# MAKERERE UNIVERSITY

## MAKERERE UNIVERSITY BUSINESS SCHOOL

**SOCIO-ECONOMIC FACTORS AFFECTING GRID ELECTRICITY ACCESS AMONG RURAL HOUSEHOLDS IN UGANDA**


**BY**

**MURUNGI HERBERT**

**2021/HD10/2952U**

**Mobile: 0779513869**

**Email:** hbtatwooki@gmail.com


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**PLAN A**

**NOVEMBER, 2023**

## DECLARATION

I hereby declare that this research report is a result of my own original ideas, and it has never been presented anywhere for academic purposes.

Signed.....

Date 05/12/2023

**MURUNGI HERBERT**

**2021/HD10/2952U**

## APPROVAL

This research report has been submitted with the approval of my supervisors, whose signatures are appended against their respective names below.

Signed..... Date.....5/12/2023

**Dr. Nkurunziza Gideon**

Makerere University Business School

Signed..... Date.....5/12/2023

**Dr. Aarakit Sylvia Manjeri**

Makerere University Business School

## DEDICATION

I dedicate this research report to my parents, Mr Kaliisa James and Mrs Specioza Kaliisa, as well as my dear sister, Ms Ruth Nyangoma, for the immeasurable support, endless sacrifices and encouragement you have rendered to me throughout the two decades of my academic journey.

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**List of Abbreviations**

| | |
|---|---|
| CAPI | Computer-Assisted Personal Interviews |
| EASP | Electricity Access Scale-up Project |
| ECP | Electricity Connection Policy |
| FAO | Food and Agricultural Organisation |
| MEMD | Ministry of Energy and Mineral Development |
| MoFPED | Ministry of Finance, Planning and Economic Development |
| NDP | National Development Plan |
| NPA | National Planning Authority |
| PPS | Probability Proportional to Size |
| SDGs | Sustainable Development Goals |
| UBOS | Uganda Bureau of Statistics |
| UN | United Nations |
| UNHS | Uganda National Household Survey |

## ABSTRACT

The purpose of this study was to examine the socio-economic factors influencing access to grid electricity among rural households in Uganda. Specifically, the study was guided by four objectives, which is to: (i) examine the relationship between initial grid connection cost and grid electricity access, (ii) establish the relationship between household income and grid electricity access, (iii) examine the relationship between education attainment and grid electricity access and, (iv) examine the relationship between reliability of grid electricity and grid electricity access. The study used the 2019-2020 Uganda National Household Survey (UNHS 2019/2020) data collected by the Uganda Bureau of Statistics (UBOS) with a total sample of 13,732 randomly selected households covering 149 districts across 15 sub-regions of Uganda, but only 10,126 rural households were observed. The study employed quantitative research approaches, and a logistic regression model was used for estimation. All the analysis was done using STATA software.

The study finds that initial electricity connection cost has a positive relationship with rural households' non-access to grid electricity. This suggests that an increase in initial electricity connection cost increases the likelihood of non-access to grid electricity by rural households. Similarly, grid reliability has a positive correlation with non-access to grid electricity. Suggesting that the non-reliability of grid electricity supply increases the probability of non-access to grid electricity by households. However, household income and education attainment of household heads have a negative relationship with non-access to grid electricity. Implying that an increase in household income and education attainment reduces the likelihood of non-access to grid electricity by rural households.

In conclusion, the findings suggest that initial electricity connection cost, grid reliability, household income and education attainment are crucial for enhancing grid electricity by rural households. Therefore, the study recommends that the government of Uganda, and the private sector should invest in grid reliability, enhance income-generating opportunities for rural households and increase awareness campaigns emphasising the advantages of grid electricity over conventional energy sources. Future studies could consider examining how each of the variables affects grid electricity in rural-urban residences and how these effects change over time.

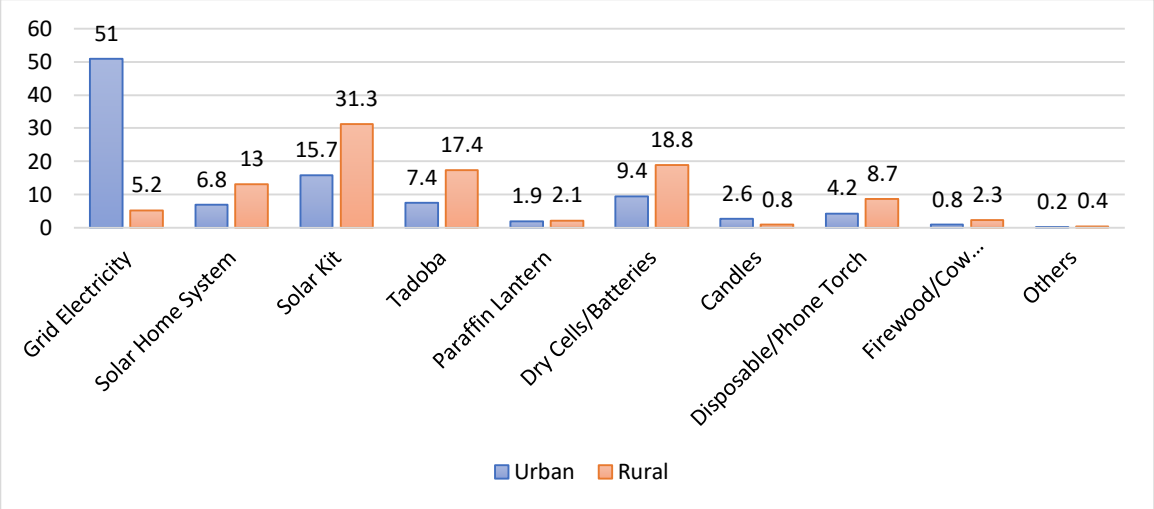
# CHARTER ONE

# INTRODUCTION

## 1.1.Background to the Study

Access to electricity is considered pivotal for achieving sustainable development goals (SDGs), including SDG1 - Poverty eradication, SDG7 Universal access to affordable, reliable and modern energy services for all and SDG3 improving the population's living standards (Bezerra et al., 2017; The United Nations, 2015). However, electricity access remains limited, with substantial discrepancies between the urban and rural areas, especially in Sub-Saharan Africa (United Nations, 2023). Globally, over 770 million people lack access to electricity, and 2.4 billion rely on conventional fuels for cooking and heating, exposing them to indoor air pollution, adverse illnesses, and premature deaths, with the majority residing in South Asia and Sub-Saharan Africa (World Bank 2022). Combined, South Asia and Sub-Saharan Africa regions constitute over 80% of the population without access to electricity (IEA, 2022; World Bank, 2021). In Uganda, over 70% of the nation's population and over 90% of the rural population lack access to grid electricity (UBOS, 2021; Manjeri et al., 2021). Consequently, unelectrified households depend on unprocessed traditional fuels (mainly biomass, kerosene, candles, and dry cell batteries) to meet their domestic energy needs, as shown in ***Fig. 1.***

Figure 1. **Household electricity access by source and rural-urban divide**




***Data source***: National Household Survey Report (UBOS 2021).

Against this background, the government of Uganda, through the Ministry of Energy and Mineral Development (MEMD), has embraced several policy initiatives to increase the proportion of the population with electricity access to 80% by 2030 and 100% by 2040 (MEMD, 2018; 2019). Such initiatives include a free electricity connection policy (ECP) 2018-2027, tariff subsidisation for cooking, rural electrification, and grid intensification (Background to the budget, MoFPED, 2022). By 2022, ECP targeted a 26% increase in rural grid electricity access as set out in the National Development Plan (NDP) III and accelerated access to 60% by 2027 (NPA, 2020). In addition, the government has put in place more ambitious energy policies, such as the revised National Energy Policy of 2019 and renewable energy policy of 2022, along with clean energy access targets documented in the SE4ALL agenda to guide rural electrification in the country.

Furthermore, in 2021, the World Bank, through EASP (Electricity Access Scale-up Project), committed Shs. 2 trillion (USD 568 million) towards enhancing the proportion of commercial enterprises, households, public institutions and parks accessing electricity in Uganda (Umeme,

2022). This project is expected to connect about 900,000 households to the grid by 2027. Despite these initiatives, most households in Uganda continue to live without access to grid electricity (Ssennono et al., 2021; International Trade Administration, 2022; Wabukala et al., 2022). It is possible that high initial connection costs, lack of reliable grid supply, low income, and limited levels of education continue to deter households from accessing electricity, as highlighted earlier in Word Bank's report (Blimbo et al., 2020). Failure to access electricity compels many households in rural areas to rely on inefficient fuels for cooking and lighting, leading to increased household air pollution and its associated side effects, such as respiratory diseases like pneumonia among children (Sundararajan et al., 2022). Hence, understanding the factors that influence grid electricity access among rural households motivated this study.

Numerous studies have been conducted to understand the main factors influencing household access to electricity at national, regional and global levels. For instance, the study by Kemmler (2013) revealed that the quality of electricity, household characteristics and the degree of community electrification affect India's household access to electricity. However, Andrade-Pacheco et al. (2019) assert that access to electricity at the household level is associated strongly with the socio-economic status of the members, including the positions occupied. Falk et al. (2021) show that different social and economic factors, such as perceptions of energy sources, gender, and perceived benefits, influenced the electrification of Tanzania's rural areas. Nevertheless, Kemmler (2013), Andrade-Pacheco et al. (2019), and Falk et al. (2021) discuss the factors influencing households' electricity access from the regional levels and in different study contexts other than Uganda. Moreover, these studies examined a few social and economic factors, leaving out other major issues such as income and education levels of the household members, which could be important in explaining households' decision to access grid electricity.

A study by Wabukala et al. (2022) cited social factors, including vandalism, lack of social acceptance, and undeliberate factors, such as equipment failure, among barriers to grid electricity access in Uganda. Likewise, a report by the Food and Agricultural Organisation (FAO) stressed high costs associated with grid connection for households at the bottom of the pyramid remain a major barrier to the attainment of SDG 7 in Sub-Saharan Africa (FAO, 2018). However, there are few empirical studies examining the effect of initial grid connection cost on grid access among rural households in Uganda's context.

In addition, the existing empirical studies fail to address the theoretical assumptions from the rational choice and the energy ladder theories, which offer detailed explanations of households' consumption behaviours or decision-making processes on the use of different energy sources. Therefore, this inquiry utilised the energy ladder theory to explain the economic factors, mainly the role of household income on their access to grid electricity, as proposed by Mainimo et al. (2022). More so, the rational choice theory was adopted to explain both the social and economic factors influencing rural households' grid electricity access, such as education levels, connection costs and reliability. Vlaev (2018); Friedman and Hechter (1988) argue that the theory uses a social science perspective to understand human behaviour, which influences decisions based on their rational calculations of benefits and costs. By adopting the aforementioned theoretical perspectives, the study aimed to address the existing theoretical and empirical gaps by undertaking a quantitative approach to investigate the relationships between rural households' grid electricity access and different socio-economic factors.

### 1.2. Statement of the Problem

Despite the government’s efforts to increase the proportion of households with access to electricity from 10% in 2012 to 60% by 2020, approximately 19% of the total households in

Uganda use grid electricity, with only 5.2% from rural areas (UBOS, 2021). This implies that only two in every ten households have access to grid electricity. The inability of most households in Uganda to access grid electricity has compelled them to resort to conventional energy sources for lighting, further lowering the quality of their welfare.

In addition, prior studies (e.g., Wabukala et al., 2022; Kakumba, 2021; Mawejje & Mawejje, 2016) that have investigated grid electricity access in Uganda have mainly analysed factors such as distance to the grid and electricity theft, among others, with less attention given to the role of the socio-economic attributes of the households. Yet, anecdotal evidence suggests that socio-economic factors such as household income, education, initial connection costs to the grid, reliability of grid supply and gender differences are crucial in explaining household access to electricity (Blimbo et al., 2020; Behera et al., 2017). Thus, this study employed the Energy Ladder Theory and the Rational Choice Theory to test and explain empirical relationships between the different socio-economic factors and lack of access to grid electricity in the context of rural households in Uganda.

### 1.3. Purpose of the study

This study sought to examine the socio-economic factors influencing access to grid electricity among rural households in Uganda.

### 1.4. Research Objectives

i. To examine the relationship between initial grid connection costs and non-access to grid electricity among rural households in Uganda.
ii. To investigate the relationship between household income and non-access to grid electricity among rural households in Uganda.

iii. To examine the relationship between the educational attainment of household heads and non-access to grid electricity among rural households in Uganda.

iv. To investigate the relationship between the reliability of grid electricity and non-access electricity access among rural households in Uganda.

### 1.5. Hypothesis

***$H_1$***: Initial connection cost has a positive relationship with non-access to grid electricity among rural households in Uganda.

***$H_2$***: Household income has a negative relationship with rural households' non-access to grid electricity in Uganda.

***$H_3$***: Education attainment of a household head has a negative relationship with non-access to grid electricity among rural households in Uganda.

***$H_4$***: Reliability of grid electricity has a positive relationship with non-access to grid electricity among rural households in Uganda.

### 1.5. Scope of the study

#### 1.5.1. Geographical and Theoretical Scope

The study only focused on the households located in Uganda's rural areas since these have lower electricity access than urban households (UBOS, 2021). Recent statistics indicate that the majority of Ugandans live in rural areas, and over 90% of rural households lack access to grid electricity (UBOS, 2021). Thus, it is important to understand why most rural households lack access to grid electricity.

Additionally, the inquiry was anchored on the Rational Choice Theory and The Energy Ladder Theory. These two theories were chosen because their assumptions cover the selected variables

and provide an in-depth understanding of the relationship between the dependent variable (electricity access) and independent variables (price, income, reliability and education levels).

### 1.5.2. Content Scope

The investigation focused on socio-economic drivers, such as incomes of the households, reliability of electricity, education level, and initial connection costs as the main independent variables and rural households' access to grid electricity as a dependent variable. This is because there is limited empirical evidence on the relationship between the explanatory and explained variables mentioned above.

### 1.5.3. Time Scope

All project activities were executed within eight months, from February to September 2023. The tasks included proposal writing and approval, data collection and analysis, and report writing and submission.

## 1.6. Significance of the Study

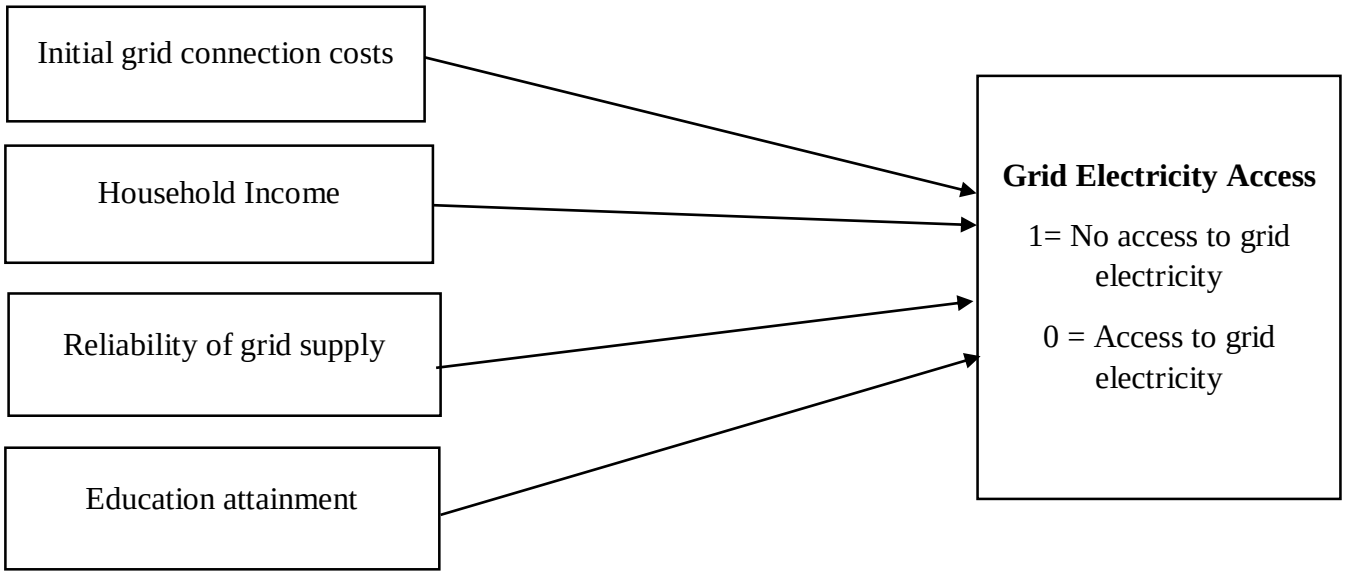
i. This study provides valuable insights into the different factors influencing the connection to grid electricity for lighting purposes among rural households in Uganda. This information can be used for research and consultancy purposes in Uganda’s energy sector.

ii. The information gathered from this study can be used to advise policymakers on decisions regarding the policies and strategies to increase access to electricity in underserved rural areas of the country and improve their welfare. By understanding the different drivers for connection to grid electricity among households, the research output supports the government strategies to increase access to clean and sustainable energy sources for all people in the country as

stated in the 7th UN Sustainable Development Goal (SDG7) and increase country's commitment to the Paris Agreement of keeping the carbon emissions below $2^0$C by reducing on the reliance on fossils fuels.

### 1.7. The Conceptual Framework

Figure 2. **Conceptual framework**




***Source:*** Bikorimana and Mwizerwa (2018)

This conceptual model was adopted and modified from an empirical study conducted by Bikorimana and Mwizerwa (2018) on the *"Macroeconomic Determinants of Electricity Access in Rwanda."* The framework depicts access to grid electricity as a dependent variable, while independent variables such as initial connection costs to grid electricity and income of the households are economic factors, and education levels of households' heads are social factors.

From the theoretical perspective, Falk et al. (2021) and Andrade-Pacheco et al. (2019) assert that numerous socio-economic factors, such as employment type, perceived benefits and perceptions of energy sources, influence households' access to electricity. Reliability of grid electricity is

considered a social factor because it is crucial for meeting households' basic needs and improving their quality of life (Dang & La, 2019). Access to a consistent power supply enables households to use different essential services and appliances, such as lighting, refrigeration, cooling or heating, communication and cooking devices (Hirmer & Guthrie, 2017). In addition, education level is categorised as a social factor because it influences the perceptions of the household members on the associated benefits of using grid electricity over alternatives (Etongo & Naidu, 2022; Rahut et al., 2017). On the other hand, income and connection cost were considered economic factors due to their influence on households' affordability of grid electricity, as discussed by Bhuiyan et al. (2022) and Moore et al. (2020).

Therefore, the study incorporated the above theoretical arguments into a general mathematical model specified as follows;

$$EA = f(P, Y, E, R) \quad (1)$$

Where:

***EA*** = Access to grid electricity among Ugandan households; ***P*** = initial connection costs to grid electricity; ***Y*** = income of households; ***E*** = education attainment of households' head; ***R*** = reliability of grid electricity.

### 1.8. Definition of Key Terms

***Grid electricity access*:** Energy access is defined as the ability to avail energy that is reliable, adequate, available when needed, affordable, of good quality, legal, healthy and safe, and convenient for all required energy services for households, community and productive uses (Tarekegne, 2020).

***Cost of initial connection:*** Initial connection costs involve the money paid to the service providers, Umeme, in this case, to extend electricity from the electric poles to the house. (Moore et al., 2020; Golumbeanu & Barnes, 2013).

***Education Attainment:*** The education attainment in this study is defined as the level of formal education a household head attained (Baatouche et al., 2022).

***Household Income***: Income is defined as interest, revenue or profit from anything (van Wyk Dippenaar, 2017).

***Reliability***: Reliability can be defined as the degree to which the customers enjoy an uninterrupted electricity supply. Since there are no known means of storing grid electricity, the reliability of its supply relies on the availability of generators, distribution and transmission networks to produce and transmit electricity in a real-time manner to consumers (Dugoua et al., 2022; Ferrall et al., 2022).

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

This chapter brings out the existing theoretical and empirical literature on socio-economic factors affecting grid electricity access by households. It brings out an appreciation of what has been done by other scholars on the variables under study and highlights limitations in existing literature or knowledge gaps that the current study addresses.

## 2.2 Theoretical Review

This study was anchored on two theories, Rational Choice Theory and Energy Ladder Theory, to support the understanding of how different socio-economic factors affect accessibility to grid electricity among rural households in Uganda.

### 2.2.1. Rational Choice Theory

Rational choice theory is a social science approach used to understand human behaviour by analysing how individuals make decisions based on their rational calculations of benefits and costs (Vlaev, 2018; Friedman & Hechter, 1988). The theory assumes that individuals are 'rational actors' who weigh carefully the possible outcomes of their actions and choose the course of action that maximises their utility or self-interest (Burns & Roszkowska, 2016). It further assumes that individuals or households possess evident preferences and have the cognitive abilities to assess the various options and their associated outcomes (Opp, 2020). For instance, the rational choice theory proposes that individuals tend to choose the alternative that offers them the highest expected utility, considering different factors such as financial costs, potential rewards and risks.

In this study, the rational choice theory's emphasis on individual decision-making based on rational calculations of benefits and costs shed light on how rural households make electricity access choices. For instance, the theory sheds light on how households compare the initial connection costs of grid electricity with the perceived benefits from the service, which influences their connection decisions. Further, the rational choice theory was adopted when explaining the influence of education level on electricity access. This is because household members with higher education levels may be more informed about the benefits of grid electricity, supporting rationality in their decision-making processes as compared to their counterparts, as discussed by Etongo and Naidu (2022); Kwan (2012); Rahut et al. (2017); Emmanuel & Japhet (2020). Lastly, the theory provided a lens for the researcher to explore how the reliability of grid electricity affects access since there is a high likelihood for households to consider the benefits and costs associated with unreliable or intermittent supply.

Rational Choice Theory faces several weaknesses which hinder its effective applications. For instance, critics assert that its assumptions of consistent preferences, perfect information, individual rationality and unrealistic do not capture the complexities of human decision-making (Hechter & Kanazawa, 1997). The theory often overlooks the influence of cultural and social factors on choices, neglecting the role of group dynamics, emotions, and social norms in shaping behaviour (Hechter & Kanazawa, 1997). In addition, the theory's focus on utility maximisation and self-interest oversimplifies human motivation since it fails to account adequately for moral or altruistic considerations (Herfeld, 2021). Thus, because of the aforementioned weaknesses associated with the ration choice theory, we opted to use it simultaneously with the energy ladder hypothesis.

### 2.2.2. Energy Ladder Theory

The energy ladder theory, also termed the energy ladder model, assumes that a household's choice of clean cooking solutions depends on their income level. This means that when households' income increases, there is a tendency to abandon less efficient energy-cooking solutions for cleaner ones hence climbing the energy ladder (Mainimo et al., 2022). The energy ladder consists of various fuel types, from the less efficient to the superior ones, demonstrated in the form of a hierarchy. These range from biomass, kerosene, and LPG to electricity; this kind of hierarchy justifies the argument that as households' level of income increases, they resort to more clean cooking solutions, which are ranked high in the rungs of the ladder. Essentially, the energy ladder model was chosen for this study due to its emphasis on the importance of income in influencing the households' choice of energy source. This indicates that as households' level of income increases, which is influenced by the education of the household members in most cases, they resort to more efficient clean energy sources and technologies, such as grid electricity. The 'energy ladder model' has been widely utilised as a theoretical and analytical framework to study the dynamics of fuel switching (Leach, 1992), making it relevant to this study in understanding the influence of income on electricity access among rural households.

However, the energy ladder theory's assumption that households rely on one type of fuel for cooking and that whenever their income level increases, they resort to more efficient fuels may not necessarily be the case (Mainimo et al., 2022).

## 2.3. Empirical Review

### 2.3.1. Grid Electricity Access

Universal electricity access is considered a vital component of inclusive and sustainable economic growth despite many households globally lacking fundamental energy services

(Bezerra et al., 2017). According to Bhattacharyya and Palit (2016), the 'cost-effective' universal electricity services pose a leading obstacle in attaining the 2030 universal electrification target, especially for the low developed countries. Although African governments have challenged their policy focus on grid-based energy access and supply, Walwyn and Hanlin (2022) report that many households still lie off-grid, calling for decentralised, affordable, and clean alternative energy solutions. Organisational, governance and financial weaknesses remain highlighted as the leading hindrances to the triumphant implementation of electricity projects in many nations (Bhattacharyya & Palit, 2016).

Besides, the low household access to grid electricity in sub-Saharan Africa has been linked to the growing demand for off-grid energy solutions, including micro-grids, due to the growing number of regional energy companies or sources involved in establishing viable distribution infrastructure (Walwyn & Hanlin, 2022). Similarly, the study by Ferrall et al. (2021) revealed that many nations with low energy access have resorted to “off-grid renewable energy sources”, causing substantial alterations in the energy landscape. However, Ferrall et al. (2021) argue that, despite the wide discussions on the “techno-economic” perspectives of electricity access, less attention has been paid to the political economy, especially in terms of bodies providing electricity services. Mainly, this study looked at Tanzania's electrification from a political economy perspective.

In most parts of sub-Saharan Africa, particularly in Uganda, grid expansion costs are generally considered high in rural areas due to low population density, a long distance from the main grids and the ragged geographical terrains of some regions (Fashina et al., 2019). Nevertheless, to increase the population's electricity access, many governments globally are adopting off-grid

options such as stand-alone solar panels and biogas digestors, cheaper than conventional technologies as grid-based electricity transitional.

### 2.3.2 Initial connection costs and grid electricity access

***$H_1$***: Initial connection cost has a relationship with grid electricity access among rural households in Uganda.

Golumbeanu and Barnes (2013) argue that Sub-Saharan Africa has the lowest electricity access rates for poor rural and urban residents globally. This undesirable performance can be attributed to multiple factors, such as higher investment costs, lower commercial viability associated with extending electricity services to rural areas and political encumbrance in utility policies (Golumbeanu & Barnes, 2013). However, one of the leading obstacles to access to electricity among households in the region is the high charges levied on consumers to connect their houses to the electricity network (Moore et al., 2020; Golumbeanu & Barnes, 2013). In the case of low-income countries, the high initial connection costs contribute to the delayed or lower connection to higher-tier energy sources, particularly grid electricity. This affects mostly communities or households that rely predominantly on seasonal income (Moore et al., 2020). Like Golumbeanu and Barnes (2013), Wabukala et al. (2023) also propose that adjustments to the initial connection costs and the existing 'electricity tariffs' could induce more households to connect to grid electricity. Thus, this could improve electricity security and the national electricity access rates.

According to Pueyo and Maestre (2019), households, mostly those headed by women and other individuals employed in the substance sector, find it unaffordable to afford connection fees or invest in electric appliances. Similarly, the study by Lee (2023) on “expanding access to electricity in Kenya” highlighted high connection costs, which are 2-3 three times higher than the 35,000 KES status quo connection prices, as among the leading factors hindering full access to

electricity among households in the country. Another study by Pueyo and Maestre (2019) on “energy access, gender and poverty" in Malawi highlighted high connection costs of US$ 5,000 (92,300 Kwacha) as another hindrance to grid electricity access despite the government's proposed program to connect more than 100,000 households for free by 2021.

Further, studies by Lee (2023) and Bonan et al. (2017) on the factors influencing grid electricity access in Kenya revealed connection fees as among the leading causes of low household access. For instance, Bonan et al. (2017) reported that Kenya's demand side of grid electricity and the scrapping off of the subsidies in terms of connection costs resulted in lower grid electricity uptake than earlier anticipated, that is 6% and 23% from 29% and 57% with subsidies. In addition, the study conducted on *"Effective Electrification Approaches in East Africa"* also indicated how connection fees are among the key challenges in electrification planning in the region, hindering the attainment of the electrification targets (Muchunku & Heinemann, 2023). On average, without subsidies, Uganda, Kenya and Tanzania require households to pay a connection fee of above $150, which the majority of rural households cannot afford (Muchunku & Heinemann, 2023). On the contrary, the connection fee in Ethiopia ranges between US$0-371, which is levied based on electricity consumption.

Uganda's "Electricity Connections Policy 2018-2027", advanced by the MEMD, provides a broader explanation of the strategies the government of Uganda intends to deploy in its pursuit of increased electricity connectivity as a means of ensuring universal access and the country's socio-economic transformation (Wabukala et al., 2022). The approved chart for "No Pole Service" is $160 (UShs. 580,000), including inspection fees and taxes (Muchunku & Heinemann, 2023). However, limited empirical research has been conducted yet to establish the relationship between initial connection costs and access to electricity in rural households. Nevertheless, 80%

of the country's households need help connecting to electricity due to high charges, especially in rural areas. Despite the government interventions with the support of development partners, such as the World Bank, African Development Bank and European Union to scale up electricity access through various programs, such as the Rural Electrification Program and EASP (Electricity Access Scale-up Project), high initial connection costs have remained persistent in the country's rural areas (Twesigye, 2019; International Trade Administration, 2022). Therefore, failure to address this challenge could hinder Uganda from attaining its Vision 2040 target of increasing the population with electricity access to 80% by 2040 (National Planning Authority, NPA, 2013).

### 2.3.3 Household income and grid electricity access

***$H_2$***: Income level of the household head has a relationship with rural households' access to grid electricity in Uganda.

Access to reliable and clean electricity is the backbone of any modern society. Blimpo and Cosgrove-Davies (2019) suggest that, for African nations to be transformed, governments should design and implement policies that aim to tackle the electricity issue head-on. However, constraints, such as 'irregular incomes, especially in Sub-Saharan Africa, remain among the major obstacles hindering access to electricity among households in the region (Blimpo & Cosgrove-Davies, 2019; Amoah et al., 2020). According to Bhuiyan et al. (2022), income growth poses both negative and positive effects on households' consumption of non-renewable and renewable energy. For instance, while the consumption of renewable energy, such as solar, hydroelectricity, and wind, was found to be high in higher-income economies, the trend was found to be low in the sub-Saharan African countries, characterised by low incomes (Bhuiyan et al., 2022). Similarly, from the "basic consumption theory", Amoah et al. (2020) argued that a

positive relationship exists between renewable energy consumption and the incomes of different economies. At the household level, the increase in per capita income induces individuals to enhance their comfort by spending extra income on “additional” modern energy services (Amoah et al., 2020).

The study conducted by Yaguma et al. (2022) revealed that 63% of Uganda's households in urban areas had access to the main grid as their primary source of electricity by 2020; however, this represents large disparities with the rural households, where less than 10% with access (International Trade Administration, 2022; UBOS, 2021). The low levels of access to grid electricity among rural households are directly linked to low incomes among the household members and repeated payment of monthly bills (Yaguma et al., 2022).

Similar to the households in Uganda's slum areas, low incomes and unaffordability of electricity compels rural households to resort to conventional energy sources, such as crop residues, torches, paraffin lantern, candles, and firewood for lighting and other energy needs regardless of their health and environmental threats (Sundararajan et al., 2022). Further, Ezor (2009) asserts that electrifying rural areas are less attractive to private businesses and the government due to the high costs of maintaining and implementing the facilities' generation, transmission and distribution networks. Many rural households consume small amounts of electricity, which raises the meter reading costs or administration expenses, making it less attractive to extend electricity infrastructure and services to such areas (Ezor, 2009). Therefore, without rural electrification subsidies or other forms of government assistance, it remains commercially undesirable for private utility firms like Umeme to distribute electricity to Uganda's rural areas.

### 2.3.4. Education and grid electricity access

***$H_3$***: Education levels of a household head have a relation to grid electricity access among rural households in Uganda.

The study by Etongo and Naidu (2022) on the "factors influencing households' adoption of solar energy technology in Seychelles" categorised education among the key determinants of households' income and other factors influencing the adoption of modern energy technologies. Household heads with formal education were found to have a 'greater awareness' of the benefits of using renewable energy sources, particularly solar PV (Etongo & Naidu, 2022). Nevertheless, while Kwan (2012) and Rahut et al. (2017) discuss the positive relationship between solar panel adoption and the level of education, De Groote et al. (2016) argue that the two do not have any direct relationship. In contrast, Etongo and Naidu (2022) further assert that variations in the education status, in the case of low-income households, explain differences in how people 'acquire and use' information regarding modern energy technology, such as solar PV and their related benefits. In this case, the less educated household heads tend to require more information and awareness on the associated benefits than their educated counterparts.

Several studies indicate the relationship between education outcomes and household access to electricity. For instance, Wagner et al. (2017) asserted that numerous economic and social benefits, such as increased access to public services, such as education, healthcare, security and street lighting, have been accompanied by increased electrification of the Tanzanian rural areas. Further, according to Daka and Ballet (2011), "access to education for all" is among the millennium objectives, and households' access to modern and reliable energy sources can influence the attainment of this objective. A study conducted in Pakistan in 1995 indicated that

neighbourhood electrification increased households' willingness to pay for education (Daka & Ballet, 2011).

The differences in education levels could be used to explain the wide gap in electricity access between Uganda's rural and urban areas (Kakuba et al., 2021; Wabukala et al., 2022). In the case of Uganda, education and access to electricity have a causal relationship. For instance, households headed by educated women were found to have greater access to modern electricity technologies than the less educated ones (Emmanuel & Japhet, 2020). On the other hand, greater access to electricity among Uganda's households was found to improve the quality of education (Faisal & Jakob, 2018). Households with access to electricity support revisions and homework for their children with minimal interruptions. Similarly, schools relying on modern electricity tend to support uninterrupted teaching and revision sessions (Faisal & Jakob, 2018). Nevertheless, the existing inequalities in access to electricity are likely to deny a section of Uganda's population the potential benefits, such as better employment, health and education outcomes.

### 2.3.5 Grid reliability and access to electricity

***$H_4$***: Reliability of grid electricity has a relationship with electricity access among rural households in Uganda.

The reliability of grid electricity guarantees a constant and uninterrupted supply of power to households in Uganda. However, power fluctuations and outages are prevalent in places with an unreliable grid, causing frequent interruptions in the availability of electricity (Nduhuura et al., 2021). These disruptions might linger for several days or even weeks, making it challenging for most households to access power to carry out their daily activities. For instance, most households use power to carry out daily tasks, including cooking, lighting, and operating electronic

appliances like televisions (Nduhuura et al., 2021). In addition, the opportunity cost between grid electricity and other sources is directly related to the grid's reliability. For instance, according to Kukumba (2021), most households in Uganda have resorted to alternatives like solar energy sources due to unstable grids. For example, approximately 26.7% of households obtain access to grid electricity as many homes frequently employ alternative energy sources like solar, diesel generators or kerosene lamps in places with unstable grids (Kakumba, 2021). These alternative sources, like generators, are more expensive and less efficient than grid electricity since they can operate for a few hours (Nduhuura et al., 2021). Consequently, rural households have greater energy costs, and with the greater expenses of power access, the poverty levels in rural areas become even worse.

Furthermore, the reliability of grid electricity is essential for advancing social progress and enhancing the quality of life. According to Blimpo and Cosgrove-Davies (2019), most households can utilise modern technologies like refrigeration for storing perishable foods and powering agricultural equipment when they can access dependable electricity. However, due to unreliable power grids, for instance, households may access insufficient electricity that can only light up bulbs but not refrigerators or fans (Blimpo & Cosgrove-Davies, 2019). Nonetheless, reliable grid electricity makes it easier to use communication devices, improving connectivity and information availability among households (Moore et al., 2020). Therefore, rampant power outages tend to discourage households from choosing grid electricity as their energy source, lowering its preference in Uganda's rural areas.

### 2.4. Summary of the Literature and Gaps/ Limitations in the Existing Studies

The reviewed literature highlights the different determinants of households' electricity access, such as political economy, vandalism, natural disasters, government policies, distances from grid

connection points, perceived benefits, and incomes. However, studies such as Lee (2023), Moore et al. (2020), Choudhuri & Desai (2020), among others, have investigated these issues from the regional perspective (that is, East Africa and Sub-Saharan Africa at large) or the notion of other countries, like Tanzania, Kenya, and Malawi. Further, Kwan (2012), Rahut et al. (2017), and Etongo and Naidu (2022) discuss the positive relationship between solar panel adoption and the level of education in Seychelles, which does not consider grid electricity access among rural households. In addition, the studies in the Ugandan context do not provide a broader explanation of the impact of household heads' education on access to grid electricity. Rather, studies such as Emmanuel and Japhet (2020) and Faisal and Jakob (2018) concentrated on the impact of electricity access on education, leaving behind a knowledge gap in establishing an empirical relationship between household heads' education and electricity access.

Besides, a study conducted by Wabukala et al. (2023) investigated the barriers to electricity access, mostly from theoretical perspectives. Nevertheless, empirical relationships should be established better to understand these factors and the magnitude of their influence. More so, the existing studies such as Ssennono et al. (2023) and Okoboi & Mawejje (2016) investigated the issue of electricity access from a general perspective, looking at different factors aggregating them at national levels. Therefore, the existing literature fails to establish quantitative correlations between different socio-economic factors and electricity access in the context of Uganda's rural households, creating a knowledge gap that this study intends to address.

# CHAPTER THREE

# METHODOLOGY

## 3.1 Introduction

This chapter describes the methods, approaches, and procedures that were adopted to carry out this study. It provides a comprehensive explanation of the research design, the data and its sources, model specification, data analysis procedures, and estimation techniques relied on.

## 3.2. Research Approach

The research approach or design serves as a basis for answering the research questions and fulfilling objectives as it involves the process of data collection, measurement and analysis (Cooper & Schindler, 2014). This study employed cross-sectional survey data and quantitative analytical approaches with the primary objective of answering the research questions. A quantitative approach was adopted in this inquiry because it is the most appropriate for hypothesis testing. The approach is also suitable for addressing the set objectives by manipulating the pre-existing statistical data (Saunders et al., 2009). The study leveraged the available cross-sectional survey data to determine the relationship between the different socio-economic factors, including household income, grid connection cost, reliability, education levels, and rural households' access to grid electricity in Uganda. The cross-sectional survey data was chosen for this investigation because it has broader coverage and captures detailed information about the topic under investigation. A descriptive and explanatory design was adopted primarily to explain the households' sample characteristics.

## 3.3. Data and Data Source

The study utilised the National Household Survey (UNHS) data collected by the Uganda Bureau of Statistics (UBOS) between 2019 and 2020, categorised as the cross-sectional data in the 7$^{th}$

series (UBOS, 2020). Field data collection was spread over a 12-month period to account for the seasonality factor. The UNHS 2019-2020 data was preferred because it is nationally representative (covering 13,732 households), comprehensive and recent. It reflected the most recent household characteristics, such as socio-economic indicators like income, gender, and education levels, which are major determinants of electricity access. Besides, the chosen cross-sectional data also supported detailed sub-grouping and disaggregated analysis, which facilitated the study on particularly rural households. Further, the UNHS 2019-2020 data provided relevant information on the background of the households under investigation, including household incomes, size, education, gender and age of the household head. It also gave useful information on the main sources for household lighting, including grid electricity coverage in Uganda's rural areas. Therefore, the UNHS survey data facilitated the empirical analysis by supporting the construction of the variables of interest.

### 3.3.1. Data quality

The 7$^{th}$ series of UNHS data was collected using internationally standardised data collection tools or approaches for handling surveys on a large scale. Computer-assisted Personal interviews (CAPI) were adopted during the collection process to ensure data quality. CAPI allows the data enumerators to use tablets to capture information, and data entry apps were installed on the gadgets to allow timely checks on the consistency of the data. Besides, the team leaders were fully engaged in executing different tests on the data in the field before transmitting it electronically for verification at UBOS headquarters in Kampala (UBOS, 2021).

## 3.4. Sample size or Number of observations.

The 2019/2020 UNHS targeted a population of 8,212,941 households across all the 129 districts and 15 sub-regions of Uganda at that time. The survey was based on the household population

and excluded the population in institutions, refugee camps, forest reserves, police and army barracks, and other special areas. A two-stage stratified sampling design was used. In the first stage, EAs were grouped by districts of similar socio-economic characteristicsand by rural-urban location. The EAs were then drawn using Probability Proportional to Size (PPS). In the second stage, households, which are the ultimate sampling units, were drawn using Systematic Random Sampling. A total sample of 15,786 households was selected for the 2019/20 UNHS sample, and 13,732 both urban and rural households were successfully interviewed, giving a response rate of 87 per cent. Therefore, this study considered a sample of 10,126 rural households with either access or non-access to grid electricity access.

### 3.4. Measurement of Variables Under Investigation

Table 1. **Measurement of study variables**

| Variable | Measurement |
|---|---|
| Grid electricity access (Independent variable) | Dummy (No = 1, Yes = 0) 0 was base |
| Income quintile | Ordered (1 = Poorest, 2 = poor, 3 & 4 = middle class, 5 = Rich) |
| Education attainment of household head | Categorical (1 =No formal education, 2= some primary, 3= completed primary, 4 = some secondary, 5= completed secondary, 6= post-secondary education) |
| Initial grid connection cost | Discrete |
| Reliability of grid electricity | Dummy (Unreliable = 1, Reliable = 0) |

### 3.5. Data Analysis Methods

The study adopted descriptive, correlation and regression analytical approaches to answer the research questions. For data analysis, the study used STATA software version 18.

### *3.5.1. Descriptive analysis:*

Descriptive statistics was used to describe and summarise the basic characteristics of the adopted dataset using the standard deviation and mean (Kaliyadan & Kulkarni, 2019). Calculating the mean of the sample helped the researcher gain insightful information that was applied accurately to the larger population (MacMillan et al., 2023). The standard deviation was also tabulated to determine how values were spread around the mean; a high S.D. indicates that the values are spread out, while a low S.D. indicates that the values are close to the mean.

### *3.5.2. Correlation analysis*

Correlation analysis was used to establish the relationship between the study variables of interest. Correlation helped in understanding the degree of association between two or more variables. The correlation coefficient (r) measures the strength of the association between the two variables. Where the relationship between the variables is not linear, the correlation coefficient does not adequately represent the strength of the relationship between the variables. The study considered the standard correlation coefficient (r), which ranges from -1 to 1. Where r = -1 indicates a perfect negative linear relationship between variables, r = 0 indicates no linear relationship between variables, and r = 1 indicates a perfect positive relationship between variables.

## 3.6 Empirical Model

The study employed a logit regression model to estimate the effect of household income, education, initial grid connection costs, and reliability on grid electricity access among households. A logit model was adopted because the outcome variable for this study – grid electricity access was measured as a dummy variable (that is, being equal to 1 if the household had no access to grid electricity for lighting/cooking, 0 otherwise). Unlike the probit model, the logit model was adopted for this study because it supports the use of large data sets and is

suitable for hypothesis testing. The logit model uses the maximum likelihood estimation approach after transforming the response variable into a logit. Therefore, the mean of the response variable provided an estimate of the probability of lacking access to grid electricity, thus allowing the dependent variable to be described as a function of explanatory variables derived from the data.

Before estimating the regression model, the data was first verified to ensure that they met the assumptions underlying the logit regression model, such as independence of errors, linearity of the logit, and absence of multicollinearity. Archer and Lemeshow (2006) argue that "once a logistic regression model has been fitted to a given set of data, the adequacy of the model is examined by overall goodness-of-fit tests". The specification error and goodness-of-fit tests ensure that the data support the estimation model. The logistic model assumes a 'logistic distribution function' employs the MLE (maximum likelihood estimation) procedure after transforming a response variable into a logit as presented below;

$$In\left(\frac{P_i}{1-P_i}\right) = X_i\beta \qquad (2)$$

Transforming equation (2)

$$P_i = \frac{e^{X_i\beta}}{1+e^{X_i\beta}} \qquad (3)$$

Where; $P_i$ represents the likelihood of occurrence of an event, in this case, implying a household has no access to grid electricity; $X_i$ represents a set of independent variables used in the model, such as income, reliability, initial connection costs, and education; e is a natural logarithm's base, while β is unknown parameters' vector to be estimated in the model.

Following previous studies (Carson, 2008), the model can be formulated as follows:

$$P_i = \frac{1}{1+e^{-X_i\,'\beta}} \quad (4)$$

A dummy variable was used to identify whether each sampled household is a grid electricity user or a non-user. $Y$ is a dichotomous dependent variable that indicates whether the household is a grid electricity user or not; a value of 1 means the household has no access to grid electricity, and a value of 0 indicates otherwise. Lastly, $X_i\,'$stands for independent variables that might affect the household decision to access grid electricity. The reduced form is given as the following:

$$Y_i = \beta_0 + \sum_{i=1}^{n} e^{X_i\,'\beta} + \varepsilon_i \quad (5)$$

The expanded form of the model is as follows;

$$\Pr(Y_i = 1) = \varphi(\beta_o + \beta_1 Inc_i + \beta_2 Educ_i + \beta_3 Cost_i + \beta_4 Rel_i + \beta_5 X_{ij} + \varepsilon_i) \quad (6)$$

Or

$$\boldsymbol{EA}_i = \beta_0 + \beta_1 Inc_i + \beta_2 Educ_i + \beta_3 Cost_i + \beta_4 Rel_i + \beta_5 X_{ij} + \varepsilon_i \quad (7)$$

Where; **Y*i* =1 or $\boldsymbol{EA}_i$** if household *i* has no access to grid electricity for lighting, 0 otherwise; **Φ(.)** is the logistic cumulative distribution function mapping the linear combination of predictor variables and their corresponding coefficients; $Inc_i$ = income of household $i$; $Rel_{ij}$ = reliability of grid electricity; $Educ_i$ = education level of the head in the household $i$; $Cost_i$ = initial connection costs to grid electricity for the household $i$; $X_{ij}$ a vector of other covariates and $\varepsilon_i$= the error term; $\beta_0$, $\beta_1$, $\beta_2$, $\beta_3$, $\beta_4$, $\beta_5$ = the corresponding coefficients for the independent variables.

### 3.7. Ethical Considerations

All research activities followed the ethical guidelines set by Makerere University and the Uganda Bureau of Statistics. Permission was sought before using or analysing particular documents. The gathered data was treated with confidentiality; where necessary, codes were used to recognise some documents.

# CHAPTER FOUR

# PRESENTATION AND INTERPRETATION OF FINDINGS

## 4.1 Introduction

This chapter presents the results and their interpretation in accordance with the study objectives. It includes a description of sample characteristics, pairwise correlation matrix, goodness of model fit, sensitivity test to confirm the robustness of the results and regression model.

## 4.2 Sample Characteristics

Table 2 presents the characteristics of the study sample. Overall, the analysis covered a total of 10,126 observations drawn from the 2019/202 UNHS dataset.

Table 2**. Descriptive statistics**

| **Variables** | **N** | **%age** | **Min** | **Max** |
|---|---|---|---|---|
| Reliability of Electricity | 1269 | 10.8 | 0 | 1 |
| Initial connection cost | 8146 | 63 | 0 | 1 |
| **Education Level of the HH** | | 0 | | |
| No formal education | 2,567 | 16.9 | 0 | 1 |
| Some primary | 5,056 | 36.3 | 0 | 1 |
| Completed primary | 1,773 | 13.3 | 0 | 1 |
| Some secondary | 2,024 | 15.2 | 0 | 1 |
| Completed secondary | 1,057 | 8.4 | 0 | 1 |
| Post-secondary plus | 1,163 | 9.8 | 0 | 1 |
| **Income levels** | | | | |
| Poorest Quintile | 2,659 | 16.4 | 0 | 1 |
| Q2 | 2,622 | 17.6 | 0 | 1 |
| Q3 | 2,670 | 19 | 0 | 1 |
| Q4 | 2,721 | 20.9 | 0 | 1 |
| Richest Quintile | 3,046 | 26.2 | 0 | 1 |
| **Sex of HH** | | | | |
| Female | 4,513 | 31.9 | 0 | 1 |
| Male | 9,219 | 68.1 | 0 | 1 |
| age | 13,732 | | 15 | 108 |
| **Region** | | | | |
| Central | 2,936 | 31.7 | 0 | 1 |
| Eastern | 4,287 | 22.9 | 0 | 1 |
| Northern | 3,362 | 21.1 | 0 | 1 |
| Western | 3,202 | 24.3 | 0 | 1 |
| **Sector of employment of the HH head** | | 0 | | |
| Not working | 3,131 | 20.5 | 0 | 1 |
| Agric. Forestry and fishing | 6,077 | 43.8 | 0 | 1 |
| Production | 1,135 | 8.5 | 0 | 1 |

| | | | | |
|---|---|---|---|---|
| Services | 3,481 | 27.2 | 0 | 1 |
| Total Observations | 10,126 | | | |

Analysis in Table 2 shows that, on average 10.8% of the rural households agreed that they had experienced reliability challenges with grid electricity supply in the community. Likewise, 63% of rural households reported that initial grid connection cost is a key challenge in accessing grid electricity. In addition, results in Table 2 show that 16.9% of the respondents had no formal education at all, 36.3% of the respondents had attained some primary level, 13.3% had completed primary level, and 15.2% had attained some secondary level education, 8.4% had completed secondary level education while 9.8% had completed post-secondary. Generally, the majority of the respondents had attained some primary-level education. This is in line with the national demographic characteristics, which show that the average number of years of schooling in Uganda is 7 (UBOS, 2022).

Respondents were asked to indicate their levels of income, and these were categorised into quintiles. Analysis in Table 2 reveals that, on average, 16.4% of the respondents belong to the poorest quintile, 17.6% were in the second quintile, 19% in the third quintile, 20.9% were in the fourth quintile while 26.2% were in the richest quintile. Further analysis reveals that, on average, 68.1% were male-headed while 31.9 were female-headed households. On average, the youngest and the oldest respondents were 15 and 108 years old, respectively. Analysis in Table 2 reveals the normal distribution of respondents across all four regions in Uganda. That is, the Central region had 31.7%, the Eastern region had 22.9%, the Northern region had 21.1%, and the Western region had 24.3%. Furthermore, results in Table 2 show that 20.5% of the respondents were not working, 43.8% were employed in agriculture, forestry and fishing activities, 8.5% were engaged in production activities, and 27.2% were in the service industry.

### 4.3. Correlations Between Variables

Table 3 presents the results of correlation analysis among the variables under study. The pairwise correlation coefficient (r) measures the strength of the association between the two variables. Where the relationship between the variables is nonlinear, then the correlation coefficient does not adequately represent the strength of the relationship between the variables. The study considered the standard correlation coefficient (r), which ranges from -1 to 1. Where r = -1 indicates a perfect negative linear relationship between variables, r = 0 indicates no linear relationship between variables, and r = 1 indicates a perfect positive relationship between variables. All the findings were found to be statistically significant at 10% ($p<0.1$).

Table 3. **Pairwise Correlations**

| Variables | (1) Initial Elect. cost | (2) Grid Reliability | (3) Education attainment | (4) Wealth Quintiles | (5) Sex of HH | (6) Age of HH | (7) Region | (8) Sec. of Employment | (9) Grid electricity access |
|---|---|---|---|---|---|---|---|---|---|
| (1) Initial Elect. cost | 1 | | | | | | | | |
| (2) Grid Reliability | -0.047* | 1 | | | | | | | |
| (3) Educ. attainment | 0.031* | -0.019* | 1 | | | | | | |
| (4) Wealth Quintiles | 0.024* | -0.036* | 0.0371* | 1 | | | | | |
| (5) Sex of Head | 0.029* | 0.005 | 0.270* | 0.027* | 1 | | | | |
| (6) Age of head | 0.048* | -0.015 | -0.238* | -0.044* | -0.153* | 1 | | | |
| (7) Region | -0.037* | -0.012 | -0.154* | -0.171* | -0.015 | 0.039* | 1 | | |
| (8) sector of Employment | -0.024* | -0.037* | 0.318* | 0.276* | 0.118* | -0.293* | -0.162* | 1 | |
| (9) Grid access | 0.042* | 0.070* | -0.365* | -0.412* | 0.006 | 0.094* | 0.304* | -0.273* | 1 |

Significance level *** p<0.01, ** p<0.05, * p<0.1

Table 3 shows that the correlation value for pair each of the independent variables was less than 0.30 or ($0.0 \leq |r| \leq 0.30$), implying a weak correlation between independent variables (Asuero et al., 2006). The correlation results suggest that the independent variables used for the estimation showed no serious multicollinearity.

### 4.4. Model Fit Test

Before making any statistical inference and estimating the main model, there is a need to check for model fit and influential observations that may affect the coefficient estimates. The results may be misleading if the researcher fails to verify whether the data meets the assumptions underlying the logit regression model adopted or not. According to Archer and Lemeshow (2006), the adequacy of the model can be assessed and examination of influential observations by overall goodness-of-fit tests, which is the area under the receiver operating characteristic curve after fitting a logistic regression model to a given set of data. Therefore, the following diagnostics were performed for the binary logistic regression analysis model: specification errors test, goodness-of-fit for survey data test and sensitivity of the model as presented in ***Table 4*** and ***Fig. 2.***

Table 4. **Model specification**

| | | Linearised | | | | |
|---|---|---|---|---|---|---|
| access | Coefficient | std. err. | t | P>t | [95% conf. | interval] |
| _hat | 1.020 | 0.055 | 18.610 | 0.000 | 0.912 | 1.127 |
| _hatsq | -0.007 | 0.013 | -0.500 | 0.615 | -0.033 | 0.019 |
| _cons | 0.000 | 0.076 | 0.000 | 0.999 | -0.149 | 0.149 |

*Note: The specification error test was performed using the link test command in Stata18, which is implemented as follows: after fitting the logit model under svy, obtain the fitted values (hat) and their square (hatsq) and then run a logit model with hat and its square as the covariates. The significance of hatsq is the link test. The model is correctly specified and a good fit if the differences between the observed and fitted values are small and significant and if there is no systematic contribution of the differences to the error structure of the model.*

***Table 4*** explains the model specification, which looks at different factors affecting the dependent variable (grid electricity access). The model adopted for this study was found to be statistically

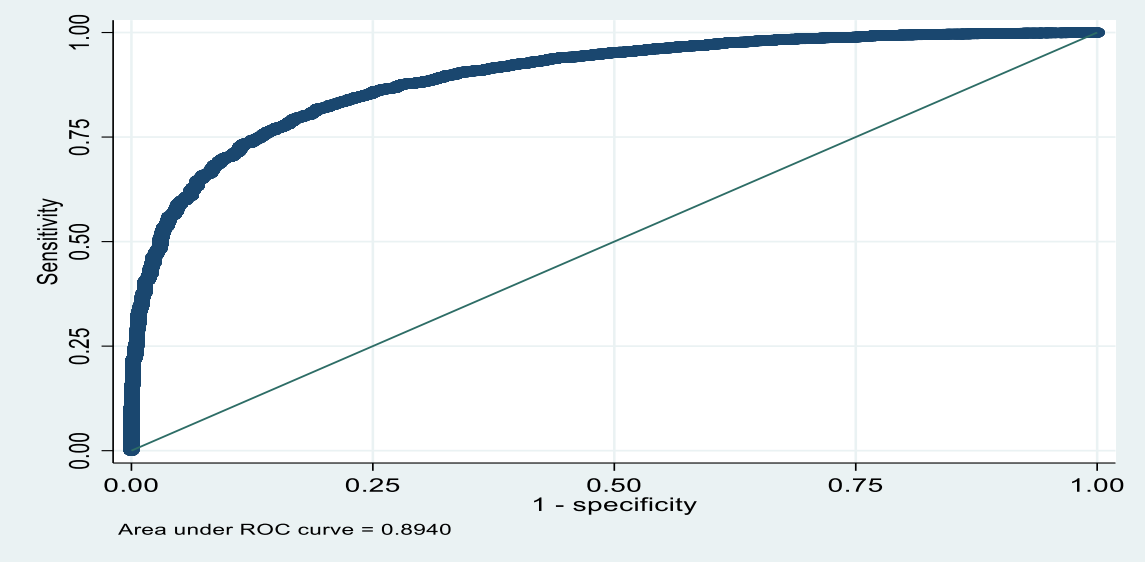
significant at 95% (p<0.05). **_hat** represents all the specified independent variables in the model. That is the educational attainment of the household head, cost of initial connection, reliability of electricity, wealth quintiles, sex of the household head, age of the household head, sector of employment and region of the household. While **_hatsq** represents all other determinants of rural households' access to grid electricity or variables that may affect the model.

According to the P-Value, **_hat** is statistically significant at 5% (P>t = 0.000). This implies that all the fitted values (variables) in the model affect the grid electricity access among rural households. Contrarily, the **_hatsq** was found to be statistically insignificant at 5% (P>0.615), which means that all the other unfitted values do not affect the model. Therefore, the model was fully specified.

### 4.5. Sensitivity analysis

ROC curve offers a visual evaluation of the performance of the binary classification model used. It shows how well they balance between false and true positives across different threshold settings considered in this study.

**Figure 2. ROC curve**



The ROC curve in ***Fig. 2*** shows FPR (the false positive rate) on the x-axis and TPR (the true positive rate) on the y-axis. The diagonal line from (0,0) to (1,1) represents a random classifier with no discrimination power (see ***Fig. 1***). Since the ROC curve above the diagonal line, rising vertically towards the left, then horizontally along the top, that is, TPR = 1, FPR = 0, it implies that the chosen model is better than random. This means that the model is stable and not sensitive to data changes.

### 4.5. Regression Results

Regression model analysis helps researchers understand and quantify the relationship between one or more explanatory variables and an explained variable. It enables researchers to identify significant predictors, make predictions, and evaluate the strength and direction of these relationships. Therefore, by modelling these associations in this study, we could make predictions, test hypotheses, and draw meaningful conclusions. This enabled us to provide valuable insights into the socio-economic factors influencing rural households' grid electricity access.

Table 5. **A summary of the logistic regression analysis**
Survey: Logistic regression

| | |
|---|---|
| Number of strata = 15 | Number of obs. = 10,126 |
| Number of PSUs = 1,530 | Population size = 8,212,941 |
| | Design df = 1,515 |
| | F (20, 1496) = 56.37 |
| | Prob > F = 0.0000 |

| **VARIABLES** | **Marginal effects** | **se** |
|---|---|---|
| Reliability of Electricity | 0.017*** | (0.005) |
| Cost of Initial Electricity | 0.053*** | (0.012) |
| **Educational of HH head (No formal education)** | | |
| Some primary | -0.006 | (0.004) |
| Completed primary | -0.011* | (0.006) |
| Some secondary | -0.052*** | (0.010) |
| Completed secondary | -0.069*** | (0.013) |

| | | |
|---|---|---|
| Post-secondary plus | -0.093*** | (0.014) |
| **Income levels (Poorest Quintile)** | | |
| Q2 | -0.014*** | (0.004) |
| Q3 | -0.033*** | (0.006) |
| Q4 | -0.067*** | (0.008) |
| Richest Quintile | -0.136*** | (0.012) |
| **Household head x-tics** | | |
| Sex of HH head(female) | 0.018*** | (0.004) |
| Age of HH head | -0.001 | (0.001) |
| Age of HH head squared | 0.001 | (0.001) |
| **Region (Central)** | | |
| Eastern | 0.091*** | (0.013) |
| Northern | 0.113*** | (0.013) |
| Western | 0.096*** | (0.013) |
| Employment status (Not working) | | |
| Agric. Forestry and fishing | 0.040*** | (0.006) |
| Production | -0.010 | (0.011) |
| Services | -0.009 | (0.008) |

Robust standard errors in parentheses
Levels of significance: * p<0.1, ** p<0.05, *** p<0.01

***Table 5*** summarises the logistic regression results and the model's statistical significance.

The primary aim of this inquiry was to examine the socio-economic factors influencing access to grid electricity by rural households in Uganda. While grid electricity access was categorised as an explained variable, socio-economic factors such as reliability of electricity, educational attainment of household head, cost of initial electricity, income levels, and other control variables like age of household head, sex of household head, region, and employment status of the household head.

### 4.5.1. Initial grid connection costs and grid electricity access

The results in Table 5 reveal that there is a positive (0.053) and statistically significant ($p<0.01$) relationship between the cost of initial electricity connection and non-access to grid electricity. This means that an increase in the initial connection costs increases the likelihood of non-access to grid electricity among rural households by 5.3%. In other words, a unit increase in the initial cost of connecting to grid electricity is associated with a 5.3% increase in the probability of rural

households not connecting to grid electricity. These findings suggest that initial grid connection cost has a strong direct effect on grid electricity access by rural households. This finding provides evidence in support of the first hypothesis (**$H_1$**), which postulated that initial connection cost has a relationship with grid electricity access among rural households in Uganda.

### 5.5.2 Household income and grid electricity access

The study stratified rural households according to their wealth quintiles. That is the poorest quintile, poor quintile (*Q2*), middle-class quintile (*Q3*), rich quintile (*Q4*) and richest quintile. Results in Table 5 show a strong negative and statistically significant ($p<0.01$) relationship between household income and non-access to grid electricity. Taking the poorest quintile as the base, we observe that an increase in household income reduces the likelihood of non-access to grid electricity among rural households. Specifically, results suggest that belonging to the poor quintile (*Q2*) reduces the probability of non-access to grid electricity by 1.4% compared to the poorest quintile. Likewise, belonging to the third (Q3), fourth (Q4), and richest quartile reduces the likelihood of non-access to grid electricity by 3.3%, 6.7% and 13.6%, respectively, compared to those in the poorest income quintile. The study findings imply that rural households with higher incomes are less likely to lack access to grid electricity compared to rural households with lower income levels. The findings provide sufficient evidence to support the second hypothesis **($H_2$)** that household income has a relationship with rural households' access to grid electricity in Uganda.

### 4.5.3 Education attainment of household head and Grid electricity access

The study stratified education levels of household heads into six groups: no formal education, some primary, completed primary, some secondary, completed secondary, and post-secondary plus. Results in Table 5 show a strong negative and statistically significant ($p<0.01$) relationship

between the household head's education level and non-access to grid electricity. Taking no formal education as the base, we observe that an increase in the household head's education level reduces the likelihood of non-access to grid electricity among rural households. Specifically, results suggest that household heads with some primary level of education compared to those with no formal education have a lower probability of lacking access to grid electricity by 0.6%.

Similarly, completing primary, attaining some secondary, completing secondary, and post-secondary plus levels by household heads reduces the likelihood of non-access to grid electricity by 1.1%, 5.2%, 6.9% and 9.3%, respectively, compared to those with no formal education. The study findings imply that rural household heads with higher education levels are less likely to lack access to grid electricity compared to household heads with no formal education. The findings provide sufficient evidence to support the third hypothesis ($\mathbf{H_3}$) that the education level of a household head has a relationship with grid electricity access among rural households in Uganda.

### 5.5.4 Reliability of grid supply and grid electricity access.

In this study, reliability was measured in terms of the frequency of power blacks or interruptions experienced by grid-connected households in rural areas. Results in Table 5 show a positive (0.0170) and statistically significant ($p < 0.01$) relationship between grid reliability and non-access to grid electricity among rural households. Implying that increase in grid power blackouts increases the likelihood of non-access to grid electricity among rural households by 1.7%. In other words, an unreliable grid power supply increases the probability of rural households in Uganda not having access to grid electricity. This finding aligns with the fourth hypothesis ($\mathbf{H_4}$) that the reliability of grid electricity has a relationship with electricity access among rural households in Uganda.

### 5.5.6 Selected Control Variables

Results in Table 5 show that female-headed households have a positive (0.018) and statistically significant (0.01) relationship with non-access to grid electricity. Taking male-headed households as a base, we observe that rural households being headed by females increase the likelihood of non-access to grid electricity access by 1.8%. Implying that female-headed rural households have lower access to grid electricity than those headed by their counterparts.

In addition, results in Table 5 show a positive and statistically significant ($p<0.01$) relationship between the region of the household and non-access to grid electricity. Taking the Central region as a base, we observe that households being located in other regions of the country increase their probability of non-access to grid electricity. Particularly, the results suggest that households located in Eastern Uganda increase their likelihood of non-access to grid electricity by 9.1% compared to those in the central region. Likewise, being located in the Northern and Western regions of Uganda increases households' chances of lacking access to grid electricity by 11.3% and 9.6%, respectively, compared to those located in the Central region. These findings imply that rural households in the Central region have greater access to grid electricity than those in other regions of the country.

In terms of employment statuses, results in Table 5 show that being employed in "Agriculture, Forestry, and Fishing" has a positive (0.040) and statistically significant ($p<0.01$) relationship with grid electricity access. Considering not working as a base, we observe that household heads being employed in agriculture, forestry, or fishing increases their likelihood of non-access to grid electricity by 4%. Implying that rural households with their heads employed in either one of the aforementioned sectors are associated with a 4% probability of not connecting to grid electricity.

# CHAPTER FIVE

# DISCUSSION OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

## 5.1. Introduction

This chapter presents a discussion of the findings, conclusion, recommendations, and areas for further investigation.

## 5.2. Discussion of Results

This sub-section entails comprehensive discussions of the study results in line with the set research-specific objectives and their respective hypothesis as follows;

The following specific research objectives guided the inquiry;

i. To examine the relationship between initial grid connection costs and non-access to grid electricity among rural households in Uganda.
ii. To investigate the relationship between household income and non-access to grid electricity among rural households in Uganda.
iii. To examine the relationship between the educational attainment of household heads and non-access to grid electricity among rural households in Uganda.
iv. To investigate the relationship between the reliability of grid electricity and non-access electricity access among rural households in Uganda.

Table 6. **Supported/ non-supported hypotheses by study results**

| Hypothesis Statement(s) | Supported | Rejected |
|---|---|---|
| $H_1$: Initial connection cost has a positive relationship with non-access to grid electricity among rural households in Uganda. | **Yes** | **No** |
| $H_2$: Household income has a negative relationship with rural households' non-access to grid electricity in Uganda. | **Yes** | **No** |
| $H_3$: Education attainment of a household head has a negative relationship with non-access to grid electricity among rural households in Uganda. | **Yes** | **No** |
| $H_4$: Reliability of grid electricity has a positive relationship with non-access to grid electricity among rural households in Uganda. | **Yes** | **No** |

### 5.2.1. Initial grid connection costs and non-access to grid electricity access

The study results reveal a positive and significant relationship between initial electricity connection fees and rural households' access to grid electricity. This finding aligns with the first hypothesis ($H_1$); hence, hypothesis one is supported. This implies that the initial connection cost significantly influences rural households' access to grid electricity. Implying that as initial connection costs increase, the likelihood of rural households lacking access to grid electricity increases as well. The approved chart for "No Pole Service" is $160 (UShs. 580,000), including inspection fees and taxes (MEMD, 2018). However, the data collected from the Uganda National Housing and Population Census 2014 projected that 85% of Uganda's population lives in rural areas and dwells on subsistence activities for survival (UBOS, 2014). High initial connection costs make access to electricity unaffordable to most of these households. Nevertheless, Golumbeanu and Barnes (2013) and Wabukala et al. (2023) suggest that in order to increase the grid electricity access, the government of Uganda should implement some adjustments in the initial connection costs and the existing 'electricity tariffs' to induce more households to demand electricity connectivity.

Further, according to Twesigye (2019) and International Trade Administration (2022), around 80% of Uganda's households need help connecting to electricity due to high charges, especially in rural areas. Despite the government interventions with the support of development partners, such as the World Bank, African Development Bank and European Union, to scale up electricity access through various programs, such as the Rural Electrification Program and EASP, no significant changes have been achieved (Twesigye, 2019). Therefore, failure to address this challenge will likely hinder Uganda from attaining its Vision 2040 target of increasing the population with electricity access to 80% by 2040 (Vision, 2040).

Further, the study's results are confirmed by other empirical studies outside Uganda, such as the study conducted by Lee (2023) on "expanding access to electricity in Kenya" and the study by Pueyo and Maestre (2019) on "energy access, gender and poverty" in Malawi. Both investigations found connection fees among the barriers to households' access to grid electricity. Like the Ugandan government policy on free connection, Pueyo and Maestre (2019) argue that despite the government of Malawi's efforts to connect over 100,000 freely to grid electricity, the policy remains ineffective since it covers only a proportion of households, leaving others without access. In addition, the positive relationship between initial connection costs and grid electricity non-access aligns with the Rational Choice theory assumption, which states that individuals or households tend to choose the alternative that offers them the highest expected utility, considering different factors such as financial costs, potential rewards and risks (Opp, 2020). Therefore, like the findings of existing empirical studies, this inquiry discovered that rural households with less income cannot pay for prevailing connection costs, thus increasing their likelihood of not accessing grid electricity.

### 5.2.2. Household income levels and non-access to electricity

The study results show an inverse and significant relationship between the income or wealth of the household head and the lack of access to grid electricity among rural households in Uganda. This finding aligns with the first hypothesis ($H_2$); hence, hypothesis one is supported. The findings suggest that as the income of the household head increases, that is, from lower to upper quintiles, there is a proportionate reduction in the likelihood of rural households lacking access to grid electricity. The low levels of access to grid electricity among rural households can be linked directly to low incomes among the rural household members (mainly engaged in substance or informal economic activities), which makes the initial connection costs and repeated payment of monthly bills complex for them (Yaguma et al., 2022). Similar to the households in Uganda's slum areas, low incomes and unaffordability of electricity compels rural households to resort to conventional energy sources, such as crop residues, torches, paraffin lantern, candles, and firewood for lighting and other energy needs regardless of their health and environmental threats (UBOS, 2021).

Furthermore, the study results on the relationship between household income and grid electricity access align with other findings from empirical studies conducted in other countries and at a continental level. These include Amoah et al. (2020) on "*Renewable energy consumption in Africa"* and Blimpo and Cosgrove-Davies (2019) on *"Electricity access in sub-Saharan Africa."* These studies highlight the positive influence of income on energy consumption, which drives energy access. Similarly, from the "basic consumption theory", Amoah et al. (2020) argued that a positive relationship exists between renewable energy consumption and the incomes of different economies. In addition, this particular finding relates to the theoretical perspectives, especially the Energy Ladder Hypothesis. In line with the findings, the theory assumes that a household's

choice of clean cooking solutions depends on their income level, which means that when households' income increases, there is a tendency to abandon less efficient energy cooking solutions for cleaner ones, hence climbing the energy ladder (Mainimo et al., 2022). Therefore, this study reveals that rural households with higher income or wealth are more likely to resort to more efficient clean energy sources and technologies, such as grid electricity.

However, this particular finding contradicts a study by Yaguma et al. (2022), which suggests that rural households' access to grid electricity remained low even in urban areas with higher household incomes. Similarly, Bhuiyan et al. (2022) assert that income growth poses both negative and positive effects on households' consumption of non-renewable and renewable energy. At the household level, the increase in per capita income induces individuals to enhance their comfort by spending extra income on "additional" modern energy services (Amoah et al., 2020). Therefore, as household heads' incomes increase, they diversify energy sources, such as substituting unreliable and inaccessible grid electricity with solar and biogas, as Kukumba (2021) argued.

### 5.2.3. Education level of the household head and non-access to grid electricity

The study results revealed a negative and significant relationship between the education level of a household head and the likelihood of non-access to grid electricity among rural households in Uganda. This finding is in line with the first hypothesis ($H_3$); hence, hypothesis one is supported. The inverse relationship between the predicted and predictor variables signifies that rural household heads with higher levels of education are associated with less likelihood of lacking access to grid electricity compared to those with lower education levels. This particular study finding conforms with the existing body of knowledge about the differences in education levels and their influence on the wide gap in electricity access between Uganda's rural and urban areas

(Kakuba et al., 2021; Wabukala et al., 2022). Most households headed by educated women in Uganda were found to have greater access to modern electricity technologies than the less educated ones (Emmanuel & Japhet, 2020). On the other hand, greater access to electricity among Uganda's households was found to improve the quality of education (Faisal & Jakob, 2018). Households with access to electricity support revisions and homework for their children with minimal interruptions.

Further, the results are supported by the existing literature and theoretical perspectives. For instance, the findings conform with the rational choice theory assumption that individuals tend to choose the alternative that offers them the highest expected utility, considering different factors such as financial costs, potential rewards and risks (Burns & Roszkowska, 2016). This implies that rural household heads with higher education levels can understand the financial costs, potential rewards and risks associated with using grid electricity for lighting and cooking compared to other energy sources. In addition, from the Energy Ladder Hypothesis perspective, household heads with higher education levels have access to higher income opportunities, thereby supporting them in adopting more efficient energy technologies (increased access to grid electricity).

Additionally, the results from this inquiry are further supported by the empirical literature or studies conducted in other countries. These include the study by Etongo and Naidu (2022) on the *"factors influencing households' adoption of solar energy technology in Seychelles";* Rahut et al. (2017) discuss "*the use and determinants of solar energy by Sub-Saharan African households."* Rahut et al. (2017) categorised the level of education of household members among the key determinants of household income and other factors influencing the adoption of modern energy technologies. Similarly, household heads with formal education were found to have a 'greater

awareness' of the benefits of using renewable energy sources, particularly solar PV (Etongo & Naidu, 2022). Nevertheless, unlike the existing empirical studies which assessed the determinants of solar PV adoption, the current research only looked at social and economic factors influencing access to grid electricity and their respective relationships, particularly among rural households in the country, using a quantitative research approach.

### 5.2.4. Reliability of grid electricity and lack of access to grid electricity

The study results reveal a positive and significant relationship between grid reliability, in terms of power blackouts, and rural households' non-access grid electricity. This finding is in line with the first hypothesis ($H_4$); hence, hypothesis one is supported. This implies that an unreliable grid power supply increases the probability of rural households in Uganda not having access to grid electricity. On the other hand, an increase in the reliability of grid power supply, that is, fewer cases of power blackout, reduces the possibility of non-access to grid electricity among rural households. In Uganda's context, power fluctuations and outages are prevalent in places with an unreliable grid, such as rural areas, which causes frequent interruptions in the availability of electricity (Nduhuura et al., 2021). In most cases, the disruptions tend to linger for several days or weeks, making it challenging for most households to access power to carry out their daily activities. For instance, the study by Nduhuura et al. (2021) discovered that most households use grid electricity to carry out daily tasks, including cooking, lighting, and operating electronic appliances like televisions. According to Kukumba (2021), most households in Uganda have resorted to alternatives like solar energy sources due to unstable grids. For example, approximately only 26.7% of households have access to grid electricity as many homes frequently employ alternative energy sources like solar, diesel generators or kerosene lamps in places with unstable grids (Kakumba, 2021).

More so, this revelation aligns with the arguments of the existing literature and the Rational Choice theory assumption that individuals or households tend to choose the alternative that offers them the highest expected utility, considering different factors such as financial costs, potential rewards and risks (Opp, 2020). Like Nduhuura et al. (2021), this study found that unreliable power supply leads households to opt for alternative energy sources, hindering poverty alleviation efforts and increasing costs. This finding is consistent with the emphasis of the existing empirical studies on reliable electricity supply in a study by Blimpo and Cosgrove-Davies (2019). This study found the reliability of electricity as a major driver determining energy choices among households and other consumers.

**5.2.5. Selected control variables**

The findings indicate that gender differences (in terms of sex) significantly influence grid electricity access among rural households in Uganda. The data revealed that rural households headed by women have higher odds of lacking access to grid electricity than male-headed households. The study's findings align with the results of Akeyo et al. (2021) and Etongo & Naidu (2022), which discuss that despite women's support for renewables, gender disparities persisted in rural areas due to limited income-generating opportunities for women. Nonetheless, the findings contradict empirical studies such as Choudhuri and Desai (2020) and Moore et al. (2020), highlighting the importance of gender norms in energy consumption patterns.

The study revealed that, among different employment sectors, rural households with heads engaged in agriculture, forestry, and fishing activities were more likely to experience non-access grid electricity. On the contrary, rural household heads employed in the services and production sectors were found to be linked to lower odds of experiencing non-access to grid electricity. This finding could be linked to the differences in income and education of rural household heads,

which result in different grid electricity access levels among households, mainly due to affordability and perceived benefits (Amoah et al., 2020; Yaguma et al., 2022 and Etongo and Naidu, 2022).

Further, the study revealed substantial regional variations in grid electricity access where rural households in the Western, Eastern, and Northern regions had higher odds of lacking access to grid electricity than the Central region. The regional disparities in access to grid electricity can be attributed to differences in poverty levels. For instance, according to the "poverty status report 2021" by MoFPED (2023), the Northern region had a high poverty rate (35.92%), followed by the Eastern region (29.2%), Western Uganda (14.43%) and Central region (8.73%). Implying that besides the central region having well-developed grid electricity infrastructure, households have higher access to income opportunities than those from other regions, which increases their accessibility and reliability.

### 5.2. Conclusion

Uganda is among countries globally with low electricity access at only 26%, and over 90% of rural households lack access to clean and reliable electricity sources. Therefore, this study investigated the different social and economic factors influencing rural Ugandan households' access to grid electricity. Particularly, the study investigated the existing relationship between rural households' grid electricity access and different socio-economic factors such as household heads' incomes, levels of education, reliability and electricity connection costs. The investigation was anchored on two theories, Energy Ladder and Rational Choice Theoretical assumptions, to determine the relevancy of its findings.

Further, the study utilised a rigorous methodology, including descriptive analysis, correlation analysis, and logit regression models, to test hypothesis statements comprehensively. In addition,

diagnostic tests or experiments were conducted to validate the used models. Tests like pairwise correlation analysis, specification error test and ROC curve to test for multicollinearity, model significance and model stability, respectively. Through a comprehensive analysis of National Household Survey (UNHS) data 2019/2020, this study sheds useful insights on how socio-economic factors such as income, reliability, sex or gender, education level, and connection costs influence the likelihood of rural households accessing grid electricity.

The study findings have significant implications for policymakers, development practitioners and scholars striving to improve rural electricity access. The analysis revealed significant positive and negative relationships between numerous socio-economic factors and rural households' likelihood of non-access to grid electricity. For instance, the investigation discovered that the household head's income and education level have negative and significant relationships with the odds of lacking access to grid electricity among rural households. These were attributed to household heads' ability to afford connection costs, monthly electricity bills and access to information to understand the benefits associated with the use of grid electricity over conventional means.

On the other hand, the initial grid connection costs and reliability were found to be positively and significantly related to the likelihood of non-access to grid electricity access among rural households in Uganda. These positive relationships were attributed to the facts that an increase in initial electricity connection costs and reliability (in terms of power blackouts) makes grid electricity unaffordable to the majority of low-income households, which compels them to resort to alternative non-renewable sources of energy such as charcoal, kerosene lamps, firewood, and candles. Generally, the study findings contribute to a better comprehension of the complex

dynamics surrounding rural electricity access in Uganda and shed light on the areas in need of targeted interventions.

### 5.3. Recommendations

Based on the study findings, the following recommendations are proposed to the concerned stakeholders in Uganda's energy industry.

The findings indicate a positive relationship between electricity reliability and non-access to grid electricity among rural households. Therefore, the government of Uganda should invest more resources to ensure reliability in grid electricity supply. This may involve maintenance, upgrades, and technology investments to minimise disruptions. The efforts to enhance the reliability of electricity supply in rural areas are crucial in increasing electricity access among rural households.

Besides, findings indicate that access to grid electricity increases with an increase in households' levels of education. Thus, the government of Uganda and the private sector involved in the energy industry should increase awareness and sensitisation campaigns about the benefits of grid electricity over traditional energy sources. This will accelerate access to information by different household members and change their perception of grid electricity. The sensitisation can be done through media houses, such as radio, television, school campaigns, and local and religious leaders.

Further, the study found that income significantly influences grid electricity access among rural households by influencing households' ability to pay initial electricity connection fees and regular bills. Therefore, the government should initiate income-generating opportunities, such as soft loans, credit on electrical appliances, and increasing funds in agricultural, fishing and

forestry sectors to support members of rural households to gain reliable incomes to afford basic needs, such as clean and reliable electricity.

### 5.4. Areas of future research

The current study was confined to social and economic factors influencing grid electricity access among rural households in Uganda. However, this study opens avenues for further inquiries into specific aspects of grid electricity access, such as the impact of cultural factors, environmental considerations, and the effectiveness of implemented interventions. Therefore, longitudinal studies are recommended due to their ability to track households' characteristics or electricity consumption behaviours over time. Such investigations could provide insights into the dynamics of electricity access and how changes in socio-economic factors impact access over the long term. The future study findings could offer a more meticulous understanding of the causal relationships between grid electricity access and socio-economic factors.

### 5.5. Limitations of the Study and their Remedies

The study was limited by the validity and reliability of the existing documents available. This challenge was addressed by obtaining data from only reliable sources, such as digital libraries like Google Scholar, the government and its departments' websites, and research institutions like UBOS, NPA, ERA, Umeme, and MEMD. Lastly, time and financial resources constrained the study to secondary data sources instead of primary. Nonetheless, the limitation was addressed by using only available secondary data (UHHS 2019-2020), which was accessed easily from UBOS.

## REFERENCES


Aarakit, S. M., Ntayi, J. M., Wasswa, F., Buyinza, F., Adaramola, M. S., & Ssennono, V. F. (2022). The role of financial inclusion in the adoption of solar photovoltaic systems: A case of Uganda. *Renewable Energy, 198,* 984–998.

Akeyo, O.M., Patrick, A., & Lonel, D.M. (2021). Study of renewable energy penetration on a benchmark generation and transmission system. *Energies, 14*:169. https://doi.org/10.3390/en14010169.

Amoah, A., Kwablah, E., Korle, K. & Offei, D. (2020). Renewable energy consumption in Africa: the role of economic well-being and economic freedom. *Energ Sustain Soc 10*(32). https://doi.org/10.1186/s13705-020-00264-3

Andrade-Pacheco, R., Savory, D. J., Midekisa, A., Gething, P. W., W. Sturrock, H. J., & Bennett, A. (2019). Household electricity access in Africa (2000–2013): Closing information gaps with model-based geostatistics. *PLOS ONE, 14*(5), e0214635. https://doi.org/10.1371/journal.pone.0214635

Archer, K. J., & Lemeshow, S. (2006). Goodness-of-fit Test for a Logistic Regression Model Fitted using Survey Sample Data. *The Stata Journal.* https://doi.org/10.1177/1536867X0600600106

Archer, K.J., Lemeshow, S. & Hosmer, D.W. (2006). Goodness-of-fit tests for logistic regression models when data are collected using a complex sampling design. *Computational Statistics and Data Analysis, 51*, 4450-4464.

Asuero, A.G., Sayago, A. & González, A. (2006). The correlation coefficient: an overview. *Critical Reviews in Analytical Chemistry, 36,* 41-59. http://dx.doi.org/10.1080/10408340500526766

Baatouche, N., de Maricourt, P., & Bernaud, J. (2022). Meaning of education and wellbeing: understanding and preventing the risk of loss of meaning in students. *Frontiers in Psychology, 13,* 796107. https://doi.org/10.3389/fpsyg.2022.796107

Behera, B., Ali, A., & Marenya, P. (2017). A ladder within a ladder: Understanding the factors influencing a household's domestic use of electricity in four African countries. *Energy Economics, 66*, 167-181.

Bezerra, P.B., Callegari, C.L., Ribas, A., Lucena, A., Portugal-Pereira, J., Koberle, A., Szklo, A, & Schaeffer, R. (2017). The power of light: socio-economic and environmental implications of a rural electrification program in Brazil. *Environmental Research, 12*. 095004. https://doi.10.1088/1748-9326/aa7bdd

Bhattacharyya, S. C., & Palit, D. (2016). Mini-grid-based off-grid electrification to enhance electricity access in developing countries: What policies may be required? *Energy Policy, 94*, 166–178. https://doi.org/10.1016/j.enpol.2016.04.010

Bhuiyan, M. A., Zhang, Q., Khare, V., Mikhaylov, A., Pinter, G., & Huang, X. (2022). Renewable energy consumption and economic growth nexus—a systematic literature review. *Frontiers in Environmental Science, 10*. https://doi.org/10.3389/fenvs.2022.878394

Bikorimana, G. & Mwizerwa, D. (2018). Macroeconomic determinants of electricity access in Rwanda: *An Empirical Analysis, 6*(1): 20-31. https://doi.10.5923/j.m2economics.20180601.03.

Blimpo, M.P. & Cosgrove-Davies, M. (2019). Electricity access in sub-Saharan Africa uptake, reliability, and complementary factors for economic impact. *Africa Development Forum*. World Bank.

Blimpo, M.P., Postepska, A., Xu, Y., 2020. Why is household electricity uptake low in sub-Saharan Africa? World Dev. 133, 105002.

Bonan, J., Pareglio, S., & Tavoni, M. (2017). Access to modern energy: A review of barriers, drivers and impacts. *Environment and Development Economics, 22*(5), 491-516. doi:10.1017/S1355770X17000201

Burns, T. & Roszkowska, E. (2016). Rational choice theory: toward a psychological, social, and material contextualisation of human choice behavior. *Theoretical Economics Letters, 6*, 195-207. http://dx.doi.org/10.4236/tel.2016.62022

Choudhuri, P. & Desai, S. (2020). Gender inequalities and household fuel choice in India. *J. Clean. Prod. 265*, 121487. https://doi.10.1016/j.jclepro.2020.121487

Cooper, D. R., & Schindler, P. S. (2014). Business Research Methods *(12th ed.)*. McGraw-Hill Education.

Daka, K. R., & Ballet, J. (2011). Children's education and home electrification: A case study in northwestern Madagascar. *Energy Policy, 39*(5), 2866-2874. https://doi.org/10.1016/j.enpol.2011.02.060

Dang, D. A., & La, H. A. (2019). Does electricity reliability matter? Evidence from rural Viet Nam. *Energy Policy, 131*, 399-409. https://doi.org/10.1016/j.enpol.2019.04.036

De Groote, O., Pepermans, G., & Verboven, F. (2016). Heterogeneity in the adoption of photovoltaic systems in Flanders. *Energy Economics, 59*, 45-57. https://doi.org/10.1016/j.eneco.2016.07.008

Dugoua, E., Kennedy, R., Shiran, M. & Urpelainen, J. (2022). Assessing reliability of electricity grid services from space: The case of Uttar Pradesh, India. *Energy for Sustainable Development, 68*, 441-448. https://doi.org/10.1016/j.esd.2022.04.004

Emmanuel, N., & Japhet, K. (2020). Impact of rural electrification on Ugandan women's empowerment. *The Journal of Energy and Development, 46*(1), 63-80. https://doi.org/10.2307/27107169

Etongo, D. & Naidu, H. (2022). Determinants of household adoption of solar energy technology in Seychelles in a context of 100% access to electricity. *Discover Sustainability, 3*:38. https://doi.org/10.1007/s43621-022-00108-4

Ezor, Z. (2009). *Power to the people: Rural Electrification in Uganda*. School of International Training Uganda.

Faisal, B. & Jakob, K. (2018). Household electrification and education outcomes: panel evidence from Uganda. *ICAE Working Papers 85*, Johannes Kepler University, Institute for Comprehensive Analysis of the Economy.

Falk, J., Angelmahr, M., Schade, W. & Schenk-Mathes, H. (2021). Socio-economic impacts and challenges associated with the electrification of a remote area in rural Tanzania through a mini-grid system. *Energ. Ecol. Environ. 6*, 513–530. https://doi.org/10.1007/s40974-021-00216-3

Ferrall, I., Callaway, D. & Kammen, D.M. (2022). Measuring the reliability of SDG 7: the reasons, timing, and fairness of outage distribution for household electricity access solutions. *Environmental Research Communications, 4*(5). 055001. https://doi.10.1088/2515-7620/ac6939

Ferrall, I., Heinemann, G., von Hirschhausen, C., & Kammen, D. M. (2021). The role of political economy in energy access: public and private off-grid electrification in Tanzania. *Energies, 14*(11), 3173. https://doi.org/10.3390/en14113173

Food and Agricultural Organisation (FAO). (2018). *Guidelines on defining rural areas and compiling indicators for development policy.* https://www.fao.org/3/ca6392en/ca6392en.pdf

Friedman, D., & Hechter, M. (1988). The contribution of rational choice theory to Macrosociological research. *Sociological Theory, 6*(2), 201-218. https://doi.org/202116

Golumbeanu, R. & Barnes, D. (2013). Connection charges and electricity access in sub-Saharan Africa. *Policy Research Working Paper; No. 6511*. World Bank, Washington, DC.

Greene, W.H. (1993). *Econometric analysis*. Macmillan Publishing Company, New York. http://dx.doi.org/10.1016/j.csda.2006.07.006

Guta, D. D. (2018). Determinants of household adoption of solar energy technology in rural Ethiopia. *Journal of Cleaner Production, 204*, 193–204.

Hechter, M., & Kanazawa, S. (1997). Sociological Rational Choice Theory on JSTOR. *Annual Review of Sociology*, 191. https://doi.org/2952549

Herfeld, C. (2021). Revisiting the criticisms of rational choice theories. *Philosophy Compass, 17*(1), e12774. https://doi.org/10.1111/phc3.12774

Hirmer, S., & Guthrie, P. (2017). The benefits of energy appliances in the off-grid energy sector based on seven off-grid initiatives in rural Uganda. *Renewable and Sustainable Energy Reviews*, 79, 924-934. https://doi.org/10.1016/j.rser.2017.05.152

International Energy Agency (IEA). (2022). *Access to electricity: SD7: Data and Projections*. https://www.iea.org/reports/sdg7-data-and-projections/access-to-electricity

International Trade Administration. (2022). Energy-overview. Uganda - *Country Commercial Guide.*https://www.trade.gov/country-commercial-guides/uganda-energy#:~:text=In%20urban%20areas%2C%2057.2%25%20of,to%204%2C354%20km%20by%202025.

Kakuba, C., Nzabona, A., Asiimwe, J. B., Tuyiragize, R., & Mushomi, J. (2021). Who accesses secondary schooling in Uganda; Was the universal secondary education policy ubiquitously effective? *International Journal of Educational Development, 83*, 102370. https://doi.org/10.1016/j.ijedudev.2021.102370

Kaliyadan, F., & Kulkarni, V. (2019). Types of variables, descriptive statistics, and sample size. *Indian Dermatology Online Journal, 10*(1), 82-86. https://doi.org/10.4103/idoj.IDOJ_468_18

Kemmler, A. (2013). Factors influencing household access to electricity in India. *Energy for Sustainable Development*, *11*(4), 13–20. https://doi.org/10.1016/S0973-0826(08)60405-6

Kwan, C. L. (2012). Influence of local environmental, social, economic and political variables on the spatial distribution of residential solar PV arrays across the United States. *Energy Policy*, *47*, 332–344. https://doi.org/10.1016/j.enpol.2012.04.074

Leach, G. (1992). The energy transitions. *Energy Policy*, *20*(2), 116–123. https://doi.org/10.1016/0301-4215(92)90105-B

Lee, K. (2023). Expanding access to electricity in Kenya. In: Madon, T., Gadgil, A.J., Anderson, R., Casaburi, L., Lee, K., Rezaee, A. (eds) *Introduction to Development Engineering. Springer, Cham*. https://doi.org/10.1007/978-3-030-86065-3_5

MacMillan, A., Preston, D., Wolfe, J. & Yu, S. (2023). 13.1: Basic statistics- mean, median, average, standard deviation, z-scores, and p-value. *Statistics and Probability Background*. University of Michigan

Mainimo, E. N., Okello, D. M., Mambo, W., & Mugonola, B. (2022). Drivers of household demand for cooking energy: A case of Central Uganda. *Heliyon, 8*(3). https://doi.org/10.1016/j.heliyon.2022.e09118

Mawejje, J., & Mawejje, D. N. (2016). Electricity consumption and sectoral output in Uganda: An empirical investigation. *Journal of Economic Structures, 5*(1), 1-16. https://doi.org/10.1186/s40008-016-0053-8

Ministry of Energy and Mineral Development (MEMD). (2018). *Electricity connections policy financing and implementation for connections period: 2018 - 2027.*

Ministry of Finance, Planning and Economic Development (MoFPED). (2022). *Background to the budget 2022/23 fiscal year.*

MoFPED (2023). *Poverty status report 2021*.

Moore, N., Glandon, D., Tripney, J., Kozakiewicz, T., Shisler, S., Eyres, J., Zalfou, R., Leon, M.D.A., Kurkjian, V., Snilstveit, B. & Perdana, A. (2020). Effects of access to electricity interventions on socio-economic outcomes in low- and middleincome countries. *Systematic Review Report*. Asian Development Bank.

Muchunku, C. & Heinemann, G. (2023). Identifying effective electrification approaches and combinations thereof to meet universal electricity access targets in Eastern Africa. In: Groh, S., Barner, L., Heinemann, G., von Hirschhausen, C. (eds) Electricity Access, Decarbonization, and Integration of Renewables. Energiepolitik und Klimaschutz. *Energy Policy and Climate Protection. Springer VS, Wiesbaden*. https://doi.org/10.1007/978-3-658-38215-5_9

National Planning Authority (NPA). (2013). *Uganda Vision 2040.*

National Planning Authority (NPA). (2020). *Third National Development Plan (NDP III) 2020/21 – 2024/25.*

Nduhuura, P., Garschagen, M. & Zerga, A. (2021). Impacts of electricity outages in urban households in developing countries: A Case of Accra, Ghana. *Energies, 14*, 3676. https://doi.org/10.3390/en14123676

Okoboi, G. and Mawejje, J. (2016). Electricity peak demand in Uganda: insights and foresight. *Energ Sustain Soc, 6(29).* https://doi.org/10.1186/s13705-016-0094-8

Opp, K. (2020). Rational Choice Theory and Methodological Individualism. In P. Kivisto (Ed.), The Cambridge Handbook of Social Theory (pp. 1–23). Cambridge: *Cambridge University Press.* https://doi:10.1017/9781316677452.002

Pueyo, A., & Maestre, M. (2019). Linking energy access, gender and poverty: A review of the literature on productive uses of energy. *Energy Research & Social Science, 53,* 170-181. https://doi.org/10.1016/j.erss.2019.02.019

Qureshi, A. S., Khan, A., Zameer, A., & Usman, A. (2017). Wind power prediction using deep neural network based meta regression and transfer learning. *Applied Soft Computing, 58,* 742-755. https://doi.org/10.1016/j.asoc.2017.05.031

Rahut, D.B., Mottaleb, K.A., Ali, A. & Aryal, J. (2017). The use and determinants of solar energy by Sub-Saharan African households. *International Journal of Sustainable Energy, 37*(8), 718-735. https://doi.org/10.1080/14786451.2017.1323897

Saunders, M., Lewis, P. & Thornhill, A. (2009). *Research methods for business students*. Pearson, New York.

Ssennono, V. F., Ntayi, J. M., Buyinza, F., Wasswa, F., Adaramola, M. S., & Aarakit, S. M. (2023). Climatic shocks and multidimensional energy poverty in Ugandan households: Does women empowerment play a moderating role? *International Journal of Sustainable Energy, 42*(1), 103–127.

Sundararajan, R., Mugerwa, J., Tayebwa, M., Lam, N., Wallach, E., Wiens, M., Ponticiello, M., Stanistreet, D., Tsai, A. C., Vallarino, J., Allen, J. G., Muyanja, D., Shrime, M. G., Nuwagira, E., & Lai, P. S. (2022). Use, cost-effectiveness, and end user perspectives of a home solar lighting intervention in rural Uganda: A mixed methods, randomised

controlled trial. *Environmental research letters: ERL [Web site], 17*(1). https://doi.org/10.1088/1748-9326/ac3f05

Tarekegne, B. (2020). Just electrification: Imagining the justice dimensions of energy access and addressing energy poverty. *Energy Research & Social Science, 70,* 101639. https://doi.org/10.1016/j.erss.2020.101639

The World Bank. (2021, June 7). Report: Universal access to sustainable energy will remain elusive without addressing inequalities. *Press Release.* https://www.worldbank.org/en/news/press-release/2021/06/07/report-universal-access-to-sustainable-energy-will-remain-elusive-without-addressing-inequalities

The World Bank. (2023). Metadata Glossary. *Data Bank.* https://databank.worldbank.org/metadataglossary/world-development-indicators/series/EG.ELC.ACCS.ZS

Twesigye, P. (2019). Scaling up rural electrification in Uganda: innovative technical and financial solutions being explored to address access challenges. *Energy and economic growth.*

Uganda Bureau of Statistics (UBOS). (2014). National population and housing census 2014. *Main Report.*

Uganda Bureau of Statistics (UBOS). (2021). *Uganda National Household Survey 2019/2020.* Kampala, Uganda; UBOS

Uganda Bureau of Statistics (UBOS). (2022). *Statistical abstract*. https://www.ubos.org/wp-content/uploads/publications/05_20232022_Statistical_Abstract.pdf

Umeme. (2022). *Number of Ugandans accessing electricity outpaces population growth*. https://www.umeme.co.ug/press-media/1570

United Nations (2015). *#Envision2030: 17 goals to transform the world for persons with disabilities*. https://www.un.org/development/desa/disabilities/envision2030.html

United Nations. (2021). *Universal access to sustainable energy will remain elusive without addressing inequalities*. https://www.un.org/en/desa/universal-access-sustainable-energy-will-remain-elusive-without-addressing-inequalities

United Nations. (2023). *Ensure access to affordable, reliable, sustainable and modern energy for all*.https://unstats.un.org/sdgs/report/2019/goal-07/#:~:text=Globally%2C%20electrification%20of%20rural%20areas,electricity%20live%20in%20rural%20areas.

van Wyk, D. & Dippenaar, M. (2017). A critical analysis of the meaning of the term 'income' in Sections 7(2) to 7(8) of the Income Tax Act No. 58 of 1962. *Original Research, 20*(1). https://sajems.org/index.php/sajems/article/view/1560/776a

Vlaev, I. (2018). Local choices: rationality and the contextuality of decision-making. *Brain Sciences, 8*(1). https://doi.org/10.3390/brainsci8010008

Wabukala, B. M., Bergland, O., Rudaheranwa, N., Watundu, S., Adaramola, M. S., Ngoma, M., & Rwaheru, A. A. (2022). Unbundling barriers to electricity security in Uganda: A review. *Energy Strategy Reviews, 44***,** 100984. https://doi.org/10.1016/j.esr.2022.100984

Wabukala, B. M., Mukisa, N., Watundu, S., Bergland, O., Rudaheranwa, N., & Adaramola, M. S. (2023). Impact of household electricity theft and unaffordability on electricity security: A case of Uganda. *Energy Policy, 173*, 113411. https://doi.org/10.1016/j.enpol.2022.113411

Wagner, C.W., Seo, S. & Aelvarsdóttir, A. (2017). Potential links between electrification and education. Policy Brief. *International Growth Centre*.

Walwyn, D. R., & Hanlin, R. (2022). Broadening energy access for poor households in rural Malawi: How Pico solar, mobile money, and cloud-based services are being combined to address energy exclusion. *Frontiers in Energy Research, 10*, 877307. https://doi.org/10.3389/fenrg.2022.877307

Wooldridge, J.M. (2002). Econometric analysis of cross section and panel data. *The MIT Press*, Cambridge.

Yaguma, P., Parikh, P. & Mulugetta, Y. (2022). Electricity access in Uganda's slums: multi-stakeholder perspectives from Kampala. *Environmental Research Communications, 4*(12). https://doi.10.1088/2515-7620/aca9ad