goal of transitioning to the use of LPG via Pathway 1. Whereas similar challenges are encountered via Pathway 2, these challenges are relatively manageable and can be coped with by rural dwellers. This is because improved cookstoves are cheaper, more accessible, risk-free and use traditional fuels, enabling a sustained and friendly transition to LPG.

Since rural dwellers have been accustomed to accessing free fuels for cooking, any substantial cost element attached to clean fuels is not likely to be accepted. It is therefore recommended that actors promote the distribution of affordable improved cookstoves to households. However, coverage is low as distribution is unable to reach many rural communities due to financial reasons.

This aside, improved cookstoves are more likely to be adopted by a few rich rural dwellers at the expense of the poor majority. This, therefore, necessitates actor investment in such technologies to make them affordable, since some poor households can be excluded in the process, as evidenced in other SSA countries (Kedir *et al*. 2019; Waswa *et al*. 2020).

Conclusion

In all, the findings of this chapter have demonstrated that a range of actors at different levels are actively playing various roles to expand rural households' access to clean energy sources for lighting and cooking. However, the transition from traditional and unclean energy sources to clean energy technologies is plagued with challenges, such as cost, availability and inadequate information, making it difficult for households to adopt and sustain the use of clean energy sources. The findings revealed a notable gap in households' knowledge on the environment and clean energy technologies, in spite of the evident linkage between the use of clean energy technologies and the environment. The findings further showed that households have economic ties with unclean fuels, which can challenge a smooth transition.

The chapter indicates that energy transition is characterised by exclusion of consumption (where some households are unable to adopt clean technologies due to various challenges) and exclusion of impact (where some households perceive transition as potentially detrimental to their livelihoods). This suggests that access to clean energy is not solely a technological issue but rather, a political and socio-economic process influenced by factors, such cost, availability and traditions. The chapter highlights that without addressing structural inequalities, such as affordability, resource dependencies and unequal energy-environment knowledge, clean energy transition risks exacerbating existing socio-economic disparities.

Given the pivotal role that various actors play in the clean energy transition process, the next chapter delves into the approaches these actors employ. Recognising the importance of involving households in the transition process, the chapter investigates the specific roles households play in this process. It also explores collaborative dynamics among the various actors, identifies areas of conflict, and examines perceptions households have regarding activities carried out by certain actors.

7. ACTORS AND HOUSEHOLDS SYNERGY IN ADVANCING LOW-CARBON SOLUTIONS

Given that strategies aimed at promoting societal wellbeing are capable of creating marginalised groups if not effectively implemented, this chapter focuses on the methods employed by households to engage with actors and their influence on households' choices and adoption of clean energy technologies. It further explores how actors interact with one another and interrogates how such interactions can strengthen the ability of actors to deploy effective strategies in the transition to clean solutions. A manuscript, based on this chapter, is currently being prepared for submission to a peer-reviewed journal.

The findings of the chapter suggest that households are not in constant communication with actors (37%) and perceive actors, particularly private clean technology providers, to be taking advantage of the transition process to make profit (59%), although these actors claim otherwise. Despite the failure of actors to actively involve households in the transition process, households reinforce the need for their involvement, admitting that it increases their chances of adopting clean energy technologies (83%). The findings further indicate a low level of collaboration among the vibrant clean energy providers, and competition among some non-state actors in the transition process.

This chapter therefore underpins the critical need for actors to actively involve households in the transition process and foster collaboration with one another. Such collaborative efforts emphasise the importance of multi-level actor engagement to address the challenges of energy transition. This approach is essential in developing effective strategies to attain a just and sustainable energy transition.

7.1 Key players in the low-carbon transition and collaborative strategies

Public-private collaborations have been fundamental in the energy transition discourse of Ghana, with private actors playing a crucial role (Adenle 2020; Karanja *et al*. 2020; Francis *et al*. 2022; Nwokolo *et al*. 2023). As a developing country, Ghana faces multiple development challenges, including limited energy access. Like many SSA countries, budgetary constraints hinder the government's ability to address all the energy challenges (Falchetta *et al*. 2021). Consequently, non-state actors are essential in complementing government efforts to expand energy access.

In rural communities, where substantial investment is required to extend electricity infrastructure (Bhattacharyya and Palit 2021; Zebra *et al*. 2021), the government's ability to prioritise rural electrification is often limited due to competing national demands. This underscores the critical role non-state actors can play in enhancing energy supply, particularly in underserved areas. Non-state actors, such as NGOs and private energy providers can provide financial resources, technologies and expertise to advance clean energy transition, and support capacity-building through local entrepreneurship training and policy advocacy (Francis *et al*. 2022). For non-state actors to be successful, there is the need for policy and institutional support from the government (Bhattacharyya 2012; Minas *et al*. 2024).

In the study communities, for instance, many actors in the clean energy sector, both state and non-state, have been active – as indicated in Chapter 6 (section 6.1). The commitment of these actors to providing clean energy solutions in the study communities could be as a result of their non-connection to the national electricity grid and households' reliance on traditional fuels, for both lighting and cooking. The government/state, that is the District Assemblies, remains the closest actor to rural communities and a major actor in Ghana's drive to transition to clean energy (Fairholm *et al*. 2018; Obeng-Darko 2019).

In interviews with some District Assembly officers, they admitted that:

"There are many private actors running programmes in rural communities in the district to promote the adoption of clean energy technologies, both for lighting and cooking purposes" – (Yaw, January 2023).

"There are several actors who visit rural communities in the district to implement clean energy projects. Some of these projects have really been impactful, and the District Assembly welcomes more" – (Kwame, November 2022).

7.1.1 Vibrant actors in off-grid rural communities

Findings reported in Chapter 6 of this research indicated that at the community level, households experienced interventions from the state/government, private providers, NGOs and FBOs (refer to Table 6.1). The research further identified the actors who are most active in the study communities, the channels they use to engage the communities and the nature of support they provide to rural households. In this context, the District Assemblies played a pivotal role as focal points of information on these aspects.

The findings indicated that the state/government, private clean technology providers and NGOs constitute the most vibrant actors driving the promotion of clean energy transition in the districts (Agyarko *et al*. 2020; Dagnachew *et al*. 2020). The activities of these actors are prominent across many of the communities within the district.

The Government of Ghana is playing a pivotal role in enhancing energy access in the study communities, facilitated by the District Assemblies. In some rural communities, solar panels have been provided to some households to address their energy needs. Furthermore, the government, through the District Assemblies, have formulated medium-term energy sector plans, serving as a framework to enhance energy access in the district.

Because they act as offshoot of the central government, all government activities in the communities go through the District Assemblies, the body responsible for implementing policies and overseeing regional development projects on clean energy solutions at the local level (Agyarko *et al*. 2020). The District Chief Executive (DCE) serves as the head of the District Assembly and holds political, executive and administrative authority within the district. Appointed by the president, the DCE represents the president's interests at the local level (Institute of Local Government Studies and Friedrich-Ebert-Stiftung Ghana 2010). This makes both the DCE and the District Assembly privy to clean energy initiatives by the government, despite their role in the planning of national energy policies remaining unclear (Akrofi and Akanbang 2021).

In the local government structure, unit committees represent the lowest administrative level, as they are the closest governance body to local communities. A unit typically consists of a settlement or a cluster of settlements with a population of 500-1,000 in rural areas and up to 1,500 in urban areas. These committees play key roles in enforcing local regulations and mobilising community members for development projects. Each unit committee comprises a maximum of 15 members, with up to 10 elected representatives and five appointed by the DCE (Institute of Local Government Studies and Friedrich-Ebert-Stiftung Ghana 2010).

Through the use of these unit committee members at the grassroots level, the District Assemblies serve as a conduit to disseminate information on national energy policies and plans to rural and distant communities. Consequently, District Assembly officials often notify households about energy initiatives or projects prior to their implementation in rural communities. This assertion was corroborated by a District Assembly officer, who affirmed that:

> *"The District Assembly is informed about every government intervention aimed at providing communities with clean energy. Once we get this information, we pass it on to the community representatives for dissemination. At times, we go to the communities ourselves to disseminate the information"* — (Kofi, January 2023).

NGOs are recognised as another vibrant actor in the districts for their efforts to provide clean energy for households. These organisations advocate for sustainable development by often facilitating community engagement and providing resources to promote initiatives in the districts. Ideally, the activities of NGOs have to be coordinated through the District Assemblies, before the actual implementation of projects in rural communities.

However, some NGOs enter the communities without prior notification of the District Assemblies. The decision not to involve District Assemblies in the interventions of an NGO can, depending on approaches adopted by the NGO, significantly impact project outcomes (Risal 2014; Bawole and Langnel 2016). District Assemblies are regarded as the ideal agents of change in rural communities, leveraging their in-depth knowledge on happenings in the communities. Therefore, the failure to involve them can hinder the successful execution of clean energy projects.

Unlike certain rural communities in SSA, private clean energy technology providers are playing key roles in providing households with clean technologies (Wassie and Adaramola 2021). Some of these providers develop, manufacture, and/or supply clean energy technologies, playing a crucial role in their deployment and adoption. Private technology providers are mostly small-scale companies and retailers who sell new technologies to households. Although they support households in meeting their energy needs, these providers are regarded to operate with profit motives.

Unsurprisingly, many of them engaged directly with households without prior notification to the District Assemblies. Even though the providers claim the products they sell are of high quality, they do not undergo any verification by the District Assembly to ensure that they meet the standards set by the Energy Commission of Ghana. Hence, households assumed the sole responsibility for product evaluation and decision-making when considering purchases. As these providers conduct house-to-house sales of their products, it is challenging for the District Assemblies to monitor their activities. According to a District Assembly official,

"It is difficult to track the activities of private clean technology providers since they do not alert the District Assembly of their entry to communities. At times, the local representatives are not even aware of their operations in their communities" – (Kwaku, December 2022).

7.1.2 Actors in action

The research further investigated the various activities that actors undertake within the communities, in their quest to enhance the adoption and utilisation of clean energy technologies. This information was sought to specifically, identify key areas where actors could improve to enhance the sustainability of clean energy initiatives. Through this investigation, the findings indicated that actors predominantly performed the following activities:

7.1.2.1 Provision of clean energy technologies

Actors were actively involved in the supply of clean energy technologies. As the districts have many off-grid and rural communities, a lot of the interventions by actors to enhance access to clean energy have targeted the provision of technologies. While the government and NGO-led initiatives come at little to no cost, the provision of clean energy technologies by private individuals and companies comes at a cost.

Furthermore, the government and NGOs tend to provide communities with larger technology interventions compared to private energy providers, who predominantly provide simple low-carbon technologies (Steel *et al*. 2016; Bukari *et al*. 2021a). A representative of a private energy company admitted that:

"The organisation is focused on the distribution of solar technologies for lighting. Its core function is to act as a retailer, selling solar technologies to households. While the organisation engages in other activities, sale of the solar products remains its primary activity within rural communities" – (Abena, January 2023).

7.1.2.2 Provision on information on clean energy

Actors, in their bid to enhance the uptake of clean energy, have also been educating households on clean energy technologies and the social and economic benefits associated with their adoption. However, this activity was not consistent as it was only undertaken when actors had a technology they wanted to introduce to the communities. A sales agent of a private solar provision company stated that:

> *"As a marketer, it is essential to talk about the products I have available for sale. Since households are usually concerned about the prices of technologies, I typically emphasise on the socio-economic benefits these products offer, such as long-term cost savings, improved energy access, and enhanced quality of life, which can offset initial price concerns and make the investment more appealing"* – (Kwabena, February 2023).

This sentiment was shared by many actors. Thus, the information they provide to households is generally limited to the social and economic benefits of the available clean technologies. However, this leaves the environmental impacts of transition, an aspect that is overlooked, as less emphasis is placed on the ecological benefits associated with the adoption of clean technologies.

Although the District Assemblies have Environmental Health and Sanitation Departments capable of championing the education of households on energy-environment issues, these departments are under-resourced, making it challenging for them to effectively execute this mandate (Agyemang-Badu *et al*. 2023). Consequently, information on the environmental benefits associated with clean energy solutions has not been efficiently disseminated to rural households. In support of this, some actors explained that:

> *"While clean energy technologies offer environmental benefits, it is essential to prioritise the cost and quality of the products, as these are the primary factors households evaluate when deciding the energy source to use"* – (Yaw, October 2022).

> *"Clean energy providers need not stress on the environmental benefits of their technologies. Emphasising on environmental benefits will result in low acceptance, as this aspect is not of primary concern for most households*" – (Akwasi, December 2022).

Some actors also attributed this limited focus on the environmental benefits of newer technologies to the perceived low literacy levels among rural dwellers, suggesting that households may find it difficult to understand the environmental benefits associated with their use. Although non-formal environmental education is known for its efficacy to increase environmental awareness, actors, have to bear the additional cost for such activities. This, consequently, creates a disincentive to some actors, particularly private energy providers (Zikargae 2021; Zikargae *et al*. 2022).

Among the few actors who emphasised the environmental benefits associated with clean energy technologies in their engagement with households, some stated that there was a general lack of interest from households. Hence, these actors, have started to deprioritise environmental benefits in favour of more tangible and short-term gain, since that resonates more directly with the concerns of households. An actor involved in the implementation of clean energy projects stated that:

"The environmental benefits associated with clean energy technologies are less emphasised during the implementation of clean energy projects. This is because rural households are indifferent toward such benefits. As a marketer, I have to tell potential buyers the things they find relevant, rather than highlighting the things they consider 'irrelevant', such as the environmental benefits" – (Kwadwo, November 2022)

7.1.2.3 Provision of technical assistance

For a successful operation of certain technologies, assistance of some actors is essential, specifically from those who provided the technologies (Hassan *et al*. 2014). This is another activity that actors engage in at the community level. Technical assistance from actors comes in forms such as installation support, operational support, maintenance and repair and customer service. Some actors have offices in the district capitals, allowing households to visit in case they need technical support. Other actors also make visits to communities, giving households the opportunity to address their technical needs directly. Officers of the District Assemblies acknowledged that:

"*Actors primarily engage in the provision of clean energy technologies and the delivery of technical support to households. Specifically, NGOs that provide households with clean energy technologies conduct monitoring visits to evaluate the efficacy of the technologies and repair any malfunctioning units*" – (Ama, October 2022).

"Actors move beyond the provision of clean energy technologies to offering households with relevant information and technical support on clean energy technologies. This has contributed to increased household awareness of clean solutions" – (Akua, December 2022).

The findings suggest that the efforts of actors, at the community level, are concentrated on the provision of clean technologies, dissemination of information on the technologies and delivery of technical assistance. These activities, if efficiently performed, are likely to enhance the uptake of clean energy technologies (Acharya and Marhold 2019; Agyarko *et al*. 2020; Qadir *et al*. 2021).

Despite households expressing concerns about the unaffordable prices of clean energy technologies, provision of financial assistance for households was not a major activity performed by actors. This implies that the current efforts of actors may be insufficient to facilitate households' transition to clean energy technologies, especially when a major barrier impeding their access, such as cost, is not prioritised in their strategies.

7.1.3 Collaboration among actors

The lack of unity in purpose in renewable energy transition is according to Tettey *et al*. (2025), a critical challenge to attaining transition objectives. For instance, collaboration with some key government agencies, such as the Ministry of Energy and the Energy Commission of Ghana, can provide an avenue for actors to streamline their activities, in accordance with the national regulatory framework (Ambole *et al*. 2019; Sanderink and Nasiritousi 2020; Sorman *et al*. 2020; Singh and Ru 2022). Hence, the failure of actors to collaborate with these government agencies could impede their application of the regulatory frameworks that guide the country's clean energy transition.

If actors do not have adequate knowledge on these regulatory frameworks, then the strategies they deploy, regardless of how comprehensive they are, might not align with the policy directives, which can potentially marginalise some vulnerable groups in the long term (Nsafon *et al*. 2023). This highlights the need for collaboration among actors in the energy sector.

However, in line with Francis *et al*. (2022), the findings reveal that there is a minimal level of collaboration among the three primary actors involved in the transition to clean energy. The few actors, who have maintained a level of collaboration with government agencies, like Ministry of Energy and the Energy Commission of Ghana, expressed concerns about pertinent issues that make it seemingly difficult to continue engaging with them.

A primary concern raised is the perceived polarised nature of these institutions. They explained that the agencies have political goals which in most cases, supersedes the interests of other actors. This dynamic makes it challenging for other actors to effectively influence national policy design and implementation processes (Akwei *et al*. 2020). Thus, the ideas of other actors, regardless of how relevant they are, are not considered in the decision-making process, particularly if the ideas do not align with the political goals.

Consequently, some actors showed a decline in interest to engage with these institutions, something which can hamper a sustainable energy transition. Building on these observations, scholars like Burke and Stephens (2017), Feldpausch-Parker *et al.* (2019) and Szulecki and Overland (2020) advocate for the concept of energy democracy. This concept emphasises the role of inclusion in energy transition, thereby advocating for all actors to have a voice in the transition process.

On the contrary, the study found a notable trend of improved levels of collaboration among NGOs. This could potentially result from their non-profit status and their development-oriented perspective, complementing the state/government in service delivery (Kwao and Amoak 2022). The NGOs involved in energy transition periodically organise and participate in seminars and conferences, where they share best practices and project outcomes with one another.

This collaborative environment reflects their shared commitment to promote the transition of households to newer technologies. A typical example is the annual energy conference organised by the Africa Centre for Energy Policy (ACEP), an NGO committed to promoting renewable energy transition in Ghana and other African countries (Africa Centre for Energy Policy 2024).

With regards to cooking fuels, there is the notable presence of the Ghana Alliance for Clean Cookstoves and Fuels (GHACCO), which is comprised of various actors (e.g. CSOs, NGOs, private producers, distributors, financial institutions, researchers, community-led organisations) championing the distribution of clean cooking technologies. GHACCO aims to facilitate actors to share best practices and build the capacity of actors, particularly in the clean cookstove sector. This insight was shared by a representative of a company that is engaged in the deployment of improved cookstoves to vulnerable communities:

> *"We take advantage of the seminars organised by GHACCO and the platform the alliance has created for actors to exchange best practices. This has been instrumental in helping us devise strategies to enhance the uptake of improved cookstoves"* – (Ama, December 2022).

The study however, found no similar alliances among clean energy providers focusing on lighting solutions. Consequently, private energy providers involved in clean energy for lighting, have limited collaboration among themselves. This phenomenon could result from their profit-driven objectives. Some private providers refrain from collaborating with others with the view that competitors may adopt their strategies to make a profit at their expense, particularly in a perfectly competitive market context. A private provider highlighted this sentiment:

"I do not share the approach I use to distribute solar technologies with other providers, neither do they share their methods with me. If I happen to come across an approach that I believe is effective, I adopt and apply it" – (Kwame, January 2023).

Despite District Assemblies being close to rural communities and having in-depth knowledge on the energy situation of rural households, the study found that NGOs do not involve the District Assemblies in the conceptualisation of projects. Therefore, District Assemblies become aware of energy projects after funding has been secured by the NGOs and the project is at the implementation stage.

This situation, where NGOs fail to involve District Assemblies from the project ideation phase, was due to the personal and political ambitions of some key officers in District Assemblies. In many cases, these personal ambitions diverge from grassroots preference, which is the focus of NGOs (Debrah 2016). This lack of early engagement often results in non-cooperation or minimal commitment from the District Assemblies, as noted by a District Assembly officer:

"Some NGOs only involve the District Assembly during the implementation of their projects. However, the District Assembly can contribute much more if involved from the ideation stage of the project, rather than just engage us when the project is being implemented" – (Yaw, February 2023).

7.2 Actor engagements

To examine the interaction between actors and rural households, and how these interactions can impact households' decisions to adopt clean energy technologies, households were asked to rank their level of agreement with the following statements: "Actors are in constant communication with you" and "interaction with actors has influenced your adoption of clean energy technologies". This helped to quantify the frequency of actor-household interactions and how this interaction influences households' decisions to adopt clean energy technologies.

On a scale of 1 to 5, with 1 being strongly agree and 5 being strongly disagree, 37% of households indicated that actors are not in constant communication with them, while 30% of households disagreed, stating that actors are in constant communication with them. Regarding how interaction with actors has affected the adoption of clean energy technologies, some households (34%) admitted that their interaction with actors has influenced their adoption of clean energy technologies, with a few (17%) disagreeing with the statement. The results of a Kendall's W test, examining households' agreement with the statements showed, x^2 (1, N = 419) = 56.178, K= 0.134 (Table 7.1).

Table 7.1: Households' interactions with actors

Variables	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	Kendall's W
Actors are in constant communication with you	2.4%	27.9%	32.9%	32.0%	4.8%	3.089	
Interaction with actors has positively influenced your adoption of clean energy technologies	2.1%	32.0%	49.4%	16.0%	0.5%	2.807	0.134

The lack of constant communication between households and key actors – whether verbal, non-verbal or mass media – implies that some households likely have inadequate information on clean energy transition (e.g. technologies, policies, laws and regulations) – as highlighted by Bishoge *et al*. (2020). The empirical results further showed a noticeable disagreement among households regarding the level of communication with actors and its impact on their adoption of clean energy technologies. That is, while some households agreed that they have constant communication with actors which has positively impacted their adoption of clean energy solutions, a significant number of households disagreed, emphasising the need for a more structured, inclusive and multilevel communication strategies (Lindgren 2020; Haque *et al*. 2021).

7.2.1 Impact of actors' communication on household current energy preferences

The empirical results further showed insights into the relationship between households' communication with actors and their current choices of energy for cooking and lighting. Regarding the choice of clean and unclean energy sources, the results indicated that a significant number of households are unable to translate their communication with actors to their choice of clean energy.

For instance, half (50%) of the households that strongly agreed that they had constant communication with actors used unclean fuels for lighting. Surprisingly, none of the households that strongly agreed that they have constant communication with actors used a clean energy source for cooking. A chi-square analysis of the relationship between households' choice of energy source for cooking (4, N = 419) = 1.315, p > .05 and for lighting (4, N = 418) = 2.207, p > .05, however, showed no significant relationship (Table 7.2).

Table 7.2: Association between communication with actors and households' choice of energy sources (clean and unclean)

Variable	Actors are in constant communication with you	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Total	P-value
Light	Clean	5	66	75	83	11	240	0.698
	Unclean	5	51	63	50	9	178	
	Total	10	117	138	133	20	418	
Cooking	Clean	0	1	1	0	0	2	0.859
	Unclean	10	116	137	134	20	417	
	Total	10	117	138	134	20	419	

The results demonstrate that while some households are able to reflect their communication with actors on their current choice of clean energy sources, other households are unable to do the same and therefore, continue to use unclean energy sources. This indicates that whereas actor interaction is vital, the quality and nature of the interaction may differ. Such a situation could impact households' energy decisions differently, as noted by Lindgren (2020).

The choice of many households to use unclean energy sources for cooking, despite their regular communication with actors, underscores the overwhelming presence of actors promoting clean lighting solutions and the focus of their communication – socio-economic benefits of technologies. Placing greater emphasis on the environmental benefits of clean technologies could enhance households' appreciation of the broader role of clean energy solutions. This understanding may influence their decision-making and encourage the adoption of cleaner cooking energy sources.

The results further suggest that the constant communication actors have with households do not significantly influence their current choices of energy solutions. This implies that although constant communication with actors might be vital in the adoption of clean energy technologies, other factors may play more significant roles in households' energy decisions (Adenle 2020; Hansen and Xydis 2020; Wassie *et al*. 2021).

7.2.2 Methods of household engagement with actors

Engaging with off-grid rural communities is challenging, particularly when their lack of access to electricity limits their access to digital information via technologies, such as radios, televisions and mobile phones (Hirmer and Guthrie 2017). The study, therefore, explored the methods households employed to reach actors.

This involved identifying the channels of communication used by households to connect with District Assemblies, NGOs, and private clean technology providers. The empirical results revealed that many households are able to reach actors by visiting their offices (82%). A considerable number of households also reached clean energy actors during community visits (77%). On the other hand, only a few households reached actors through telephone calls (5%) (Table 7.3).

Table 7.3: Methods used by households to reach actors

Methods	Number of occurrences	Percent of cases
Telephone/mobile phone	21	5.01%
Office visits	345	82.34%
Community visits	322	76.85%

Multiple responses were allowed.

The findings indicate that households do not often resort to the use of telephones or mobile phones in contacting actors. This may be as a result of their non-connection to the national electricity grid, which complicates the use of certain electrical appliances for communication. Access and use of these technologies in off-grid rural communities is known to improve communication and enhance banking access, which can contribute to the uptake of clean energy technologies (Nique and Opala 2014; Hirmer and Guthrie 2017; Hellmuth *et al*. 2019).

Even though some solar technologies can charge mobile phones, the results suggest that only a few households had access to such technologies. Baurzhan and Jenkins (2016) highlighted that solar technologies capable of charging mobile phones are costly, posing a significant barrier to their affordability for impoverished rural households. Moreover, some rural communities, as noted by Tognisse *et al*. (2021), lack stable network connectivity. This situation further reduces the attractiveness of the use of mobile phones for some rural households.

While many households reached actors through office visits, this method came at a cost to them as the offices were mostly located in the district capitals, which are usually far from rural communities. Consequently, these rural households have to incur transportation costs if they need to visit the offices of these actors. This situation could serve as a disincentive for households' adoption of clean energy technologies.

As recognised by Nuru *et al*. (2021), the establishment of technical offices in island or isolated rural communities is essential for the deployment of mini-grids, as it enhances the resolution of technical problems. Similarly, the presence of offices in the study communities is equally crucial in the deployment of simple clean energy technologies. Having offices in communities would make it easy for users to get access to technical support when needed.

Community visits are the most productive means for households to reach actors, as it comes at no cost to households. These visits by actors are known to drive participation in energy programmes and promote the uptake of new technologies (Shoemaker *et al*. 2018). However, actors do not visit the communities regularly. Some actors, particularly private providers, move from one community to another to sell their technologies. This implies that households relying on community visits to engage with actors may experience longer waiting periods.

7.2.3 Household satisfaction with actors' interactions

Constant relationship with actors, when associated with household satisfaction, promotes the adoption of clean technologies, by fostering trust, enhancing communication and providing support and information (Shoemaker *et al*. 2018; Goggins *et al*. 2022). The study therefore explored households' level of satisfaction with the relationship with actors. A number of households (36%) expressed dissatisfaction with their relationship with actors. Conversely, some households (39%) expressed satisfaction with the relations they have with actors (Table 7.4).

Table 7.4: Households' satisfaction with social relations with actors

Variables		Occurrences (N = 415)	Percent of cases
Satisfaction with relations with actors	Completely satisfied	15	3.6%
	Moderately satisfied	150	35.8%
	Somewhat satisfied	100	23.9%
	Moderately dissatisfied	86	20.5%
	Completely dissatisfied	64	15.3%

The empirical results suggest that not all households are satisfied with the relations they have with actors. This emphasises the need for actors to develop strategies aimed at improving their relationship with households. A good relationship, can among other things, recognise the customs and traditions that reinforce the fabric of rural communities. This would enhance household satisfaction and involvement in the transition process.

However, it is important that the recognition to the customs and traditions of rural communities goes mere acknowledgement to also, incorporate the views of households in the planning and implementation of clean energy projects. This act can promote inclusivity in clean energy solutions, which is associated with household satisfaction with actors engagement, and regarded as vital in attaining transition objectives (Lemaire 2018; Tesfamichael *et al*. 2020; Mukisa *et al*. 2022).

7.3 Household engagement in the transition process

Despite the role household involvement in the transition process plays in the adoption of clean technologies, rural households indicated their limited engagement in the identification of their specific energy challenges, and in the design or production of newer technologies. Actors often assume that the problems rural communities face are homogenous across different scales. Therefore, a single solution or technology was deemed sufficient to address energy access issues of communities.

Consequently, the technologies actors deploy in various communities are generally uniform. This approach by actors, fails to contextualise clean energy solutions to the unique energy challenges of individual rural communities, which presents a challenge towards an energy transition (Broto *et al*. 2018; Heffron and McCauley 2018; Heiskanen *et al*. 2022). An actor admitted in an interview that:

"I agree that engaging households in the identification of energy challenges and the design of solutions/technologies would significantly improve the development of sustainable solutions. However, it would be challenging for us to do so, as our role is limited to importing and distributing clean technologies" – (Kofi, October 2022).

Actors involved in the deployment of clean technologies in rural households often rely on imports. Like other African countries, a significant number of the clean solutions, especially solar technologies, are imported from China (Jackson *et al*. 2021). This reliance on importation inhibits actors' disposition to involve households in the design process of the technologies, since they do not have control over it.

However, actors in their quest to meet the energy needs of rural households, emphasised their commitment to procure technologies that they believe are both affordable and meet the quality standard set by the Energy Commission of Ghana. A private energy provider stated in an interview that:

"The solar technologies deployed in our project communities are of high quality and really affordable. The company monitors the market to source the best and most affordable technologies for rural communities, recognising that the residents are relatively poor" – (Afua, December 2022).

Consequently, actors typically engaged households only after they had identified and imported the clean energy technologies they plan to deploy in rural communities. That is, households were usually involved at the implementation stage of the transition process. At this point, households are introduced to the products and informed about the associated benefits.

Involvement of households at the implementation stage is usually a marketing strategy for actors to facilitate the uptake of the new technologies by rural households. During this phase, actors take products to rural communities to advertise, with the goal of encouraging households to purchase them. As a result, households are treated primarily as consumers, a practice that is criticised as being unjust in the transition process (Bartiaux *et al*. 2018; McCauley *et al*. 2019; Droubi *et al*. 2022).

Continued engagement with households, after the adoption of technologies, is also considered relevant in enhancing access to clean energy. This can be likened to the principles of monitoring and evaluation, which contributes to the sustainability of clean energy projects (Radovanović *et al*. 2021). Engaging households to evaluate the benefits and challenges associated with their adoption can help actors in the design and implementation of subsequent projects.

Despite acknowledging the relevance of post-implementation visits, not all actors, especially private providers, conduct follow-up visits to the communities they have implemented projects. That is, after the implementation of projects, actors visit rural communities less frequently than they did prior to households' adoption of the technologies. A private solar technology provider noted:

> *"I am constantly on the move from one off-grid community to the other. While I agree that it is necessary to get feedback from buyers, I rarely visit the communities after selling the products. I, however, give my number to households so that they can contact me if they encounter any problem"* – (Kwaku, January 2023).

7.3.1 Household engagement and adoption of clean technologies

Ruiz-Mercado and Masera (2015) and Agyarko *et al*. (2020) highlight the significant roles households can play in the planning and implementation of a project and how these roles impact their adoption of cleaner technologies. This involvement ensures that households receive the requisite information and technical support, whilst enabling actors to address the specific concerns of rural households.

The study therefore assessed the likelihood of households to adopt new technologies, if involved in the transition process. Many households (83%) admitted their likelihood to adopt cleaner technologies, if actively engaged in the transition process, from problem identification to implementation. Only a few households (7%) disagreed that such involvement would likely affect their adoption of these technologies.

Moreover, many households (77%) valued the role information and technical support plays in the adoption of clean technologies, agreeing that they are likely to adopt the technologies if they have access to information and technical support. The results of a Kendall's W test examining households' agreement with the statements showed, x^2 (1, N = 419) = 23.211, K= 0.055 (Table 7.5).

Table 7.5: Households' likelihood to adopt clean energy technologies

Variables	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	Kendall's W
Households are likely to adopt clean technologies if involved in the transition process	43.2%	39.6%	10.5%	6.2%	0.5%	1.811	0.055
Households are likely to adopt clean energy technologies if there is adequate information and technical support	24.1%	53.0%	20.3%	2.6%	0%	2.014	

In line with Ruiz-Mercado and Masera (2015), Cloke *et al*. (2017), Agyarko *et al.* (2020), Baxter *et al*. (2020), Sovacool (2021a) and Boateng *et al*. (2023a), a significant number of households indicated their likelihood to adopt modern technologies, if involved in the transition process. This involvement of households entails their active participation in all phases of the transition process and acknowledging their perspectives in the decision-making process.

Additionally, the active participation of households, such as involvement in decision-making, can provide actors with the requisite information to contextualise clean energy initiatives, to suit the specific needs of rural communities as transitions "play out in different ways across contexts and scales" (Sareen and Haarstad 2018, p. 630). Active household participation in energy transition can thus, ensure inclusive decision-making, while acknowledging local needs. This can in turn, address procedural and recognition injustices, thereby enhancing the uptake of modern technologies (Cantarero 2020; Zulu *et al*. 2022).

The findings further emphasise the need to provide households with adequate information and technical support, as this is intricately linked to their adoption of clean technologies (Mfune and Boon 2008; Hellmuth *et al.* 2019). In many cases, the withdrawal of technical assistance by actors makes it challenging for households to sustain the use clean energy technologies. It can be argued that if households do not receive the technical assistance they need after purchasing a new technology, then they are likely to lose trust in actors. As noted by Zulu *et al*. (2022), this mistrust in actors is likely to lead to low uptake of clean solutions.

The findings, based on the Kendall's W analysis, also suggest that while many households perceive that their involvement in the transition process and their access to adequate information and technical support influence adoption of clean technologies, others do not share this view. Thus, there is a low level of agreement among households regarding the potential influence of their involvement in the transition process and access to adequate information and technical support on their adoption of new technologies

This underscores the imperative for actors to have a comprehensive and holistic approach to energy transition. Such an approach needs to consider a range of factors, including the social and technical dimensions. The findings reemphasise the need for actors to intensify their efforts in the transition process, by more actively involving households and providing them with support and information on clean energy.

7.4 Household views on cost and the motivation of actors

Since investment in the energy sector is regarded as a profitable venture, which could be exploited by actors at various levels for profit (Goldthau 2017; Goddard and Farrelly 2018; Van den Heuvel and Popp 2023), the study explored the perception of households on the cost of clean energy technologies. It also examined how households perceived the transition process and the motivation of some actors to engage in the provision of clean energy technologies.

7.4.1 Household perceptions of costs for switching to clean technologies

The empirical results showed that many households view the prices of new technologies as expensive (88%), while only a few consider them to be affordable (3%). Following the high costs of clean energy technologies, as reported by households, a substantial number of them (59%) admitted that actors are taking advantage of the transition process to make profit, while a few (7%) stated otherwise (Table 7.6).

Table 7.6: Households' perception of the cost of clean energy technologies

Variable	Category	Percent of cases, N = 412
Description of the cost of obtaining clean energy technologies	Very expensive	28.2%
	Expensive	59.7%
	Moderate	7.9%
	Affordable	2.4%
	Very affordable	0.2%
Actors are exploiting transition for profit making	Strongly agree	18.1%
	Agree	41.1%
	Neutral	33.7%
	Disagree	5.3%
	Strongly disagree	1.4%

The empirical findings indicate that the prices of clean energy technologies are generally high for households. The poor economic situation of rural households, coupled with the perceived high cost associated with obtaining clean energy, makes it challenging for them to afford the transition. This finding suggests the need for actors to take proactive measures to address affordability challenges. Making the technologies more affordable, could play a key role in promoting adoption and transition, especially in underserved communities (Acharya and Marhold 2019; Guta 2020; Twumasi *et al*. 2021; Wassie *et al*. 2021).

The empirical findings further imply that households perceive actors to be benefitting financially from the transition process, often at their expense, as they find the associated prices as expensive. Although actors, particularly private providers, seek to make a profit from their investment, it is essential to ensure that this quest does not supersede the environmental and developmental needs of rural communities.

Achieving this objective would be challenging, especially when private investors are in most cases, driven by profit motives. This therefore necessitates actions to mitigate exploitation by actors while addressing the developmental challenges of rural communities. The concept of energy communities aims to address this by serving multiple purposes concurrently –

addressing the energy, environmental and developmental challenges of households (Walsh *et al*. 2020; Interreg Europe 2022).

Since private providers are among the vibrant actors and are generally regarded to be motivated by profit, it was important to gain insights of their perspectives on the transition process as well. Through interviews, the study explored their motivations and identified the major challenges they faced, with the goal of acquiring understanding of the private sector's role in promoting energy solutions in rural communities.

7.4.2 Private energy providers: motivations and challenges

Despite the assertion that private companies are reluctant to provide rural communities with energy access because of households' low-income levels, low purchasing power and low consumption levels (Sovacool 2013), findings from this study suggest otherwise. Private clean energy providers were active in rural communities, demonstrating a strong presence While profit might play a key role in their involvement in the transition process, it is important to recognise the policymaking, supply and manufacturing roles of private energy providers in addressing rural energy needs (Sovacool 2021b).

Some private providers stated that they are very flexible in their dealings with rural communities due to the economic challenges households face. A representative of an energy company that specialises in the provision of improved cookstoves, noted that:

> *"The prices of our technologies are very affordable and discounted at times since the materials used in their production are mainly sourced in Ghana. We also have payment plans for households that are unable to make a lump-sum payment for the products."* – (Adwoa, December 2022).

The energy providers acknowledged that households are genuinely interested in and willing to transition to new technologies, affirming that the energy sector presents an economically viable investment opportunity. While stating that they provided the cheapest technologies on the market to rural communities, these providers admitted that cost remains a significant obstacle preventing households' adoption (Acharya and Marhold 2019; Twumasi *et al*. 2021; Wassie *et al*. 2021).

The economic situation of rural communities has made some private providers to, occasionally, shift focus to target urban communities, where there is greater financial stability. While asserting that cost was also a challenge for some urban households, as noted by Adams *et al*. (2023), private providers specified that it was minimal in comparison with rural communities. A representative of one company stated that:

> *"Even though the target beneficiaries are rural households, the prices of clean energy technologies make it challenging for some households to adopt them. Consequently, the target is gradually shifting towards urban households"* – (Kwame, October 2022).

In view of this, some private providers have payment plans for households that cannot afford to make a lump-sum payment. However, these providers raised concerns about the failure of some households to adhere to the payment plans for their loans. This advances the discourse on affordability metrics, as raised by Gill-Wiehl *et al*. (2021), where they recommended that affordability should not be over-simplified. They argued that affordability ought to, among other things, consider the actual income of households in order to ensure a sustained transition to clean energy technologies.

The inability of some households to pay back their loans has caused some providers to cancel the payment plan initiatives they have for households, particularly those without stable or regular income streams. The cancellation of payment plans has made it more challenging for many rural households to access clean energy technologies, especially as many of them are characterised by incomes that are low, inconsistent and hard to predict (Gill-Wiehl *et al*. 2021). A representative of a private provider stated that:

> *"Although the payment plans facilitate the adoption of clean technologies, the company does not offer these plans to all households due to the failure of some to pay for the full cost of the product. Personally, I do not support the use of payment plans since it is often difficult to recover funds from households after giving them the products"* – (Abena, January 2023).

Tradition and culture of rural households is another major challenge to household adoption that was identified by private providers. Lin and Kaewkhunok (2021) consider this as a significant factor affecting some households and their decision to adopt new technologies. This barrier was typically raised by actors involved in the provision of improved cookstoves, as households remain comfortable with their use of woodfuels. They affirmed that rural households face no difficulties with regards to accessing traditional fuels for cooking, unlike for lighting (Bawakyillenuo *et al*. 2021; Boateng *et al*. 2023b).

Consequently, a shift from the use of traditional fuels to adopting improved cookstoves, LPG and other clean alternatives for cooking, is perceived as a luxury for some households. This makes it challenging for them to adopt cleaner technologies for cooking, even when they have the financial means to do so. A representative of a private company involved in distributing clean technologies indicated that:

> *"Transitioning rural households from the use of traditional fuels to improved cookstoves is extremely difficult. Many households are culturally attached to woodfuels, which are able to effectively meet their cooking needs. As a result, they are not seeking alternative sources, whether clean or unclean"* – (Afua, October 2022).

Conclusion

This chapter has demonstrated that both state and non-state actors play critical roles in Ghana's clean energy transition. It highlights a lack of cohesion, particularly among District Assemblies and NGOs. Despite calls for unity in achieving energy transition, competition among private clean energy providers hindered collaboration. Overall, limited collaboration among state and non-state actors was identified. Although households recognised that their active participation in the transition process can facilitate adoption, actors did not involve them in all phases of the process.

The findings reveal procedural and recognition injustices at multiple levels. At the local level, some households were excluded from the decision-making process, while at the national level, certain non-state actors were similarly unrecognised. Various forms of exclusion – process, structural, and poststructural – were also identified. Although political decentralisation plays a role by getting District Assemblies closer to households through unit committees, polarisation among these state actors hindered effectively collaboration with non-state actors. These exclusions and injustices contribute to the high cost of clean technologies, making households perceive private clean energy providers as exploiting the transition process for profit.

The empirical results of the research, as presented in Chapters 5, 6 and 7, have investigated the energy decisions of off-grid rural households, households' perspectives on the energy-environment-livelihoods nexus, and synergy between actors and households in advancing low-carbon solutions. A summary of the detailed information contained in these chapters is provided in the following chapter.

8. KEY INSIGHTS AND FINDINGS

The Green Revolution demonstrated how technological advancements, policies and investments aimed at improving societal well-being can inadvertently lead to social exclusion, underscoring the need to carefully manage clean energy transition to avoid similar outcomes. By focusing on simple/mundane low-carbon technologies, this research, as presented in Chapters 5, 6 and 7, has examined low-carbon energy transition in off-grid rural Ghana.

The research began by asking the following research questions: What are the connections between the concepts of energy justice, socio-technical transitions, just energy transition and political ecology? How can energy decisions of rural households be explained? What are households' perspectives on the energy-environment-livelihoods nexus? Who are the key actors in the low-carbon transition, and what strategies do they employ to improve access?

A range of primary and secondary sources were used to address these research questions. In answering the first research question, secondary data sourced from published literature were used, while primary data were used to answer the remaining three research questions. This chapter provides a synthesis and summary of the research findings.

8.1 An integrated approach for a comprehensive insight

The study identified a linkage between the concepts of energy justice, STT and political ecology. It further advances a novel framework (PESET) that serves as a connection between the concepts, with the aim of providing a blueprint for promoting the adoption of low-carbon technologies in the Global South. The PESET framework uses political ecology as a wider framework to incorporate STI and energy justice to attain just energy transition objectives.

In a situation where countries in the Global South are regarded as the beneficiaries of clean energy technologies that are produced in developed and emerging economies, there is a likelihood of these technologies being imposed on vulnerable households in the region. Such a situation can perpetuate the notion that advanced environmental knowledge emerges from the Global North and is subsequently transferred in the Global South. This may foster paternalism, where the liberty of some countries and groups is limited, under the guise of promoting clean energy technologies.

The PESET framework therefore provides a better, more inclusive and sustainable approach to clean energy transition. This framework is particularly important for an energy transition, particularly in the Global South context. The applicability of the framework aims to address the energy challenges that households face and thereby, encourage the use of cleaner technologies. It further identifies energy transition as an issue of justice and recognises its likelihood to worsen the conditions of marginalised households and communities, especially if the process is not properly implemented – for further details, refer to Chapter 2.

Using this novel political ecology approach to examine energy transition in rural Ghana, the research addressed three key aspects of the transition: the what (energy access in off-grid rural Ghana and strategies to enhance clean energy adoption), the why (reasons behind rural households' selection of a particular energy type) and the so what (the impacts of a low-carbon transition on the lives of rural households). Summary of these findings are presented below.

8.2 Household energy decisions in off-grid rural Ghana

The findings have shown that rural households utilise a mixture of clean and unclean energy sources, both for lighting and for cooking. However, it was evident that despite many households utilising cleaner technologies for lighting, they failed to do same for cooking purposes. So, for cooking purposes, households predominantly relied on woodfuels (firewood and charcoal). Many households that used clean energy technologies for lighting, also failed to exclusively use these technologies and therefore, complemented them with unclean sources like non-rechargeable battery-powered torchlights.

The findings indicated that energy choices in rural Ghana are shaped by interplay of political, economic and social factors. Since households had access to a multitude of energy sources, they considered availability, cost and reliability as very important factors, whilst ranking accumulated knowledge and environmental impact as less important factors, in selecting an energy source. It is based on these factors that households selected their principal energy sources. Households principally used PV lanterns/solar torchlights and non-rechargeable battery-powered torchlights for lighting, and woodfuels for cooking. Females played a key role in collecting woodfuels and cooking for households, indicating the gendered roles in cooking energy access in rural households.

The research further highlighted that the provision of clean energy sources in rural communities is politicised at times. If political actors, who are responsible for the wellbeing of households, fail to view energy access as a right, then such attitude is likely to reverberate through other actors. Distributive and procedural injustices were also evident in the clean energy transition process. A situation where households' energy access is not regarded as a right by duty bearers and where energy injustices persist, puts the achievement of a universal access to clean and affordable energy beyond reach – for further details, refer to Chapter 5.

8.3 Households' perspectives on the energy-environment-livelihoods nexus

The findings showed that many actors are engaged in the provision of lighting solutions, reflecting their focus on the energy demands of households for lighting. The types of clean energy interventions and the varying levels of actor involvement indicate institutional unevenness, with some actors being more active than others. The strong presence of private clean energy providers and NGOs in rural communities further highlight the influence of neoliberalism in rural energy access.

The findings suggest the need for a transition to clean energy not to be viewed solely as a technological issue. While households were aware of clean energy interventions, various economic and social factors inhibited their adoption of clean technologies. Additionally, not all households had knowledge on the relationship between energy choices and their environmental impacts. The inability of households to establish this link may lead them to consider environmental impacts as insignificant when selecting an energy source – implying that, households would likely choose not to shift from the use of unclean fuels.

The findings also underscore the need to recognise that clean energy transition is not universally beneficial, as the introduction of new technologies has the potential to negatively impact households. For instance, some households admitted that a complete transition to clean energy can increase income and improve health, whilst also being capable of reducing income and increasing expenditure. Even though the positive impacts have the potential to enhance households' adoption of clean technologies, the negative expectations can cause otherwise. Additionally, the economic ties households have with the production and sale of unclean fuels can further, intensify their decision not to make the shift to clean solutions. More specifically, the production and sale of charcoal was found to be a source of income for some rural households – for further details, refer to Chapter 6.

8.4 Actor and household synergy in advancing low-carbon solutions

The research highlighted that access to energy is shaped by both the state and non-state actors who often make key energy decision, such as where to implement projects, who benefits and who is left out. Even though the District Assemblies function as representatives of the government at the district level, many actors bypassed them when implementing projects in rural communities. Aside from the government that has representatives at the community level, few actors had permanent presence in the communities and therefore, only visited the communities when they had interventions to implement.

Despite the crucial role engagements among actors play in the successful implementation of projects at the community and household levels, there was a minimal level of collaboration among actors. The findings revealed that competition existed among private clean energy providers, driven by concerns that competitors might replicate their strategies for profit, especially in a perfectly competitive market. Similarly, actors did not actively involve households at all levels of the transition process. Households were mainly involved at the implementation stage of projects and thus, limiting their role in the transition process to that of mere users of clean technologies.

The findings uncovered other forms of injustices and exclusions in the clean energy transition process. For instance, some households were excluded from the structural and poststructural aspects of the transition. Procedural and recognition justices were identified at the household and national levels, where the perspectives of some households and actors were disregarded in decision-making process. These exclusions and injustices, combined with the limited financial support provided from actors, made it challenging for poor rural households to access clean technologies – for further details, refer to Chapter 7.

9. CONCLUSION – FROM INSIGHTS TO ACTIONS

Using the PESET framework to examine low-carbon transition in off-grid rural Ghana, the findings revealed that low-carbon technologies have been introduced in rural communities to address the energy needs of marginalised or excluded households, implying that there is the inclusion of intention. Yet, while households may contribute to identifying energy-related challenges, their perspectives are largely disregarded in the selection of these low-carbon technologies. Despite the active participation of both state and non-state actors in the clean energy transition, the exclusion of Community-Based Organisations highlights the challenges households face in voicing concerns or opposing interventions.

Consequently, access to low-carbon energy in rural Ghana is shaped by state and non-state actors, as well as affluent and well-connected residents, thereby marginalising less powerful and impoverished households. While it is difficult to determine definitive beneficiaries in this transition, it is evident that poor and politically disconnected rural households are the primary losers, as the findings uncovered multiple forms of injustices and exclusions faced by households (Fig. 9.1).

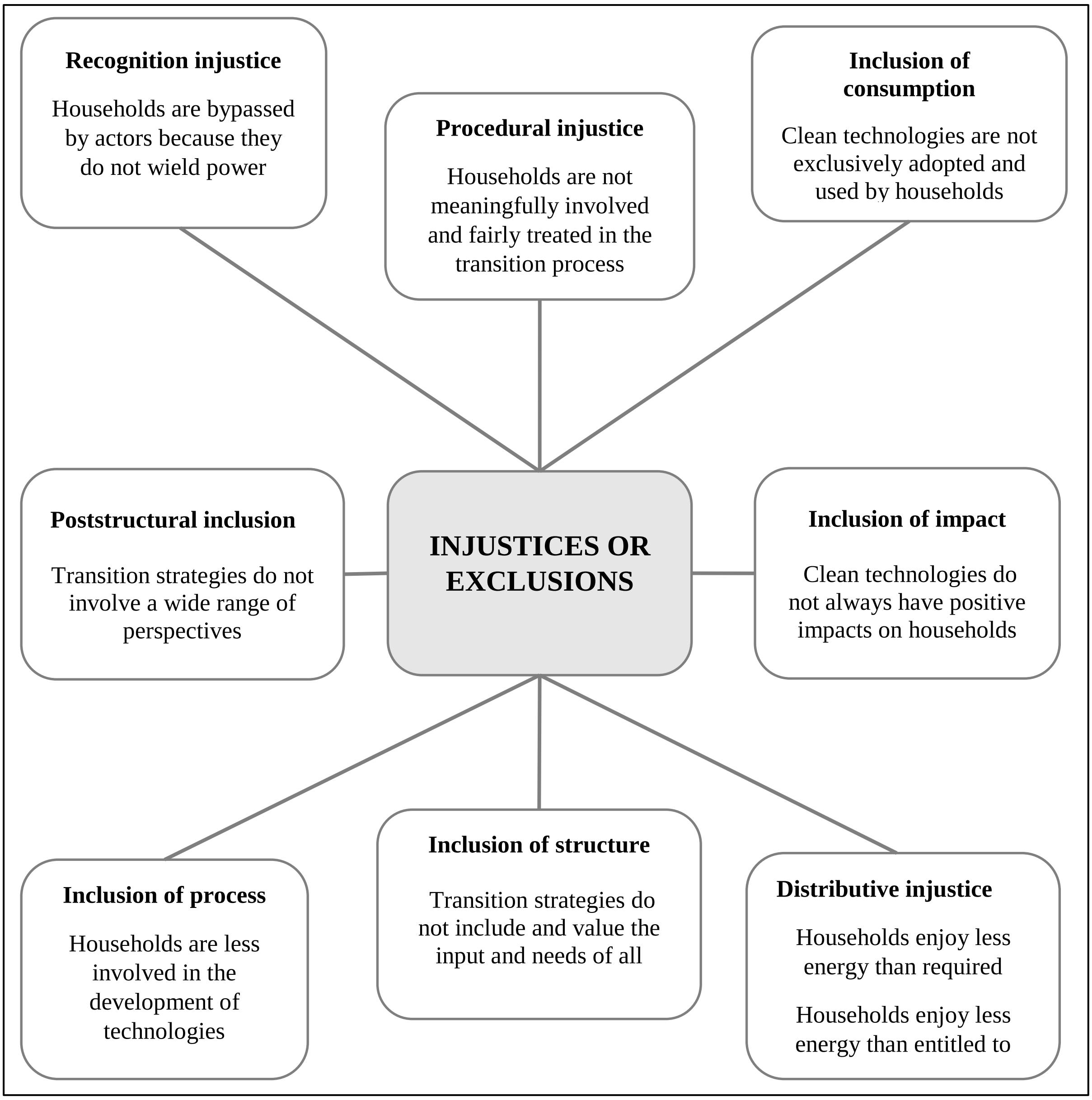

Fig. 9.1: Forms of injustices/exclusions identified in low-carbon energy transition

(Source: Author's construct).

Thus, to achieve sustainable energy transition in rural SSA, it is essential to address these exclusions and injustices. Recognising that energy access transcends the provision of energy resources, efforts geared towards the transition can focus on collective action and policy interventions that consider the energy situation of potential rural beneficiaries, since without thoughtful consideration, a transition can further worsen the living conditions of marginalised communities. Promoting sustainable energy transition can help generate livelihood opportunities for the growing population of SSA through the creation of new industries, while expanding existing ones. By investing in renewable energy infrastructure, SSA can achieve a more stable and reliable energy supply, which plays a crucial role in industrialisation and the region's overall socio-economic growth and development.

However, the "one-size-fits-all" approach to achieving SDG 7, particularly with regards to clean cooking fuels, is likely unattainable in rural SSA – as evident in the case of Ghana. Therefore, it is important for actors who aim to support the drive to attain SDG 7 to contextualise efforts. In the case of rural Ghana, as shown in the research, a sustainable transition to clean energy needs to address the highlighted forms of injustices and exclusions, and tackle all the barriers to adoption. These barriers constitute the "main dimensions of sustainability in energy development and consumption" – technical, social, economic, environmental and institutional dimensions (Kabeyi and Olanrewaju 2022, p. 16).

A shift to a cleaner energy transition, after these barriers have been overcome, does not imply that households will tend to use the technologies unless the transition is associated with impacts that households regard as positive. If a transition process negatively impacts the socio-economic conditions of households, they are often likely to challenge the process. Even if households fail to challenge the process now, they may in the future, likely revert to the use of their old energy sources. The findings therefore suggest that overcoming all the forms of exclusions and barriers to adoption, while ensuring that the transition process eventually results in positive impacts on the wellbeing of rural households, can enhance the uptake of clean energy technologies. This form of transition could encourage them to continue to invest in the use of clean energy technologies and hence, a pathway to energy transition that is encouraged (Fig. 9.2).

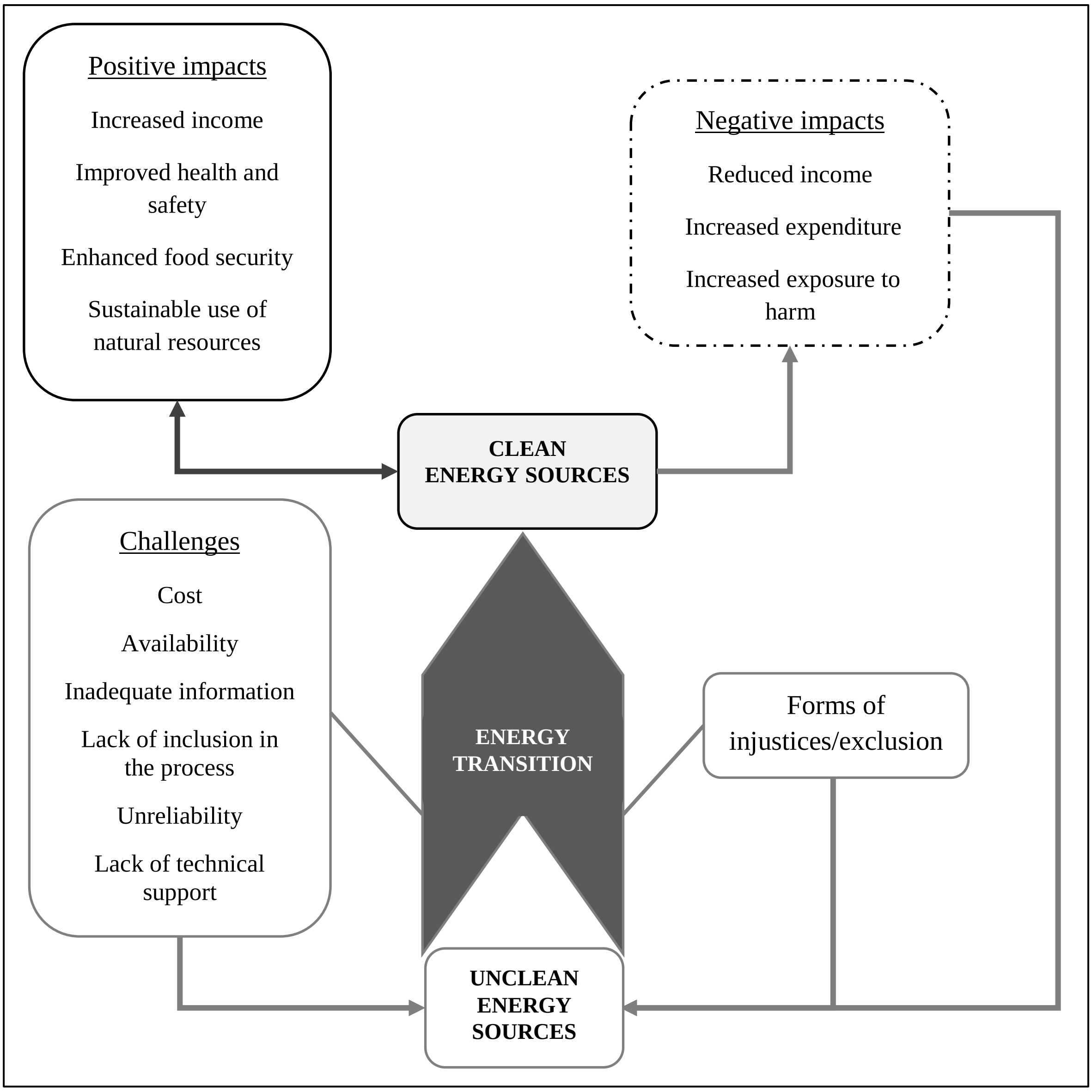

Fig. 9.2: Pathway to clean energy transition in rural Ghana

(Source: Author's construct).

9.1 Policy recommendations

Government agencies within the energy sector operate within political contexts but also engage with the broader objectives of ensuring universal energy access and environmental sustainability. Therefore, effective low-carbon energy transitions are more likely when efforts extend beyond political affiliations and expectations. Commitment to investing in clean energy technologies, alongside inclusive engagement with diverse actors in regulatory and policy formulation, aligns with the principles of a just transition. Additionally, the government can provide tax incentives to actors which may help reduce technology costs, making them more accessible to low-income households. Supporting local organisations in producing their own clean energy technologies could further mitigate price fluctuations influenced by imported goods and inflation.

Actors can support rural households in becoming prosumers, a concept some scholars describe as energy citizenship. While energy citizenship and energy democracy are sometimes used interchangeably, Wahlund and Palm (2022) highlight distinctions between the two. Regardless, they emphasise that energy citizenship contributes to energy democracy by enhancing participatory engagement. While empowering households, actors can develop alternative livelihood programs for those reliant on charcoal production and sales. These programmes may focus on green energy jobs, such as solar panel installation and maintenance. Investing in such initiatives has the potential to strengthen household economic viability and promote the adoption of clean technologies.

Additionally, it is important for actors to implement measures that ensure the availability of reliable and affordable clean technologies for rural households. In addressing issues of affordability, financial support mechanisms for lower-income households can be provided. This could involve collaboration with financial institutions to offer low or interest-free credit facilities to rural households. While some actors are currently investing in the provision of clean technologies, it is recommended that they direct future efforts towards the creation of energy communities. Such a shift from the provision of clean energy technologies to energy communities can contribute positively to the environmental and developmental needs of rural communities.

Collaboration and coordination among actors can also facilitate the exchange of knowledge and the sharing of experiences, contributing to the development of sustainable strategies tailored to the energy needs of rural communities. Such a cooperative approach may help reduce duplication of efforts, particularly in contexts where numerous off-grid communities require interventions. Partnerships with households could also be fostered by involving them in the design of solutions that address their specific needs. Engaging households as co-designers of energy projects can promote a sustained transition by encouraging ownership and active participation in these initiatives.

To ensure a sustained adoption of clean technologies, enhancing household knowledge on low-carbon solutions and environmental issues is essential. Given the existing knowledge gaps, actors involved in clean energy transition could consider not only providing technologies but also, integrating educational initiatives that address the energy-environment nexus. Incorporating awareness campaigns into energy transition efforts can help potential beneficiaries to make informed decisions. It is also critical for actors to maintain engagement with households beyond the initial adoption phase. Given that rural households have extensive experience with traditional energy sources, unresolved challenges with low-carbon technologies post-adoption may lead to a return to traditional fuels.

Given the heavy reliance of rural households on woodfuels for cooking and their role as a source of income, sustainable charcoal production and responsible forest management practices are encouraged as interim measures, while working towards a full transition to cleaner cooking technologies. This recommendation is particularly important considering the gender dynamics in woodfuel collection, as women are primarily responsible for gathering woodfuels in rural households. Any reduction in tree availability would disproportionately affect this group.

9.2 Research implications

This research, while rooted in the field of Geography, integrates other fields, such as energy studies, sustainability transitions, development studies and innovation studies. This multidisciplinary nature ensured a holistic approach to examine low-carbon transition and fostered the development of innovative ways to enhance energy access. The findings therefore, provide valuable insights toward advancing a just and sustainable energy transition.

Article 1, for instance, critically reviews concepts such as energy justice, inclusive innovation and political ecology. Article 2, although not directly derived from the primary data of the research, utilises contents of its literature review to examine energy access more critically. Article 3 explores households energy decisions and provides insight on the specific energy needs of households, while Article 4 sheds light on household energy-environment knowledge. Article 5 examines strategies used by actors to promote clean energy access and their engagement with households.

The research, through these articles, addresses a gap in the literature by incorporating the theories of energy justice, inclusive innovation, and political ecology within the context of clean energy transition. It also challenges the simplistic binary perspective that equates energy availability with access, a notion increasingly criticised in energy studies. Additionally, the study highlights the role of simple low-carbon energy technologies, which are often overlooked in transition discourse, and provides a focused analysis of rural Ghana, a region that remains underexplored in low-carbon energy research.

Moreover, the research contributes to ongoing debates on the benefits of clean energy transition by challenging the dominant narrative that associates energy transition solely with positive outcomes. It offers a critical perspective on rural energy transition in SSA, arguing against a one-size-fits-all approach that often marginalises low-income households. Finally, by uncovering areas of both collaboration and conflict among various actors, the research provides insights for refining strategies to enhance clean energy adoption.

9.3 Research limitations

This research draws its findings from a sample of off-grid rural communities in the Eastern Region of Ghana. Even though the findings can be applied in other SSA countries for policy formulation, they need to be carefully considered. This is because countries in the SSA region may have some social, economic and environmental contexts that may influence the effectiveness and relevance of the findings.

The energy sector of Ghana is gradually transforming, marked by changing policies and regulatory frameworks. A change in policy and regulatory frameworks has the potential to significantly impact the findings of the study. Thus, any alterations in policy dynamics after data collection could alter the study findings. Hence, it is critical for policymakers, researchers and other relevant actors to consider these evolving dynamics when interpreting the findings.

The methods of data collection employed in this research ensured the gathering of a substantial amount of data. However, due to time constraints, the researcher was unable to analyse all the data. This notwithstanding, the data relevant to answer the research questions were thoroughly analysed. As an early-career researcher, having this extensive data presents significant opportunities for future research and further exploration.

While the materials and methods used in the research were rigorous, the researcher acknowledges that there are other geographical approaches which could have been effectively applied in the research to investigate the subject matter from different perspectives. Using these varied methodologies can facilitate the in-depth examination of energy transition. However, this was beyond the scope of the research.

Women in leadership positions are capable of advancing energy transition. Even though the critical role of women as leaders of organisations has been acknowledged in many research works as vital in low-carbon transition, the selection of organisations to be involved in the study did not consider gender dynamics in organisational leadership. This decision was based on the focus of the research.

9.4 Future research areas

Since rural households heavily rely on non-rechargeable batteries to power their light source, it is suggested that future works investigate the disposal practices of these batteries. The study has further shown that households consider the environmental impacts of their energy sources as less important. Forthcoming works could, therefore, examine the level of households' knowledge on energy, renewable waste management and the environment.

Additionally, the study highlights the need to educate households on energy-environment issues as it is critical in achieving SDG 7. It is therefore recommended that future works explore the approaches used by actors in conceptualising and implementing energy transitions in rural SSA and the associated benefits. Filling these gaps can provide valuable insights into practical approaches for promoting the adoption of low-carbon technologies.

The concept of energy communities, when applied in SSA, has the potential to bridge the gap in energy access with the Global North and as evident in projects in the Global North, overcome the urban and rural divide that plagues the region and close the gap between the rich and poor. Future research works could, therefore, examine the application of the energy community concept in SSA, its usefulness in the Ghanaian context and from the resultant, find methods to promote its creation.

Future research works may employ other alternative methodological approaches to investigate energy transition in rural Ghana, using different case studies, research paradigms and data collection methods. These works could also expand the scope of examination. For instance, they could investigate the roles of women-led households and organisations in rural SSA, with a particular attention to how they empower other women in the transition process. Furthermore, future studies could explore energy policies in Ghana and examine how they promote inclusivity in a transition process.

9.5 Concluding remarks

This research has proven to be an invaluable learning experience. At the outset of this research, I anticipated that my enquiry into energy transition, in the rural Ghanaian context, would conclude with my findings. However, review of the findings reveal that this work is just the starting point of a series of explorations into energy transition in rural SSA. In fact, the answers to the research questions have further raised more questions that need to be addressed, indicating the inherently iterative nature of geography. This research has indeed demonstrated to me that, as an African proverb aptly puts it,

> *" Knowledge is a garden. If it is not cultivated, one cannot harvest it".*

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Appendix A: Ethical Clearance Letter

Research Ethics Committee

MIREC Final Decision Form

APPLICATION NUMBER:	A21-056

1. PROJECT TITLE

A Political Ecology Approach to Low-carbon Transition in Rural Ghana

2. APPLICANT

Name:	Dickson Boateng
Department / Centre / Other:	Geography
Position:	Postgraduate Researcher

3. DECISION OF MIREC CHAIR (✓)

☐	Ethical clearance through MIREC is not required and therefore the applicant need take no further action in this regard.
✓	Ethical clearance is required and is hereby granted by the Chair without need for referral to the MIREC committee.
☐	Ethical clearance for a funding application or a similar purpose is granted by the Chair ***pro tem*** without need for referral to the MIREC committee. However, the applicant must subsequently seek ethical clearance from MIREC prior to embarking on any related project work involving human participants or their data.
☐	Ethical clearance is granted following review of the application by the MIREC committee.
☐	Ethical clearance is not granted following review of the application by the MIREC committee.

4. REASON(S) FOR DECISION

A21-056: Dickson Boateng PGR - A Political Ecology Approach to Low-carbon Transition in Rural Ghana I have reviewed this application and I believe it meets with MIREC requirements. It is, therefore, approved.

5. SIGNATURE OF MIREC CHAIR

Name (Print):	Dr Marie Griffin
Signature:	
Date:	27th January 2022

Appendix B: Participant Information Sheet

MARY IMMACULATE COLLEGE

Faculty of Arts, Department of Geography

Limerick, Ireland.

PARTICIPANT INFORMATION SHEET

Dear participant,

I am Dickson Boateng, a postgraduate student in the Department of Geography at the Mary Immaculate College, Limerick, Ireland. As a requirement for my postgraduate study, I am undertaking a research project entitled 'A broad political ecology approach to low-carbon transition in rural Ghana'. This research study has received approval from the Mary Immaculate College Research Ethics Committee (MIREC) (Reference number: A21-056).

Invitation

I invite you to take part in this research. Before participating, you need to understand what this research is about and the reason why it is being undertaken. Please carefully read the following information. If you do not understand anything or you want clarification on any information, please do not hesitate to contact me.

What will your involvement entail?

The study seeks to examine transition to low-carbon energy under the lens of political ecology. In doing so, it will examine energy situation of the community as well as injustices created by low-carbon energy transition and the strategies to enhance just rural energy transition. Your involvement in the study will necessitate answering a series of questions. All of the questions that you will be asked are designed in relation to the stated objectives. Your answers will be vital in achieving the aims of the study.

What about confidentiality?

Identifiers will not be used in the study. Digital data will be encrypted and stored safely on the researcher's personal device for the duration of the study. Non-digital data will be collated and kept by the researcher and stored in a locked briefcase. Data (both digital and non-digital) will only be accessible to the researcher, students and staff members involved in the study. The data will be shredded and/or deleted and/or overwritten after completion of the study.

In case of any queries or concerns, feel free to reach Dickson Boateng through his University email address -(Dickson.boateng@mic.ul.ie) or the research supervisors; Dr. Julian Bloomer and Dr. John Morrissey via their University email (Julian.Bloomer@mic.ul.ie; John.Morrissey@mic.ul.ie).

Alternatively, If you have any concerns about this study and wish to contact an independent authority, you may contact: Mary Collins, MIREC Administrator, Mary Immaculate College, Limerick. Telephone: 061-204980; E- mail: mirec@mic.ul.ie

Appendix C: Participant Consent Form

MARY IMMACULATE COLLEGE

Faculty of Arts, Department of Geography

Limerick, Ireland.

PARTICIPANT CONSENT FORM

Title of Project: A broad political ecology approach to low-carbon transition in rural Ghana.

Researcher's name: Dickson Boateng

To be completed by the participant.

- I know what the study is about having read the information sheet
- An opportunity to seek clarification and discuss the study has been offered to me
- I have received answers to all my queries and find them satisfactory
- I have acquired requisite information about the study and understand it
- I understand that participation is voluntary and I can withdraw from the study at any time with/without any reason whatsoever
- I understand that I am not entitled to any remuneration for taking part in the study
- I understand that the information I provide will be used anonymously for research purposes
- I agree to take part in this study ☐

Signed (participant)	Date
Participant name (block letters)	
Signature of researcher	Date
Supervisors: Dr. Julian Bloomer and Dr. John Morrissey	
Researcher's contact details: Dickson Boateng (dickson.boateng@mic.ul.ie). Tel: [redacted]	

Appendix D: Survey questionnaire

QUESTIONNAIRE FOR FIELD STUDY ON: A NOVEL POLITICAL ECOLOGY APPROACH TO LOW-CARBON ENERGY TRANSITION IN RURAL GHANA

This study is being conducted by a postgraduate doctoral student at Mary Immaculate College, Ireland [Dickson Boateng – Dickson.boateng@mic.ul.ie]. This is strictly for academic purposes and your responses will be treated confidentially. Please read the project information sheet and sign the informed consent form before completing this survey questionnaire. Your co-operation to facilitate this study is greatly appreciated.

Thank you.

Questionnaire number...

Date administered……………………………………………………...

SECTION 1

Please **tick** ONLY THE BOX of the response given and explain briefly if required

Background of respondents

1. Name of community…………………………………………

2. Sex (a) Male [ ] (b) Female [ ]

3. Age of respondent

(a) 18-20 [ ] (b) 21-30 [ ] (c) 31-40 [ ]

(d) 41-50 [ ] (e) 51-60 [ ] (f) 61 and above [ ]

4. Status in this community

(a) Native [ ] (b) Migrant [ ]

5. Size of household

(a) Less than 3 [ ] (b) 3-5 [ ] (c) 6-8 [ ] (d) 9 and above [ ]

6. Educational level

(a) Never schooled [ ] (b) Basic [ ] (c) Secondary [ ] (d) Tertiary [ ]

SECTION II

Household energy sources

7. What are your sources of energy? (multiple responses allowed)

Lighting	Torchlights (battery-powered) [ ] PV Lanterns/solar torch [ ] Others (specify)….	Mini-grid [ ] Solar Home Systems [ ]	Local lantern [ ]
Cooking	Firewood [ ] Charcoal [ ]	Cookstove [ ] Others (specify) …………	LPG [ ]

b. What is your main source of energy?

Lighting	Torch [ ] PV Lanterns/solar torch [ ] Others (specify)….	Mini-grid [ ] Solar Home Systems [ ]	Local lantern [ ]
Cooking	Firewood [ ] Charcoal [ ]	Cookstove [ ] Others (specify) ……………	LPG [ ]
Who does the cooking in the house? Husband [ ] Wife [ ] Children [ ] Boys [ ] Others (specify)………… Girls [ ]			

8. What is your criteria for selecting an energy source? (Choose in order of priority from 1-5, with 1 being the most important)

CRITERIA	**1**	**2**	**3**	**4**	**5**
	Highest importance	High importance	Moderate importance	Low importance	Lowest importance
Availability					
Cost					
Environmental impact					
Reliability					

Accumulated knowledge					

9. Are your household's energy needs being met?

Lighting	Reasons
Yes [ ]	
No [ ]	
Cooking	Reasons
Yes [ ]	
No [ ]	

10 a. How reliable is your household's main source of energy?

ENERGY SOURCE	RELIABILITY	REASON (S)
Lighting	1- Very reliable [ ] 2- Reliable [ ] 3- Somewhat reliable [ ] 4- Unreliable [ ] 5- Very unreliable [ ]	
Cooking	1- Very reliable [ ] 2- Reliable [ ] 3- Somewhat reliable [ ] 4- Unreliable [ ] 5- Very unreliable [ ]	

10 b. If UNRELIABLE, how do you cope with the energy challenges of your household?

(a) Resort to other sources [ ] (b) Reduce quantity consumed [ ] (c) Nothing [ ]

(d) Others (specify) ………………………………………………………………………

Clean energy interventions and knowledge

11. To what extent do you agree with the following?

STATEMENT	1 Strongly agree	2 Agree	3 Neutral	4 Disagree	5 Strongly disagree
Energy sources can have an impact on the environment					
Household's main energy source can impact the environment					
You are aware of plans by actors to migrate to clean energy					

12. Which of the following clean energy sources do you know? (multiple responses allowed)

Lighting	PV Lanterns/solar torch [ ] Wind [ ] Others (specify)….	Mini-grid [ ] Solar Home Systems [ ]	Hydro [ ]
Cooking	Improved cookstove [ ] Others (specify)……	LPG [ ]	

13. What barriers prevent you from utilising these clean energy sources? (Multiple responses allowed)

(a) Not available [ ] (b) High cost [ ] (c) Inadequate information [ ]

(d) Change averse [ ] (e) Unreliability [ ] (f) Lack of technical support [ ]

(g) Lack of inclusion in the process (planning to implementation) [ ]

14. What clean energy intervention has been provided in the community (in the past 10 years)?

ENERGY SOURCE	INTERVENTION (S)

Social relations

15. To what extent do you agree with the following statements?

STATEMENT	1 Strongly agree	2 Agree	3 Neutral	4 Disagree	5 Strongly disagree
Actors are in constant communication with you					
Interaction with actors can/has influenced your adoption of clean energy technologies					
I am likely to adopt a clean energy technology if involved in its planning and implementation					
Information and technical support from actors influence adoption of clean technologies in general					

16. How do you reach clean energy providers or actors? (multiple responses allowed)

(a) Phone [ ] (b) Office visit [ ] (c) Emails [ ] (d) Community visits [ ]

(e) Others (specify) ………………………….

17. Are you satisfied with your social relations with the actors?

(a) Completely satisfied [ ] (b) Moderately satisfied [ ] (c) Somewhat satisfied [ ]

(d) Moderately dissatisfied [ ] (e) Completely dissatisfied

Possessions and dispossessions

18. How has or will a transition to clean energy positively affect your household's wellbeing and environment? (multiple responses allowed)

LIVELIHOOD OUTCOMES	REASONS
(a) Increase income [ ]	
(b) Improve wellbeing [ ]	
(c) Reduce vulnerability [ ]	
(d) Improve food security [ ]	
(e) Enhance sustainable use of natural resources [ ]	
(f) Others (specify)	

19. How has or will a transition to clean energy negatively affect your household's wellbeing and the environment? (multiple responses allowed)

LIVELIHOOD OUTCOMES	REASONS
(a) Reduce income [ ]	
(b) Deteriorate wellbeing [ ]	
(c) Increase vulnerability [ ]	
(d) Worsen food security [ ]	

(e) Unsustainable use of natural resources [ ]	
(f) Others (specify)	

20. Is the livelihood of your household tied to any of the following? (Multiple responses allowed)

(a) Charcoal [ ] (b) Firewood [ ] (c) Local lantern [ ] (d) Torchlight [ ]

(e) Low-carbon technologies [ ] (f) Others (specify)…………………………

21. What percentage of your household's income comes from trading in charcoal?

(a) 0-20% [ ] (b) 21-40% [ ] (c) 41-60% [ ] (d) 61-80% [ ] (e) 81-100% [ ]

22. How would you describe the cost of obtaining clean energy for your household?

(a) Very expensive [ ] (b) Expensive [ ] (c) Moderate [ ] (d) Affordable [ ]

(e) Very affordable [ ]

23. Do you agree that actors (e.g. private clean energy technology providers and NGOs) are exploiting you or your community for profit in their low-carbon transition objective?

(a) Strongly agree [ ] (b) Agree [ ] (c) Neutral [ ] (d) Disagree [ ]

(e) Strongly disagree [ ]

Recommendation

24. What do you suggest actors can do to enhance your adoption of low-carbon technologies?

a. At the household level ………………………………………………………………...

…………………………………………………………………………………………………

…………………………………………………………………………………………………

b. At the community level ………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………

Appendix E: Interview schedules

DISTRICT ASSEMBLIES AND LOCAL GOVERNMENT OFFICIALS

Household energy sources (focus on lighting and cooking sources)

1. What are the energy sources of households in the community/district and what are the energy access challenges faced?
2. What are households' main energy uses and what technologies are used — simple and/or sophisticated?
3. What makes it challenging for households to access clean energy technologies, particularly LPG and solar technologies?
4. Why do households over rely on woodfuels?

Transition to cleaner technologies

5. Are you aware of plans to transition rural communities to clean energy technologies?
6. Do actors involve you in the clean energy transition process, and at what stage?
7. What do you think is/are the motive(s) of clean energy providers in providing low-carbon technologies in the community/district?
8. How do you view the prices of clean energy technologies and why do you think these technologies are being promoted in the community/district?
9. What are the potential positive and negative impacts associated with a full transition to cleaner technologies?

Strategies used by actors

10. Who are the active actors in the community/district and what strategies are used to enhance the uptake of clean technologies?
11. At what stage of project implementation do providers involve rural households and why?
12. Does the District Assembly involve rural households in the transition process by the state/government?
13. Do actors collaborate in the transition process?
14. Do you think involvement of rural households in the transition process is necessary for enhanced uptake of cleaner technologies?
15. What do you suggest actors can do to enhance household adoption of low-carbon technologies?

CHIEFS / OPINION LEADERS

Household energy sources (focus on lighting and cooking sources)

1. What are the energy sources of households in the community and what are the energy access challenges faced?
2. Why has the community not been connected to the national electricity grid; are there any negative impacts associated with this non-connection?
3. What are households' main energy uses and what technologies are used – simple and/or sophisticated?
4. What makes it challenging to access clean energy technologies, particularly LPG and solar technologies?
5. What criteria do households use in selecting an energy source?
6. In an event energy source for lighting is not available, what alternative source do you resort to?
7. Why do households over rely on woodfuels and who often does the fetching of firewood and cooking?
8. Are there any negative effects on your health regarding the use of woodfuels?
9. Do you replace cut trees after fetching firewood?

Transition strategies by actors

10. Are you aware of plans to transition the community to clean energy technologies?
11. Do actors involve you or other households in the clean energy transition process and at what stage?
12. How do you view the prices of clean energy technologies and why do you think these technologies are being promoted in the community?
13. What are the potential positive and negative impacts associated with a complete transition to cleaner technologies?
14. What do you suggest actors can do to enhance household adoption of low-carbon technologies?

CLEAN TECH PROVIDERS

Clean energy interventions (focus on lighting and cooking sources)

1. What clean energy technologies do you provide and what is/are your focal communities?
2. What makes it challenging for households to access clean energy technologies?
3. Why do households over rely on woodfuels (if involved in the distribution of clean cooking technologies)?

A shift to cleaner technologies

4. Are you aware of plans by other actors to transition households to the use of clean energy technologies?
5. What is/are the motive(s) of your involvement in the transition to low-carbon technologies?
6. How do you view the prices of clean energy technologies and what strategies do you deploy to overcome the price challenge, if any?
7. What are the potential positive and negative impacts associated with a full transition to cleaner technologies?

Strategies by actors

8. What strategies do you deploy in communities to promote the adoption of clean energy technologies and which activity do you focus on?
9. At what stage of project implementation do you involve households and why?
10. Do you collaborate with other actors in the quest to transitioning households to cleaner technologies?
11. Do you think the involvement of households in the transition process is necessary for enhanced uptake of cleaner technologies, and what are the challenges therewith?
12. What do you suggest actors can do to enhance household adoption of low-carbon technologies?

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Kind regards,

Roopa Lingayath

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Appendix H: Summary of themes from qualitative interviews

Topics	Main themes	Sub-themes
Household energy uses	Electricity	Lighting
		Powering smaller appliances
	Cooking	
Household energy sources	Clean sources	Solar Home Systems
		PV lanterns/solar torchlights
		LPG
		Improved cookstoves
	Unclean sources	Non-rechargeable battery-powered torchlight
		Firewood
		Charcoal
Criteria for selecting main household energy source	Cost	
	Availability	
	Reliability	
	Indigenous knowledge	
Reason for relying on woodfuels	Tradition/custom	
	Affordable	
	Available	
	Less risky	
Responsible for cooking and gathering firewood	Females	Wives
		Children (Girls)
Effects associated with the use of woodfuels	Health	Irritation of the eyes
Vibrant actors providing clean technologies	Government	
	NGOs	
	Private technology providers	
Barriers inhibiting adoption of clean technologies	Cost	
	Availability	
Potential benefits associated with transition	Increase income	Less expenditure
		Enhanced economic activities
		Extend productive hours
	Improvement in food security	Enhanced food preservation
	Reduction in vulnerability	Engage in evening activities without external attacks
		Reduced exposure to predators
	Sustainable use of natural resources	Reduced deforestation
Potential negative impacts associated with transition	Reduction in income	Reduced income from trading in charcoal
		Collapse of the charcoal business
		Payment of bills
	Exposure to harm	Risk of burning from LPG
Strategies by actors	Provision of technologies	
	Disseminating information	Information on clean energy technologies
		Social and economic benefits of technologies to households
		Environmental benefits of clean technologies