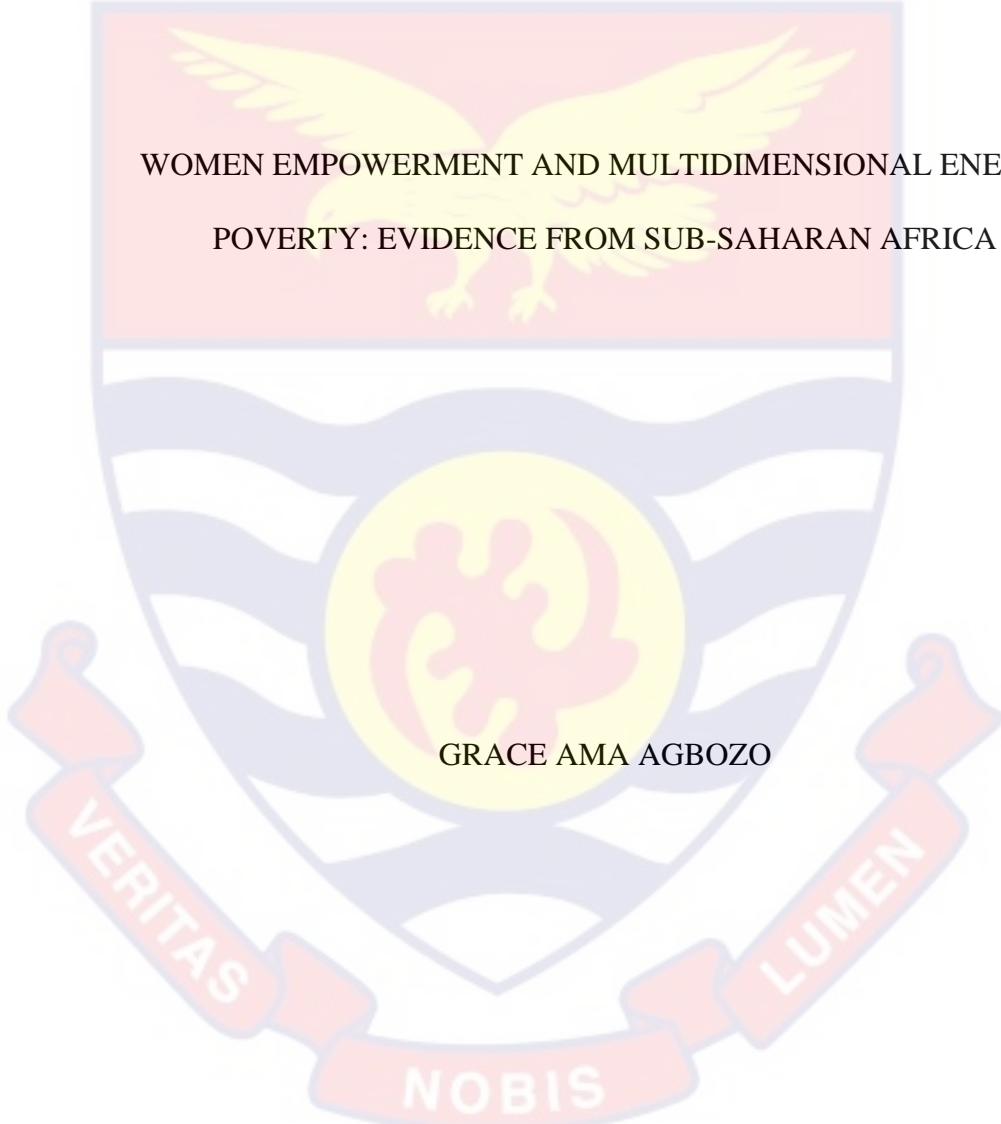


UNIVERSITY OF CAPE COAST



WOMEN EMPOWERMENT AND MULTIDIMENSIONAL ENERGY
POVERTY: EVIDENCE FROM SUB-SAHARAN AFRICA

GRACE AMA AGBOZO

2025

UNIVERSITY OF CAPE COAST

WOMEN EMPOWERMENT AND MULTIDIMENSIONAL ENERGY

POVERTY: EVIDENCE FROM SUB-SAHARAN AFRICA

BY

GRACE AMA AGBOZO

This thesis is presented to the Department of Economic Studies of the School of Economics, College of Humanities and Legal Studies, University of Cape Coast, in partial fulfillment of the requirements for the award of Master of Philosophy degree in Economics

JUNE 2025

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere

Candidate's signature..... Date.....

Name: Grace Ama Agbozo

Supervisor's Declaration

I hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature..... Date.....

Name: Dr. Gloria Essilfie

ABSTRACT

With myriads of policy options accessible for alleviating energy poverty, the women empowerment-energy poverty link has gained diminutive scrutiny notwithstanding its capacity towards achieving Sustainable Development Goal (SDG) 7, with an emphasis on economic and a green energy transition by 2030. A rising demand exists to extend equitable opportunities for energy resources towards accomplishing SDG 7 which has a ripple influence on reaching multiple SDGs and other significant economic targets. This study utilises multidimensional metrics to evaluate the effect of women's empowerment on energy poverty. Data employed for the research was obtained from the Demographic and Health Surveys program across 33 countries in Sub-Saharan Africa totaling 132,143 women married or living with a partner as the analytical sample. Descriptive statistics, bivariate analyses, ordinary least squares, and two-stage least squares econometric techniques were applied to this inquiry. The statistical findings which adjusted for endogeneity indicate that the empowerment of women reduces energy poverty. The results are resilient across various measures of energy poverty. The dominance analysis of the four components of women's empowerment (autonomy, education and literacy, resource ownership, and attitudes towards gender-based violence) reveals that education and literacy substantially impact the reduction of energy poverty. The study further demonstrates that women's empowerment affects energy poverty via entrepreneurial opportunities given to women that expand their economic and social capacities. To alleviate energy poverty in Sub-Saharan Africa, it is advocated that initiatives specifically developed to foster women's empowerment should be promoted. Secondly, government and non-governmental organisations' initiatives to reposition women need to focus on multiple dimensions of female empowerment, predominantly on their capacity to make pronouncements and their economic position within society.

KEYWORDS

Autonomy

Education and Literacy

Energy poverty

Entrepreneurship

Gender-based violence

Resource Ownership

Women Empowerment



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DEDICATION

To my daughter: Ohemaa-Antonia Yayra Agbozo



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LIST OF ACRONYMS



DA	Dominance Analysis
DHS	Demographic and Health Survey
GDP	Gross Domestic Product
IEA	International Energy Agency
IMF	International Monetary Fund
ILO	International Labour Organization
MDGs	Millennium Development Goals
MEPI	Multidimensional Energy Poverty Index
NDCs	Nationally Determined Contributions
OLS	Ordinary least Squares
SDGs	Sustainable Development Goals
SSA	Sub-Saharan African
TSTS	Two Stage Least Square
UN	United Nations
UNDP	United Nations Development Programme
UNHCR	United Nations High Commissioner for Refugees
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

The seventh Sustainable Development Goal, clean and inexpensive energy, aims to enable equitable accessibility to dependable, fairly priced, and cutting-edge energy supplies (Target 7.1). By 2030, the global energy mix must intensely increase the amount of renewable energy, as defined by the SDG framework. The logic behind it acknowledges that women and children may be affected differently by energy poverty and pollution (UN, 2016). Attainment of clean, affordable, dependable, and modern energy sources is directly related to the Sustainable Development Goals (SDGs), particularly those of no poverty, zero hunger, good health and well-being, gender equality, climate action, and life on land. This, in turn, improves socioeconomic development (Crentsil et al., 2019; Rosenthal et al., 2018; Sola et al., 2016). Notwithstanding these advantages, governments and development organisations have struggled to hasten the shift of households from the utilisation of conventional to contemporary fuels for cooking and lighting because of the expensive nature of modern, environmentally friendly fuels and the limited financial resources of developing nations (Koomson & Danquah, 2021).

Given these issues, there is an urgent need for policies and programs that encourage using clean energy technology, particularly in low-income and developing countries. Expanding access to modern energy sources benefits environmental sustainability and increases economic resilience and social well-being. Hence, addressing these energy difficulties is vital for reaching larger sustainable development objectives, decreasing inequality, and

supporting the long-term economic and social advancement of disadvantaged communities.

Background to the Study

Decisions surrounding energy usage and consumption greatly influence the economy, nature, and human welfare (Biermann, 2016; Churchill et al., 2020; Frempong et al., 2021; Rodriguez-Alvarez et al., 2019; Shahbaz et al., 2013; Shahbaz & Lean, 2012; Thomson et al., 2017). Despite continued worldwide efforts, a considerable share of the world's population still lives in energy poverty. In 2016, over 2.8 billion people lacked access to clean cooking fuels (IEA, 2017), whereas 2.5 billion persons remained dependent on traditional biomass for cooking (Koomson & Danquah, 2021). According to the World Health Organization (WHO), nearly 3 billion people worldwide lack clean cooking options, exposing them to dangerously high echelons of internal air contamination from solid fuels for heating and cooking (WHO, 2018). Additionally, IEA (2020) and Koomson & Danquah (2021) state that 578 million residents in SSA lack power access, while 905 million need clean cooking fuels.

Reddy (2000) explains energy poverty generally as “the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe, and environmentally benign energy services to support economic and human development.” This concept incorporates the different ways energy dearth appears in rural families, where traditional fuels like fuelwood and biomass are routinely utilised for cooking and heating. These sources are not only inefficient but also damaging to both health and the environment, especially among rural people in Sub-Saharan Africa. The increased interest in

understanding how policies, socioeconomic variables, and other activities impact family energy dearth and well-being in emerging republics underscores the need of tackling this problem (Frempong et al., 2021).

Eliminating prejudice against the female gender is not merely an inherent right of humanity but also crucial for increasing socioeconomic advancement. Empowering women, as stated in Sustainable Development Goal 5 (SDG 5), has a ripple effect that boosts overall economic performance (Essilfie et al., 2020). The UNDP, in partnership with diverse international bodies, has continuously highlighted the significance of female empowerment in endorsing economic success (United Nations, 2016). However, in underdeveloped and emerging nations, insufficient energy availability limits women's economic potential and well-being. In rural regions, women and girls typically spend major sections of their day gathering fuelwood, which decreases their opportunities for schooling and paid work, hence reinforcing cycles of poverty and inequality (Dutta, Kooijman & Cecelski, 2017; OECD, 2018).

Figure 1 depicts the dependency on biomass fuels for cooking (line graph) with the number of hours (bar graph) spent each day harvesting fuel. The results reveal that in countries like Cameroon, Niger, and Sierra Leone, women and girls spend over 3 hours every day gathering fuelwood. This not only exacerbates gender gaps but also restricts their possibilities for education and economic involvement, hence prolonging poverty and impeding development efforts in these places (IEA, 2017).

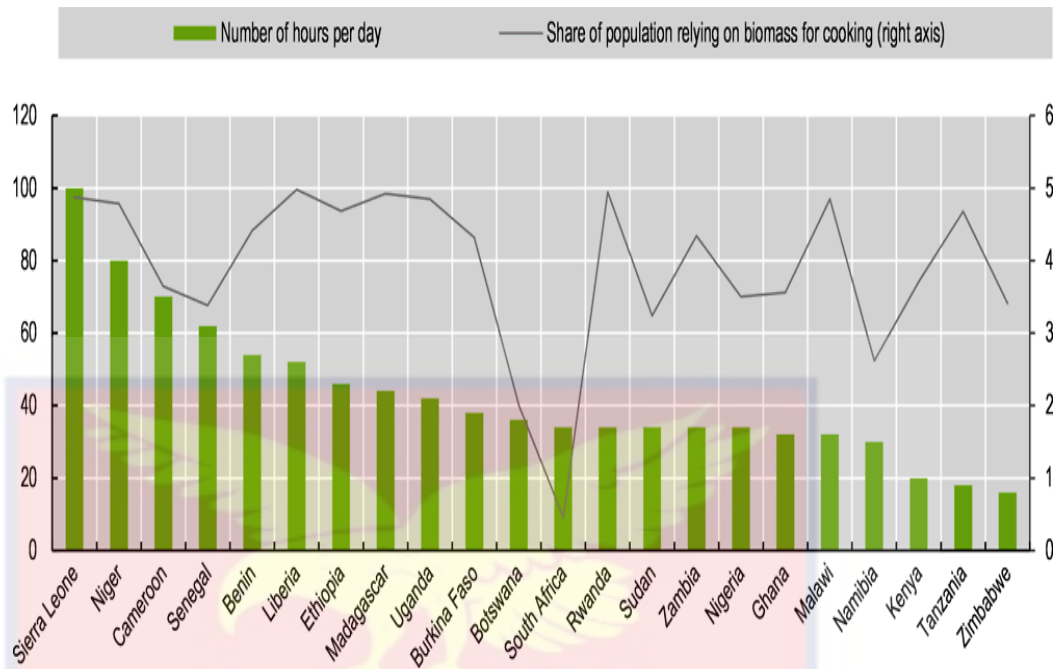


Figure 1: Average number of hours spent collecting fuel per day per household in selected countries in Africa
Source: IEA, 2017

Girls' access to school is substantially impeded by the time they spend harvesting biomass fuel. Electrifying houses not only promotes girls' school attendance but also enhances women's job chances (Lewis et al., 2013). Research conducted by O'Dell et al. (2015) in Brazil indicated that females who grew up in rural regions with access to electricity were 59% more likely to finish elementary education by the age of 18 compared to their counterparts without electricity access. Furthermore, the research emphasised that although increasing access to electricity expanded professional options for both males and females, the female gender gained more intensely since the usage of electrical equipment decreased the time spent on home duties.

The detrimental effect of energy deficiency on intellectual performance similarly has far-reaching intergenerational repercussions. Limited educational options for females not only constrain their immediate learning but also maintain a cycle of lower educational achievements for future generations,

therefore perpetuating a negative spiral (Azomahou & Yitbarek, 2016; Mare & Maralani, 2006). Addressing energy poverty is therefore vital not just for increasing present educational chances but also for breaking the cycle of poverty across generations.

The entire well-being and health of women and their offsprings are greatly impacted by energy poverty. The detrimental impacts of air pollution are disproportionately suffered by individuals in economically disadvantaged countries, as well as marginalised populations in higher-income nations, who depend on polluting energy sources for their daily requirements (WHO, 2018). Given that women are the major users and suppliers of home energy internationally, they face the brunt of this burden. Notably, pregnant women suffer heightened risks from air pollution, which may negatively influence fertility, pregnancy outcomes, and neonatal health. Recent research shows that microscopic airborne particles may reach the placenta, engendering foetal exposure (Bové et al., 2019).

Additionally, there is a worrying relationship between gender-based violence (GBV) and the dangerous behaviours involved in accessing energy supplies. Collecting fuelwood sometimes exposes women and girls to risks, particularly in places with competition for few resources or when private property lines are breached. In humanitarian circumstances, fuel collection offers a considerable danger of sexual harassment and violence. Research by the Global Alliance for Clean Cookstoves (2016) indicated that 42% of the 673 refugee families questioned in Chad reported suffering GBV during firewood gathering over a six-month period. Women and girls commonly suffer physical threats, such as sexual assault, snake bites, and injuries, when

collecting firewood (Frempong et al., 2021; Martin et al., 2011; Matinga & Clancy, 2020; Porter et al., 2013). In Darfur, Medecins Sans Frontieres (MSF) offered rape treatment to over 500 women and girls in 2005, with 82% of cases attributed to attacks during fuelwood collection (MSF, 2005). Such instances raise the danger of infectious illnesses and early pregnancies, which may impair or even stop girls' schooling. Thus, adopting contemporary cooking technology might considerably enhance girls' educational chances in impoverished countries by minimizing these dangers (Frempong et al., 2021).

Females and their offsprings are also the principal sufferers of indoor air pollution produced by inefficient cooking stoves extensively utilised in Sub-Saharan Africa. As females expend more time inside than males, they have higher likelihood to be exposed to dangerous emissions from old fuels, especially when modern cooking equipment is unavailable. The usage of traditional biomass, such as firewood, dung, and agricultural leftovers, has been found to adversely affect agricultural ecosystems and human health (Venkataraman et al., 2010). In compliance with WHO (2018), over 4 million people, predominantly women and children, die yearly due to indoor air pollution, which elevates the menace of asthma, lung disease, pneumonia, stroke, cancer and other health issues.

Globally, more than a quarter of the population depends on conventional biomass for cooking and heating (IEA, 2017). Figure 2 below demonstrates that more than eighty percent residents in SSA predominantly relies on solid fuels, underlining the urgent need for cleaner, more efficient energy solutions to enhance health and quality of life in the area.



especially in off-grid and mini-grid contexts, are anticipated to be the most inexpensive method for delivering universal energy access in many locations. This transition would notably help women, who presently spend billions of hours gathering fuelwood, freeing up time for other productive tasks. Empowering women is viewed as vital to supporting the shift from polluting energy sources to clean energy, given their significant roles as energy users, decision-makers, and contributing to home management, including cooking, childcare, and income-generating activities (Fraune, 2015).

Attitudes towards energy policy vary among genders, notably regarding the utilisation of green power sources and executing a clean energy transition (Fraune, 2016). However, gender issues are typically disregarded in energy policy, with women generally underrepresented in the energy industry, particularly in grassroots community-driven methods (Fraune, 2015). To fully leverage the advantages of the green energy transition, impediments to women's engagement in the energy business must be removed. This research succours the existing body of knowledge by offering empirical proof on how multiple facets of feminine empowerment—assessed through autonomy in decision-making, education and literacy, resource ownership, and attitudes toward gender-based violence affect energy poverty in Sub-Saharan Africa. Additionally, the research investigates entrepreneurship as a possible channel via which women's empowerment might relieve energy poverty, emphasising the multidimensional influence of empowering women in promoting sustainable development.

Problem Statement

Energy poverty in Sub-Saharan Africa poses a substantial impediment to economic progress and quality of life. In this setting, women, who are frequently the major caregivers and administrators of home resources, experience a unique and severe kind of energy shortage. According to Kaygusuz (2011), both Sub-Saharan Africa and South Asia face considerable energy deficits compared to other areas internationally, with the situation increasing in Sub-Saharan Africa since 2000. This area is characterised by a lack of access to ecologically acceptable and safe fuels, combined with a strong dependence on conventional energy sources (Kaygusuz, 2011; Munien & Ahmed, 2012).

The core cause of energy poverty is inadequate accessibility to contemporary power sources, which exacerbates health hazards, impairs educational achievement, limits livelihood prospects, and makes it particularly tough for poor populations especially women to escape the cycle of poverty. Ultimately, this slows progress toward attaining Sustainable Development Goal 7 (SDG 7), which focuses on guaranteeing cheap and sustainable energy (particularly objectives 7.1 to 7.3) by 2030 (Alert & Paper, 2017).

An examination of the most current Demographic and Health Survey (DHS) data from Sub-Saharan African nations finds a significant incidence of energy poverty throughout the area. Figure 3 shows the top 10 energy-poor nations in Sub-Saharan Africa, concentrating on those that depend primarily on solid fuels for cooking and lack access to electricity. According to the graph, all these nations demonstrate energy poverty rates over 70%. This study underlines the critical need for Sub-Saharan African governments to conduct

targeted measures to address the region's high levels of energy poverty. The results from this study seek to serve as a policy guide, giving concrete suggestions to enable Sub-Saharan African nations in their attempts to ameliorate energy poverty and advance towards sustainable development.

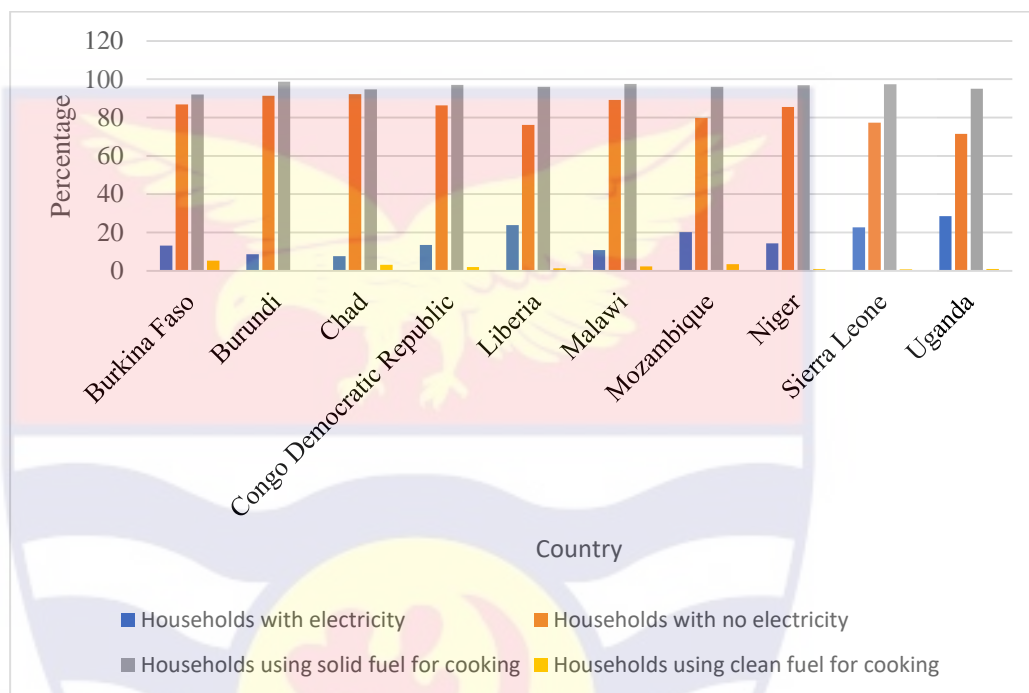


Figure 3: Top 10 energy poor countries in SSA
Source: DHS, 2023

Regarding the first goal of this thesis, which tries to show a direct linkage between female empowerment and energy deprivation in Sub-Saharan Africa, prior research has thoroughly explored issues effecting energy poverty in different locations. However, most research have focused on distinct geographical settings (Day, 2020; Nguyen & Su 2021; Roy & Alam, 2021; Su, 2021). For example, Day (2020) employed data from rural Bangladesh to study gendered energy poverty and energy injustice, demonstrating that conventional fuel consumption disproportionately impacts women due to gender gaps in energy access. Similarly, Roy & Alam (2021), utilising primary data from 914 married women in rural Bangladesh, found that female

empowerment greatly helps to lowering economic and comprehensive poverty, including energy poverty.

In contrast, research regarding the causal connection between female empowerment and energy destitution in Africa is scarce and generally focused on country-specific analysis (Alert & Paper, 2017; Egbendewe, 2021; Munien et al., 2012). For instance, Alert & Paper (2017) stressed that renewable energy efforts in Nigeria risk failure without the active involvement of women, since they are the major users and, in many instances, providers of energy. This underscores the essential need for empirical study on the correlation between feminine empowerment and energy dearth throughout Sub-Saharan Africa to inspire effective policy suggestions and initiatives. By addressing this gap, the present research adds to Sustainable Development Goal 7 (SDG 7) and offers empirical data on how empowering women might decrease energy poverty in the area.

While prior research implies a link between energy poverty, and development, the gender components of this relationship remain underexplored (Munien & Ahmed, 2012). Several researchers (Churchill, 2020; Churchill et al., 2020; Frempong et al., 2021; Koomson & Danquah, 2021; Lin & Okyere, 2020; Sovacool et al., 2012; Xu et al., 2020) which have investigated energy poverty alongside indicators such as financial inclusion, health, education, and environmental factors, consistently demonstrate an adverse relationship between energy scarcity and various economic indicators. For example, Koomson and Danquah (2021) studied data from the Ghana Living Standards Surveys (GLSS6 and GLSS7) and concluded that improved financial accessibility improves family energy poverty. Additionally,

Frempong et al. (2021) observed that the usage of cooking gas in rural Ghana significantly improves children's scholastic performance, indicating that access to cleaner energy sources might promote human capital development in low-income nations.

This study intends to make a substantial addition to knowledge by investigating the influence of female empowerment on energy destitution in Sub-Saharan Africa. An important feature of this investigation is discovering which components of feminine empowerment have the superior influence on enhancing living standards and well-being (Eneyew & Bekele, 2012; Essilfie et al., 2020). Previous researches have generally relied on aggregated measures of feminine empowerment (Abdullahi, 2017; Burney et al., 2017), which may hide the subtle implications of various empowerment characteristics. Given the intricacy of women's empowerment, disaggregating these components is vital for implementing targeted interventions to alleviate energy poverty successfully.

Furthermore, women's empowerment may impact energy poverty via different routes, such as entrepreneurship, economic development, financial inclusion, and energy price. This research intends to analyse how entrepreneurship promotes the link between women's empowerment and energy poverty. Additionally, the study tackles a momentous methodological breach in the previous literature by adjusting for endogeneity via instrumental variable (IV) estimates. Specifically, it leverages the “neighbourhood prevalence rate of women empowerment” as a measure. To enhance the research, subsample modelling is undertaken to analyse differences in the

women empowerment-energy poverty nexus depending on geography, and mass media exposure.

Goal of the research

The goal of this study is to evaluate the influence of female's empowerment on a family's energy poverty in Sub-Saharan Africa. It intends to give important information to increase academic literature on how feminine empowerment supports in decreasing energy poverty and provide policy suggestions. Women empowerment and energy poverty have emerged because Sub-Saharan African countries have to contend with high levels of energy poverty, with greater consequences for women and children. Hence, comprehensive research on the subject would inform stakeholders on how women's empowerment could potentially minimize this menace.

Study Objectives

The fundamental purpose of the research is to analyse the effect of women's empowerment on energy poverty in Sub-Saharan Africa. Specifically, this research attempts to;

- i. Estimate the effect of female empowerment on energy poverty
- ii. Examine the differential effects of the dimensions of women's empowerment on energy poverty
- iii. Assess how entrepreneurship mediates the effect of women's empowerment on energy poverty

Hypothesis of the Study

For objective 1

- i. H_0 : Women Empowerment does not affect Energy poverty
 H_A : Women Empowerment reduces Energy Poverty

For Objective 2

ii. H_0 : Women Empowerment Dimensions have the same effects on energy poverty

H_A : Women Empowerment Dimensions have different effects on Energy Poverty

For objective 3

iii. H_0 : Entrepreneurship does not enhance the effect of Women Empowerment on Energy Poverty

H_A : Entrepreneurship enhances the effect of Women Empowerment on Energy Poverty

Significance of the Study

The crucial component of generating long-lasting stability and improved quality of living is the capacity development of the primary participants in family harmony, particularly females. Most developmental organisations acknowledge the links between energy poverty and gender issues and place a premium on empowering females as a strategy to reducing energy poverty at the household level in particular. There is an increasing notion that investments in female empowerment connect to favourable wider advantages in development related to education, healthcare, reducing poverty, improving food security, and good health for children (Essilfie et al., 2020).

The research gives value since it follows a complete method and discovers the primary determinants of women's empowerment connected to improving household energy use in SSA. Policymakers may obtain the increased clarity of rules necessary to better comprehend how women may be empowered either by autonomy, education, and literacy, or resource

ownership to reduce energy poverty and embrace ecologically friendly energy for home consumption.

The study will contribute in the establishment of policies aimed at obtaining low-priced and hygienic energy with women considered as the mainstream producers and consumers of energy. It gives a thorough investigation of the link between the different features of women's empowerment and energy poverty. The study describes how women's degree of autonomy, education and literacy, resource ownership, and absence of gender-based violence could contribute to boosting household usage of renewable energy and energy services in SSA.

Organisation of the Research

This study is arranged into five chapters. Chapter One establishes the framework of the investigation, providing crucial aspects such as background information, an overview of the issue, research goals, hypotheses, and the importance of the study. Chapter Two looks into the relevant scientific literature and methodically investigates the theoretical underpinnings behind the findings. Chapter Three covers the study methodology and describes the data utilised to evaluate the link between female empowerment and energy destitution.

Chapter Four focuses on presenting the study's results and interpreting them in contrast with current empirical investigations and theoretical frameworks. Finally, Chapter Five gives an overview of the research, makes conclusions based on the primary results, and offers suggestions for policy and future research.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter aims to analyse both theoretical and empirical literature regarding women's empowerment and energy poverty to contextualise the current study. The chapter comprises two principal components. The initial section analyses the theoretical literature connecting feminine empowerment with energy deprivation, while the subsequent section reviews existing empirical studies.

Women Empowerment: Concept and Dimension

Women's empowerment advocates saw the need to stop the constraints, as well as the forms of abuse and discrimination that go along with the traditional and conservative roles that society has assigned to women (O'Neil, Domingo & Valtaers, 2014). Social constructs, including patriarchy, familial traditions, and religious narratives, have established hierarchies and ingrained beliefs that confine women to subordinate positions, restricting their participation in domestic policymaking and diminishing their entree to opportunities in the public domain (Stromquist, 1995).

This is regarded as enslavement or unfreedom in the words of (Sen, 1999). Sen described unfreedom as any type of obstacle that might be present in a society's political, social, or economic spheres. Women's traditional privileges being restricted is an example of non-freedom. Therefore, encouraging women's empowerment was a way to advance their independence, one of which is the ability to make decisions for the home.

The notion of empowering women is complex, characterised by varying perspectives about its definition and assessment (Agarwala, 2006; Duflo, 2012; Kabeer, 1994; Kabeer, 1999). Women's empowerment is conceptualised as the capacity to make choices (Kabeer, 1994, 1999; Malhotra, Schuler, & Boender, 2002) or the ability to acquire the components of a high-quality living (Duflo, 2012). Another meaning is "the relative position of women or their exercise of power within the gender system" (Williams, 2005). The necessity for women to take greater control over external and internal causes is a frequent issue in these authors' formulations. This incorporates independence, self-sufficiency, autonomy, and self-esteem. Kabeer (2001) characterised empowerment as the increase of women's capacity to arrive at an educated choice in an environment where they were previously denied of this skill. Thus, it indicates a process by which women move from vulnerability to empowerment (Kabeer, 2005).

Empirical researches have explored a range of metrics to encompass the multifaceted nature of women's empowerment. The measures most commonly utilised encompass inheritance and divorce statutes or assets at the onset of marriage (Agarwal, 1994; Fafchamps, Kebede, & Quisumbing, 2009; Quisumbing & Maluccio, 2003), non-labour earnings of both genders (Thomas, Contreras, & Frankenberg, 1997), disparities in educational attainment (Smith et al., 2003; Thomas, 1994), and the ratio of female to male life expectancy at birth (Smith & Haddad, 2002). Other researches have adopted measurements that are less economic or quantitative. For example, Fafchamps et al. (2009) utilise cognitive ability or violence as a proxy indicator for women's empowerment. Hashemi, Schuler and Riley (1996)

utilise decision-making authority, lawful awareness, engagement in public protest and political campaigns as empowerment methods within the scope of microcredit operations in Bangladesh.

Afridi (2010) proposes an indicator that blends scholastic success with decision-making, freedom of movement, physical abuse, and access to money.

Bloom, Wypij and Gupta (2001) highlight the necessity of financial supervision, authority in decision-making, and the flexibility of movement. Considering the relevance of the standards and conceptions that people utilize to exercise their autonomy, cultural and gender norms around marriage and divorce have been seen as indications of empowerment.

According to Desai (2010), empowerment involves four components: resources, agency, outcome/achievement, and process. The phenomenon of empowering the female gender is represented in the allocation of resources within the family, as indicated by household results (Doss, 2013), an expanded capacity to make decisions, the elimination of domestic violence, or a synthesis of these features (Imai et al., 2014). Additionally, it is claimed that the broad idea of empowerment may cover negotiating authority (Imai et al., 2014). They employed the following metrics to quantify feminine empowerment: the degree of freedom of movement and autonomy in making decisions; the prevalence of domestic violence; and the relative academic attainment determined by dividing the number of years that women and men spent in school.

Following past research, this study adopted these factors to quantify women's empowerment; (a) Autonomy, (b) Resource Ownership, (c) Education and Literacy (d) Gender-based violence. The first variable assesses

women's decision-making authority regarding their healthcare, household purchases, mobility (family visits), and partner's wages (DHS, 2023). The second statistic reflects assets owned by women (land and or home) (DHS, 2023). The third captures the educational background of the wife (DHS, 2023; Imai et al., 2014; Smith et al., 2003; Thomas, 1994). The fourth indication is intermediary for the depth at which a woman faces danger of assault that possibly impacts her capacity of choice-making and independence (Ackerson & Subramanian, 2008; DHS, 2023; Fafchamps et al., 2009; Imai et al., 2014), sexual harassment, and intimate relationship violence. Assets are amenities and essentials that increase female capability for decision-making. They might be ideological or materialistic (financially or physically) (Desai, 2010). Hunt and Samman (2016) also emphasised that social protection, proper work opportunities, and education are crucial aspects that boost women's empowerment.

Women's agency is defined by their ability to perceive and achieve their aims (Desai 2010, Donald et al., 2017; Kabeer, 2005). According to Alkire et al. (2013), women need to be allowed to make choices and actively engage in defining the alternatives that are vital for them and their families. The visible advantage of empowerment is result or accomplishment (Desai, 2010; Kabeer, 2005) which includes gains in well-being, health, and education, as well as engagement in politics and the economy.

Theoretical Literature Review

Prior to probing the empirics addressing the causal link between empowering women and energy poverty, it is necessary to contextualise these topics philosophically. Hence the first section of this chapter presents a

summary of the ideas underpinning the study followed by an empirical review of the literature in its latter.

The Theory of Bargaining Models

Policymakers and experts typically forecast that improving women's negotiating power may greatly improve crucial developmental outcomes, including kids' healthiness, the well-being of family affiliates, and the overall welfare of women. Empowering women is considered to impact critical components of domestic production like income, employment, food security, and energy usage. In this setting, various hypotheses concerning the bargaining process inside homes have arisen since the 1980s. Historically, most scholars considered families as coherent entities where people behave as if they had agreed on the most effective method to distribute their combined resources. In this conventional structure, the family head is believed to make choices on behalf of all members, pooling resources such as money and labour (Becker, 1974). This method, generally referred to as the Unitary Model, tackles choices relating to parenting, education, health care, domestic production, labour involvement, land ownership, and marital dynamics (Alderman, Chiappori, Haddad, Hoddinott, & Kanbur, 1995; Becker, 1974).

However, the Unitary Model has encountered serious criticism. Lundberg, Pollak, and Wales (1997) offered evidence that undermines its assumptions. They discovered that, after a change in UK legislation in the late 1970s that routed child payments to mothers, household expenditure on clothes for women and children grew, but spending on men's apparel did not—thereby violating the Unitary Model's assumption of shared resources. Critics claim that the approach ignores the discrepancies inside families, such as wage

gaps between spouses, and presupposes that one family member can oversee and enforce resource sharing efficiently. Folbre (1986) attacked the approach by noting that the notion of women and girls voluntarily abandoning their leisure, education, and nutritional requirements would only be conceivable if they had the capacity to demand equal participation. Additionally, the Unitary Model fails to account for the internal dynamics of resource distribution within families, disregarding the possibility for disparities based on individual preferences (Alderman et al., 1995). Given this data, Alderman, Chiappori, Haddad, Hoddinott and Kanbur (1995) recommended moving the burden of proof away from the Unitary Model, leading to the creation of non-unitary models.

The non-unitary model framework focuses on individual preferences and the capacity to negotiate, embracing both “cooperative and non-cooperative” bargaining models. In the non-cooperative paradigm, results may be inefficient since agreements are not always binding or enforceable, and pooled budgets are not assumed (Essilfie et al., 2020). However, this thesis adopts the “cooperative” framework of the non-unitary model. In cooperative bargaining models, both spouses get benefit from the consumption of shared commodities (such as energy choices), and the negotiating process is impacted by external environmental variables, such as the fear of divorce (McElroy, 1990; McElroy & Horney, 1981). In the context of household energy consumption, it is assumed that both the woman and her spouse make choices about energy usage and quality as part of their individual utility optimisation (Fafchamps et al., 2009; Maitra, 2004; Park, 2007). This technique provides

for a more sophisticated understanding of how bargaining dynamics within families affect energy choices and women's empowerment.

Employing the cooperative form of the non-unitary model, we suppose that we have a woman, w , and a husband, h , in a house. Household energy consumption q is considered to be a “public good” for both couples. Let X_j be the j th person’s consumption ($j = w, h$) and q the baseline level of energy quality. The utility j th person is denoted as $U_j(X_j, q_j / A_j)$. Here, A_j , external environmental variables is treated as a “vector” of external factors which affect the choice of an individual j . A_j might be contingent on the components resolute beyond the family, such as unearned money for j in addition to his or her qualities. Every person is expected to pick x_j (personal consumption) to maximize q (energy consumption of the household). In this context, the home utility function is denoted as $EU_w(X_w, q; A_w) + (1 - E)U_h(x_h, q; A_h)$ where E reflects the negotiating power of the woman (the spouse) in the family unit ($0 < E < 1$). The family utility optimisation problem is defined as follows:

$$\text{Max } U^H = EU_w(X_w, q; A_w) + (1 - E)U_h(x_h, q; A_h) \dots \dots \dots (1)$$

Subject to:

$$I = P_w X_w + P_h X_h + p_c q \dots \dots \dots (2)$$

I is a family's earnings, P_i denotes the personal commodity of the wife or husband, and P_c is the cost of public consumables is an energy selection in this instance. Generally, q^* (quality of household energy) will be dependent on variables like

E, P_c, I, P_i and A_i as follows:

$$q^* = q^*(E, I, P_w, P_c, P_h, A_w, A_h) \dots \dots \dots (3)$$

The model emphasises choices made by the household concerning energy use. For example, “bargaining power” E signifies feminine empowerment shown by her academic accomplishment and engagement of females in policymaking processes. Since the woman is more likely to assign importance to q than the husband, the greater the woman's negotiation supremacy, the higher the E . A_i indicates the attitude of each family member about energy utilisation.

Energy Transition Theories

Transformation theories of “energy-ladder and energy-stacking” are the primary theoretical underpinnings of energy poverty. They highlight the idea that offers the foundation for energy use, impoverishment, and the availability of energy supplies. The research on energy deprivation generally emphasises on how vital it is to convert from convectional environmentally unsafe fuel to more contemporary energy sources. The energy-ladder and energy-stacking are the two main principles that drive energy utilisation and energy transitions.

Energy Ladder theory

In accordance with the “energy ladder” concept, families move to greener and more efficient energy sources as their income improves. This happens when households convert from more traditional, or “dirtier,” energy sources to newer energy sources. Consequently, families move to higher levels as they “climb the energy ladder” (Hanna & Oliva, 2015; Hosier & Dowd, 1987). According to Schlag and Zuzarte (2008), rising the energy ladder is a three-phase process.

The desire of a family to pick less hazardous fuels as their socioeconomic status improves is a symptom of these stages. In the initial and

lowest stages, they utilise easily accessible solid biomass fuels that are more polluting but less costly. In the intermediate phase, they then transition to fuels that are more efficient but have a bigger carbon impact (kerosene and charcoal). The penultimate step illustrates a changeover to the cleanest fuels, such as liquefied petroleum gas and electronic cooking equipment. The switching mechanism is depicted in Figure 4. This theory's results are akin to those of the neoclassical utility-maximising consumer theory, which maintains that a rise in income induces a relative rate of replacement for more urbane energy sources (Van Der Kroon, Brouwer, & Van Beukering, 2013). As a consequence, energy poverty is less widespread in places with better family incomes overall. However, according to certain writers' evaluations of the literature, the energy ladder hypothesis has some shortcomings.

According to Hosier (2004), the conventional idea of an energy ladder presupposes that families consume just one kind of fuel and that it uses it in an ordered manner. Researchers are forced to rate fuels based on their preferences because there is little agreement on how to rank them. Furthermore, a household may detest a fuel's efficiency and environmental friendliness. The ordering of fuels at the level of the family is based on a range of characteristics, such as availability, consumption, and cost. Therefore, each fuel has merits and demerits for homes. It is argued that households do not always alter their fuel completely; rather, current research indicates that this movement depends on a variety of behavioral and socioeconomic factors in addition to income status (Kowsari & Zerrif, 2011; Waleed & Mirza, 2022), which highlights the energy stacking theory.

Energy Stacking theory

As opposed to the “energy-ladder theory”, which implies flawless replacement with rising incomes, “the energy-stacking concept” propels families to use a variety of energy types that serve as only a portion as opposed complete alternatives for conventional fuels (Choumert, Motel, & Le Roux, 2017; Swarupk & Rao, 2017; Van Der Kroon et al., 2013). This suggests that households may continue to use less sophisticated energy sources despite increases in income levels, depending on additional factors like geography, profession, and comfort (Mirza & Kemp, 2009). A plethora of interpersonal and social factors, such as family values and convictions, dietary desires, and culinary customs may also affect cooking fuel selection.

In some instances, renowned foods are observed to need more time to cook and or have a unique taste when cooked with a cleaner fuel like LPG (Masera et al., 2000; Ouedrago, 2006). Fuel consumption may also be influenced by gender perspectives and intra-household decision-making. This implies that autonomy and absence to gender-based violence in the home influences energy choices. In particular situations, households led by women chose refined fuels (Malla & Timilsina, 2014), even though in some cases women might not be given the authority to make decisions regarding the use of environmentally safe energy sources regardless of whether they would rather do so (Choumert, Combes, & Le Roux 2019; Muneer 2003, Miller & Mobarak 2013). Thus, empowering women to partake in household decisions may influence the choice of clean fuel adoption in the home. Therefore, energy use and financial position are not the key factors that influence a household's energy mix when investigating energy poverty. The approach of the research would need to take into account the influences of household



Consequently, the energy ladder is inadequate to describe the core issue. As such, energy stacking is favored in the literature over the energy ladder; yet, there is a large degree of diversity in the estimates of energy stacking models owing to varied conceptual and empirical methodologies to estimate it. In addition, compared to the energy ladder model, the fuel ranking in the energy stacking model is more complicated. To sum up, the theories of transformation acme the relevance of how growing revenue and other socioeconomic conditions alter families' choices about which energy to use. From a microeconomic point of view, conventional energy sources are poorer products owing to their less desirable qualities. Nevertheless, as established by the energy theory of transition, fluctuations in incomes merely cannot accurately foresee uniform transitions to energy types, due to the complicated interaction of variables affecting families.

Given numerous variables influencing the use conventional cooking appliances and energy sources, there is an urgent requirement for policy and program measures to explicitly incorporate stove and fuel stacking in their diagnostic, monitoring, and enforcement techniques to promote consumer energy adjustments towards healthier options (Ruiz-Mercado et al., 2015). Without such measures, the negative implications of residual use of biomass for cooking would remain severe. Hence this thesis will accept both transition theories as they better highlight the correlation between feminine empowerment and energy deprivation alongside the mediation function of entrepreneurship in increasing the women empowerment-energy poverty nexus.

Thus, the fuel stacking theory explains the importance of autonomy and absence of gender-based violence components females' empowerment in decreasing energy poverty and the energy ladder theory indicates the function of entrepreneurship and resource ownership (which leads to an increase in income) in reinforcing this relationship.

Empirical Literature Review

The empowerments of females and energy destitution have been the focus of several studies. To better comprehend women's empowerment and energy deprivation, this section evaluates empirical studies.

Energy Poverty and Women Empowerment

The impact of women's empowerment in alleviating energy poverty has been researched in diverse situations across different nations. In qualitative research including women, men, and community leaders in rural Bangladesh, Day (2020) showed that energy poverty differs by gender when evaluated through a multidimensional, service-oriented perspective. The research emphasised that traditional fuel consumption leads to a sort of gender-based energy inequity. It also stressed the relationship between this inequity and the absence of procedural energy justice, coupled with poor consideration of rural women's demands at multiple governance levels from household decision-making to national energy policy. Day stated that adopting an energy justice paradigm is vital for investigating the gender-energy nexus to identify underlying social factors and establish policy options that go beyond technical solutions to solve women's energy poverty.

However, although this work adds to the literature, it has numerous drawbacks. The study employed purely qualitative methodologies, which,

although offering in-depth viewpoints, do not allow for statistical analysis or measurable modelling. This constraint affects the capacity to generalise results and may lead to redundancy in comparisons. Additionally, as the research was geographically confined to Bangladesh, its conclusions may not be universally relevant, especially in the setting of Sub-Saharan Africa. Another gap is the lack to address endogeneity, which may develop owing to reverse causality between female empowerment and energy dearth. Furthermore, women's empowerment is diverse; a disaggregated approach will better advise policymakers on which particular areas to address in the skirmish against energy dearth. To overcome these gaps, the present study adopts an instrumental variables (IV) technique to tackle endogeneity, as well as a multidimensional measure of female empowerment. This research also solves the locational gap by evaluating data from 33 Sub-Saharan African nations to analyse the influence of women's empowerment on decreasing energy deprivation.

Nguyen et al. (2021) performed research including 51 developing nations between 2002 and 2017 to assess the impact of alleviating energy poverty on gender disparity. They concentrated on four dimensions: employment, health, education, and socio-political-economic rights. Utilising a two-step generalized method of moments (GMM) estimator to address endogeneity, their findings were statistically robust. The research revealed that eliminating energy poverty enhances employment prospects for women, notably in the industrial and service sectors, resulting to an increase in female wage and salaried workers compared to males. Alleviating energy poverty was also demonstrated to diminish gender differences in health outcomes and to

promote gender equity regarding schooling and socio-economic entitlements. The authors stressed that the leadership of developing nations should prioritise addressing energy poverty as a vital first step toward overcoming gender inequities.

Given the bi-causal link between gender empowerment and energy poverty, this thesis intends to explore the influence of women's empowerment on lowering energy poverty while also addressing endogeneity via the use of a two-stage least squares (TSLS) estimator. By adopting this method, the present study intends to give a greater understanding of how empowering women might help to energy poverty reduction, especially in the setting of Sub-Saharan Africa.

In an investigation on "A Gendered Perspective on Energy Poverty and Livelihoods Advancing the Millennium Development Goals in Developing Countries," Munien and Ahmed (2012) studied energy poverty via a feminist perspective. The essay stressed the interwoven connection between energy availability and the fulfilment of the Millennium Development Goals (MDGs). It underscored the need to address the fundamentally different situations encountered by women and men in terms of energy use, consumption habits, and the ensuing repercussions. The gendered livelihoods approach described in the research highlights that poverty particularly energy poverty has substantial gender implications, especially when it comes to income and resource ownership (primarily energy assets). The authors stated that tackling factors such as sexism, discrimination, fragility, and limited involvement in decision-making processes is more influential than concentrating exclusively on measurable measurements of poverty.

The study highlights that energy poverty disproportionately impacts women and that reaching the MDGs is unlikely if gender inequality and energy deprivation remain. The authors urged for policies that promote energy efficiency with gender-responsive development outcomes, especially those that meet women's unique needs. While the study made major contributions to the literature by expanding knowledge of how women's engagement might contribute in reaching the MDGs, it has noteworthy shortcomings that our present research intends to address.

First, the study did not apply any econometric methodology to assess the association between gender and energy poverty; it relied only on a systematic analysis of existing research to derive findings. Second, the research did not concentrate on any particular geographical setting, limiting its application to localized policy suggestions. To overcome these gaps, the current study employs econometric tools to reconnoitre the connection between feminine sovereignty and household energy usage. Specifically, it employs a baseline model using Ordinary Least Squares (OLS) and the Two-Stage Least Squares (TSLS) technique to handle possible endogeneity owing to reverse causation between women's empowerment and energy poverty. By doing so, our research presents a more rigorous and spatially relevant analysis to support policy solutions.

According to Alert and Paper (2017), Nigerians continue to experience extreme energy poverty despite the country's enormous renewable energy resources. The research noted that about 95 million Nigerians depend exclusively on conventional woodstoves for cooking, which significantly affects livelihoods, diminishes quality of life, and hurts the economy.

Abdullahi stated that poor access to modern energy sources lies at the foundation of energy poverty. This lack of access leads to drudgery, heightened health risks, hindered education, restricted livelihood options, and fewer prospects for the poor to overcome poverty, eventually endangering the fulfilment of the SDGs by 2030.

The research stressed that women are not just a special interest group in the adoption of renewable energy to relieve energy poverty in Nigeria but are also the principal consumers and, in many instances, producers of energy. They observed that women form the fastest-growing sector of entrepreneurs and company owners in numerous emerging nations, including Nigeria. Thus, barring women from renewable energy programs risks making such efforts unproductive. The author also underlined that energy professionals that disregard women in their study and analysis miss a major share of global energy consumption and production trends. He found that engaging with women on community energy initiatives provides great promise for decreasing energy poverty in Nigeria. Furthermore, the authors indicated that supporting women's entrepreneurship might fuel economic progress, since women's financial independence has a tremendous influence on communal development.

This research offers crucial empirical information on the impact of women's empowerment and engagement in solving energy poverty, especially in a Sub-Saharan African environment like Nigeria. It underscores the vital role that women play in the transition to a greener energy future in the area. Therefore, the present study intends to improve on existing information by undertaking a multi-country analysis throughout Sub-Saharan Africa. This

larger perspective might inspire policy suggestions for other governments in the area, helping to decrease energy poverty and promote sustainable development.

Existing research offers empirical information on the bearing of energy availability on empowering the female gender. For example, Burney et al. (2017) performed an impact assessment research titled “Impact of a Rural Solar Electrification Project on the Level and Structure of Women’s Empowerment” in Benin, West Africa. Using a quasi-experimental technique, they examined improvements in empowerment among project beneficiaries one year after implementing the “Solar Market Garden” initiative, compared to non-recipients in the juxtaposition of “treatment and non-treatment villages. The findings demonstrated that women beneficiaries reported greater overall empowerment, manifested in new policymaking authority, increased flexibility, financial freedom, self-confidence, household equity, and community participation. The research concluded that the “Solar Market Garden” considerably boosted women’s empowerment, notably by encouraging economic independence.

However, the research focused largely on how energy availability effects women's empowerment, demonstrating a bi-directional link between empowerment and energy poverty. It did not, however, address the question of endogeneity. Additionally, it was confined to a country-specific examination. The new study extends on this by using data from numerous nations in Sub-Saharan Africa while also resolving endogeneity problems.

Further observations from the 2012 World Development Report by Sills et al. (2012) show the interdependence of energy, gender, and

development. The analysis stated that energy interventions may have substantial gender-related outcomes if they are properly developed using context-specific tactics that account energy limitations and household decision-making processes. The efficacy of energy policy, however, relies on how family choices reflect female-specific demands, the opportunity cost of time, and general well-being. Research reveals that although both men and women engage in fuelwood gathering, women frequently shoulder a disproportionate percentage of the effort. Studies reveal that the distribution of work between genders and the selection of fuel sources are impacted by relative shadow incomes and cultural norms (Charmes & Kohlin, 2011; Dutta et al., 2017; Matinga, 2010). To optimise the effect of energy efforts, project designs must be adapted to the unique energy restrictions and household dynamics of the target community.

Research on the confluence of gender and energy reveals that giving electricity to homes and communities may considerably boost women's empowerment, notably in healthcare, education, and work. Rural electrification projects generally try to fulfil gender targets by distributing illumination, television, and electricity-powered products (Sills, 2012). The advantages of electrification are especially important for women, who often devote extra time at home and are accountable for domestic activities that may be made more effective with access to electricity. According to Sills (2012), lights and television are among the most prevalent uses of electricity, accounting for at least 80% of rural energy use. The advent of electricity decreases dependence on costly candles and kerosene lamps, so lowering interior air pollution, fire dangers, and burn hazards while providing higher-

quality illumination. Additionally, access to power and television extends information access, improves educational options, and promotes productive job capability. Enhanced illumination also augments the effective execution of home activities, improves public safety, and opens up new income-generating options, hence contributing to women's empowerment and socio-economic growth (Sills, 2012).

In Guatemala, study by Grogan and Sadanand (2009) discovered that rural electrification enhanced female work engagements by 9 percent with negligible impact on male employment. Their results related this mostly to the assumption that electricity lowers women's time by boosting the effectiveness of domestic operations, particularly cooking. The findings are substantially consistent with earlier research which relied on a substantial number of electrically powered and non-powered households and account for several potential confounders. For example, Pokherl et al. (2010), Barkat (2002), and Chowdhury (2010) indicate that electricity minimizes the time that women waste gathering fuelwood (in Bhutan) and enhances the evening time they allocate to money producing activities and the possibility of acquiring employment (in Bangladesh). These findings support the premise that electrification helps women more when it is linked with effective social marketing and finance programs for appliances that cut down on the amount of time needed for household tasks or business services that allow women to use electricity (Sills, 2012).

Evidence from this research reveals that the relationship between having accessibility to green energy and the empowerment of women is bi-directional. Thus, actions oriented towards expanding access to ecologically

benign energy tend to increase women's empowerment and vice-versa. Hence it is necessary to explore the role women empowerment may play in encouraging access to clean and cheap energy as required in SDG 7 which is the fundamental purpose of this thesis.

Entrepreneurship, Empowerment, and Energy Poverty

One of the economic sectors with the quickest rates of growth in the world is women's entrepreneurship, which significantly boosts capital accumulation, job creation, and technological innovation (Brush & Cooper, 2012). The expansion of females' private enterprise is vital for any country's economic success and is acknowledged as a critical driver for sustained economic progress (Mboko & Smith-Hunter, 2009). This progress is vital for nations attempting to compete successfully in the international economy. Storey and Greene (2010) propose that there is no more significant action a nation can do to improve company growth than by enabling more females to partake actively in entrepreneurship. Such activities not only increase women's civic position but also boost their donations to community and countrywide economic expansion (Osirim, 2001).

Moreover, encouraging women to earn a living favourably influences many aspects of their life. Financial empowerment for women may have far-reaching benefits beyond the individual level; studies reveal that females redirect about 90% of their earnings into their relations and societies, likened to only 30-40% for males (Borges, 2007; Dutta et al., 2017).

Women are also more likely than males to spend a large share of family money to their children's education, especially for girls (IMF, 2013; Lewis, 2013). According to the International Labour Organization (ILO),

females' employment both remunerated and voluntary may be the utmost and vital poverty-reducing element in emerging nations. The evidence demonstrates that women's entrepreneurship not only boosts individual empowerment but also initiates a cascading impact on decreasing poverty. Consequently, this study intends to explore how entrepreneurship mediates the link between women's empowerment and energy poverty, offering insight on the wider socio-economic implications of empowering women entrepreneurs.

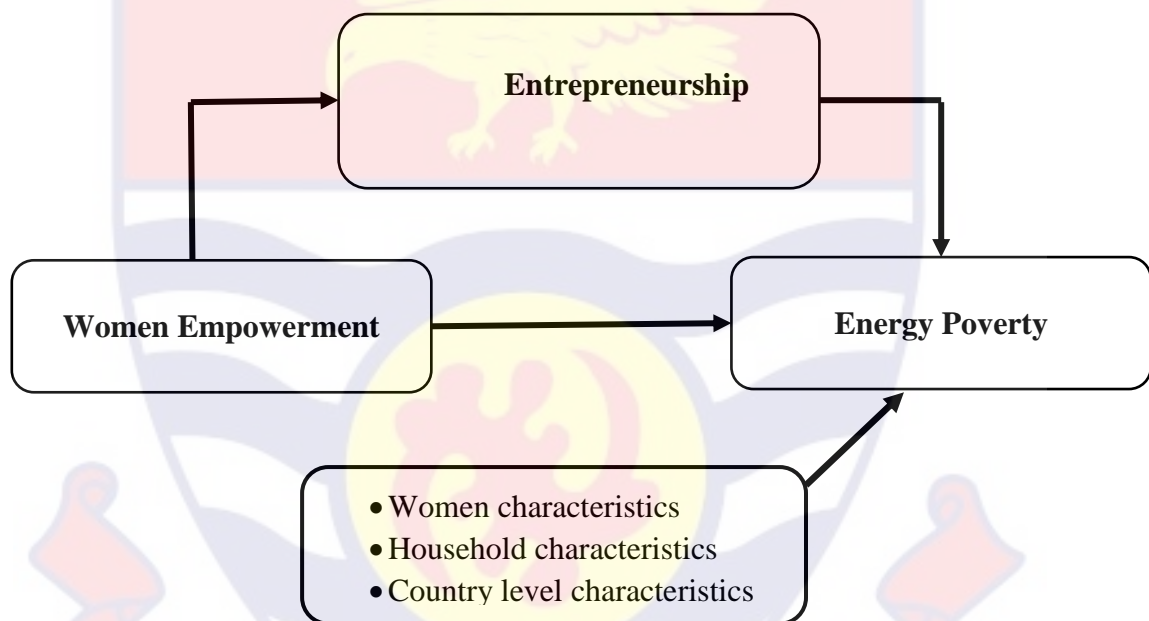


Figure 5: Conceptual link between Entrepreneurship and Energy Poverty
Source: Agbozo (2025)

Given the practical evidence of the multiple benefits that can be achieved from the use of clean energy and the hazards presented by bad energy equipment and services, research oriented towards the conceivable means of accomplishing this aim must be given great emphasis. One significant method via which governments might accomplish the green transition is by addressing women as they are the main producers and consumers of energy and energy services. Therefore, the present research will

help the policy considerably, by studying the effect of women's empowerment on energy poverty elimination in Sub-Saharan Africa (SSA).

Energy Poverty and Other Covariates

Energy poverty and exposure to mass media

The growth of mass media as a crucial component of modern civilization's accessibility to information has been extraordinary. The obtainability of information is crucial for successful decision-making by people and customers (Stigler, 1961; Stiglitz, 2000). Research shows that exposure to mass media, notably via newspaper circulation, radio, and TV, may have a good influence on lowering poverty and inequality (Bandyopadhyay, 2014; Bandyopadhyay, 2005). This is linked to the function of the media in giving knowledge, establishing preferences, and impacting behavior. In particular, a study on “Are Mass Media and ICTs Associated with Inequality and Poverty?” by Bandyopadhyay (2014) to examine connections between “media consumption and information and communications technologies (ICTs) with inequality and poverty”, observed that newspaper circulation has a robust adverse correlation with inequality. He also observed that Radios, TVs, and ICT expenditures, represented as a fraction of GDP, demonstrate an inverse association with poverty.

Moreover, according to Sills (2012), lights and television comprise the first popular uses of power, which represent no less than 80% of rural energy use. The initial and greatest implications of electricity come via lights and television. The author also suggested that light and television enhance accessibility to knowledge, and the capacity to learn, and lengthen a productive workday. The obvious function of media is that of supplying

information in the form of news, and information contained in other social media material such as commercial and entertainment programs (Ferrara & Ferrara, 2015). However, the effect of mass media on public knowledge and attitudes toward environmental concerns may be both beneficial and bad, with news media favorably associated with concern about environmental issues, and television adversely associated with pro-environmental conduct (Mikami, 1999). Therefore, this study will control for exposure to mass media since it is a variable that influences energy poverty.

Energy poverty and wealth quintile

There is a complicated link between wealth quintile and energy poverty in Sub-Saharan Africa, as indicated by a review of relevant literature. Garba (2021) discovered a negative link between the usage of biomass fuels and GDP per capita, showing that individuals in the lower wealth quintiles, who are more inclined to depend on conventional fuels, are more susceptible to energy poverty. Similarly, Asiedu (2022) underlined that poverty, economic inequality, and the status of the financial sector all impact energy use, with lower-income groups being disproportionately affected by energy poverty.

The economic advantages of green energy adoption and its role in poverty reduction were stressed by Khobai (2021), who suggested that policies encouraging clean technology might assist alleviate energy poverty, particularly among the lowest wealth quintiles. Ye (2021) and Renner (2018) further studied the influence of wealth quintiles on energy poverty; Ye discovered that the impacts are more prominent among lower-income groups, while Renner demonstrated that changes in energy costs have welfare consequences that may worsen energy poverty. Additional evidence of the link

between wealth and energy poverty was provided by Hou (2018), who found that wealth accumulation tends to shift households toward cleaner fuels, and Galvin (2020), who proposed progressive taxation as a strategy to increase the incomes of the lowest-income households, thereby reducing energy poverty.

Moreover, Husnain (2021) underlined the relevance of economic progress, especially in low-income nations, in tackling energy poverty. Collectively, these studies demonstrate the necessity of incorporating wealth quintiles in the creation of policies aimed at tackling energy poverty, since the economic position of families plays a key influence in their access to cleaner energy sources.

Energy poverty and Sex of household head

The comprehension of gender aspects in poverty has been profoundly affected by feminist scholarship and activism, which questioned the "gender blindness" of conventional poverty evaluations and policies (Kabeer in Chant, 2003). Feminist researchers argued that poverty is essentially gendered, stressing economic discrepancies between men and women, the exclusion of females from development projects, and the effect of technology on gender disparities (Wamukonya, 2002). Medeiros and Costa (2008) identify the "feminisation of poverty" as a change in poverty levels that disproportionately impacts women or female-headed families, combining two socially undesirable phenomena: poverty and gender inequality. These biases are obvious at the junction of resource poverty and gender discrimination, with women enduring larger poverty burdens, income gaps, and restricted access to economic opportunities. Additionally, women tend to have lesser levels of education, good health, and social involvement (Chant, 2003). Gender

differences may also show geographically, with men and women inhabiting separate social and professional contexts.

Cecelski (2004) believes that gendered settings typically constrain women to the private realm of the house and kitchen, integrating their social and professional spheres. In the context of energy, these gendered spaces become crucial leverage points for decision-making linked to health, technology adoption, income-generating activities, and the demand for secure public places for women. Abdourahman (2010) further underlines the idea of time poverty, highlighting that the uneven allocation of time between men and women in both the family and the business significantly inhibits women's access to economic rights. In patriarchal countries, women are generally allocated labour-intensive jobs that cover reproductive, producing, and communal obligations, leaving them with limited time to seek economic prospects compared to males.

The rising incidence of female-headed families is an important aspect in gender-poverty research, since these households are generally categorised among the "poorest of the poor" due to their increased risk of suffering severe poverty (Chant, 2003). Several reasons contribute to this, including forced labour migration, marital breakup caused by financial hardship, and a lack of official marriage (Chant, 2003). Female headship exacerbates poverty, since women generally juggle triple roles productive, reproductive, and communal involvement which constrains their time and resources. Additionally, they confront job discrimination and cannot benefit from the "dual-earner" advantage, being the only providers for their homes among the demands of neoliberal economic upheavals (Chant, 2003).

Moreover, the surge in female labour force involvement, especially in informal and temporary jobs, adds another degree of complication. Informal labour is generally characterised by gender discrepancies in job status and compensation, a lack of benefits, and income volatility (Kaygusuz, 2011). As revealed by the present study, home headship strongly affects poverty levels, especially energy poverty. The outcomes demonstrate that female-headed families are more probable to suffer poverty, underlining the necessity to account for this variable in future investigations. Thus, this research will include household headship as one of its control variables to corroborate or dispute this assumption.

Energy poverty and age of a woman

A woman's age has been found to have a considerable effect on her chances of suffering energy poverty. Ahmed (1998) and Sujatha (2000) observed that chronic energy insufficiency and higher energy expenses for home and childcare tasks are widespread among older women, particularly those over 35. Abbas (2020) gave more evidence for this, demonstrating a negative causal link between multidimensional energy poverty and women's health, with age being a key contributing component. Vartanian (2002) also stressed how midlife qualities, such as income and work status, have a lasting influence on older women's financial stability and may contribute to energy scarcity in old age.

Energy poverty and children a woman begets

The number of children a woman has may considerably affect her sensitivity to energy poverty. According to Oosthuizen (2020), women who live in disadvantaged urban environments and usually have younger kids are

more susceptible because of their increased energy consumption. According to Caceres-Delpiano (2012), this is exacerbated worse by the deleterious impacts of reproduction on family income and welfare participation. Famewo (2022) focuses further on the social and economic implications of energy poverty on women and students in rural regions, especially those with bigger families.

The combined impact of this research demonstrates the deep relationship between a woman's sensitivity to energy poverty and the number of children she has.

Energy poverty and partner's occupation

A man's employment may greatly influence energy poverty, with particular jobs being more prone to its consequences. Families where husbands/partners are jobless, are more probable to face energy destitution as their income level will comparatively be low compared to their counterparts' households with partners working. This is established by the study done by (Yeboah et al., 2020) which reveals that families without jobs experience a lesser opportunity cost of obtaining fuelwood, thus, leading to increased dependency on ecologically unfavorable energy sources.

In addition, Drescher and Janzen (2021) revealed that energy deprivation is associated with family size, educational attainment, work position, and home characteristics. Yeboah (2020) has proposed that an average gain in general health enhances the chance of a family being energy-rich. The researcher related his statement to the assumption that families with more well-being have wider spending thresholds and, consequently, expenditures on energy and LPG may increase. This is largely due to the impression that biomass kinds of fuels are poorer products, accordingly, a

welfare gain leads to households optimising their utilities by migrating away from fuelwood and biomass.

Energy poverty and age of household head

The age of household head is one of the determinants of energy poverty as mentioned by several authors. In Ghana, for instance, Yeboah (2020) observed that older household heads had a decreased risk of suffering energy poverty. Kebede (2022) also found a similar tendency in Addis Ababa, notably for those between the ages of 30 and 60. This is contrary to the research demonstrating energy use increases with the age of household head and family size (Allen, Janda, & College, 2006; Raty & Carlsson-kanyama, 2009) and consequently perpetuates energy poverty. This is tied to the idea that houses with elderly heads have more members and fewer resources, *ceteris paribus*, thus they resort to cheap sources of energy to fulfill cooking and lighting demands which inevitably leaves them energy-poor. Nie (2021) and Ashagidigbi (2020) also revealed that age had a major effect on energy poverty, with older household heads in China and Nigeria, respectively, more likely to be affected. These contradicting findings show that other characteristics, such as location, wealth, and education, may have an influence on the connection between the family leader's age and energy poverty

Energy poverty and household size

Numerous research works have investigated how household size affects energy poverty. While Chen (2022) indicated the contrary in China, where larger households had a greater likelihood of being subjected to energy poverty, Yeboah (2020) discovered that households with more members in

Ghana were less likely to encounter it. Ye (2018) found that energy poverty rates in South Africa declined with income, pointing to a possible relationship between household size and income. Scheier (2022) drew attention to the differences in the energy load that exist among various household types in the US, suggesting that larger households may have to pay more for energy. These findings show that there is a complicated link between family size and energy poverty that may fluctuate depending on the circumstances.

Energy poverty and housing conditions

Several researches have demonstrated how inadequate housing materials have a major impact on energy poverty. Both Streimikiene (2023) and Burlinson (2018) highlight the multifaceted character of fuel poverty, with housing conditions being a critical component. Chen (2022) emphasises this even more, discovering that homes that are older, larger, and have inadequate insulation have an increased risk of becoming energy deficient. In these kinds of homes, energy self-restriction's behavioral and psychological components are also emphasised. To combat energy poverty, Debnath (2020) expands on this by examining the socio-architectural influence on energy demand in slum rehabilitation homes. This emphasises the necessity of inclusive energy planning in building houses. When taken as a whole, these studies highlight how important housing materials are to determining energy choice. The findings underscore the significant impact of poor building materials in perpetuating energy poverty.

Energy poverty and location

A study of the research on the influence of rural-urban location on energy poverty in Sub-Saharan Africa finds a large gap, with rural regions

having higher degrees of being energy-poor (Ashagidigbi, 2020). This is partly owing to the presence of archaic and dangerous energy sources in these regions, which not only contribute to environmental degradation but also pose health hazards (Ashagidigbi, 2020). Yeboah (2020) reported a greater incidence of energy poverty in rural parts of Ghana and underlined the relevance of off-grid energy projects in alleviating this imbalance. Wu et al. (2021) underscored the relevance of renewable energy development in alleviating energy poverty in China, with an emphasis on regional inequities.

Furthermore, the evaluation of energy destitution in South Africa according to household-required utilisation of energy reveals that lower-income groups in rural regions are more prone to energy poverty (Ye, 2021). Other studies in the literature also suggest that geography has a key influence in energy accessibility which results in increased energy poverty in rural regions (Bhattacharyya, 2006; Mirza & Kemp, 2009). These studies together imply that rural-urban environments may greatly impact energy poverty, with rural communities frequently experiencing higher issues.

Energy poverty and GDP per Capita

The association between economic progress and energy poverty is nuanced and varied. Singh et al. (2021) and Al-tal et al. (2021) both underline the beneficial effect of economic progress on lowering energy poverty, specifically in Sub-Saharan Africa. Singh et al. (2021) especially underscores the function of energy access in promoting growth in the economy, while Al-tal et al. (2021) highlights the relevance of energy efficiency advances and other macroeconomic factors in reducing energy poverty. Asiedu (2022) also underscored the significance of finance and economic advancement in

reducing the adverse impacts of income gap and poverty on energy consumption.

Other authors have discovered a causal association between GDP per capita and energy poverty. Garba (2021) demonstrated a negative causal link between the utilisation of conventional fuels and GDP per capita, suggesting that energy poverty exacerbates economic concerns. This is corroborated by Yakubu (2017), who discovered a causal association between energy use and GDP in various countries in Sub-Saharan Africa. Yakubu (2017) and Lekana (2020) both emphasised the importance of energy consumption in economic growth, with Yakubu (2017) identifying a causal relationship between GDP and energy consumption in some Sub-Saharan African countries, and Lekana (2020) highlighting the role of governance quality in this relationship. These studies collectively stress the need for sustainable energy policies to alleviate energy poverty and assist economic growth in the region.

The cumulative impact of these researches emphasise the complex relationship that exists between energy poverty and other socioeconomic factors. Hence it is important to account for these variables in the current study of the women empowerment-energy poverty nexus. Thus, the choice of control variables employed in this thesis is informed by the evidence from the literature on afore-reviewed economic indicators.

CHAPTER THREE

METHODOLOGY

Introduction

In this chapter, the approaches utilised to study the link between women's empowerment and energy poverty are addressed in depth. It comprises the research design, data sources, empirical models, and estimating methods performed to evaluate the hypotheses. Additionally, the chapter gives a description of the important variables employed in the research, presenting a full overview of the analytical framework chosen for the study.

Research Design

A study's paradigm refers to the technique a researcher utilises to systematically and scientifically integrate numerous parts of the investigation (Wengel et al., 2019). Paradigms are frameworks that assist us comprehend how the world functions by defining the way things function in the universe. They serve as the framework for doing research, founded in certain cultural assumptions, beliefs, practices, and procedures, therefore giving a systematic approach to study (Guba & Lincoln, 1994; Jankowicz, 2005). Paradigms also define the ontology, epistemology, and technique of a research topic (Anaman, 2014). Researchers typically follow two paradigms; positivism and constructivism (Guba & Lincoln, 1994).

Positivism is anchored on evidence acquired and examined using the scientific method (Hovenkamp, 1990). This paradigm says that researchers should have no impact on the observable facts and should avoid subjective interpretations (Friedman, 1953). It functions by creating testable hypotheses and ideas that may lead to generalisations. Positivist research commonly

includes instruments like questionnaires, surveys, personality evaluations, and standardised testing methods for collecting data. In contrast, constructivism focuses on monitoring and evaluating how people acquire knowledge, stressing that individuals construct their understanding of the world via experiences and reflections on those experiences. Constructivism tries to construct notions of human behaviour based on social and personal experiences, leaning significantly towards qualitative research (Guba & Lincoln, 1994). Unlike positivism, the constructivist paradigm accepts that qualitative research is distinctive and sensitive to subjective value judgments, which may restrict objective generalisation (Friedman, 1953).

A third paradigm, sometimes referred to as the mixed methodologies approach, integrates both positivist and constructivist paradigms to provide a more thorough analysis. This method employs qualitative and quantitative approaches to acquire a greater knowledge of how the world operates. However, this research utilises a quantitative method, since it concentrates on hypothesis testing and the generalisation of results. The quantitative technique is judged useful for evaluating phenomena by assessing a representative sample of the populace at a certain moment in time (Dolnicar & Ring, 2014). Additionally, compared to qualitative approaches, quantitative research is less prone to researcher biases, allowing for more objective conclusions.

Description of Data Sources

Data was derived from the Demographic and Health Survey (DHS) Program, which offers data on multiple variables across nations for monitoring and analysis of the population of women and children across fertility, health, family planning, nutrition, and empowerment. The sample technique is

systematic and targets families and their members with focus on women and other household factors. Over the years, the DHS continuously provides data on household energy consumption results in a uniform method which engenders its comparability across developing nations. Thus, the DHS data has been utilised frequently for measuring and monitoring home energy output and consumption. In this research, home energy production and consumption data are typical across 33 countries in sub-Saharan Africa. There were multiple rounds or stages of the DHS data for each nation, however, this analysis is confined to the latest waves of DHS data for each country. The justification for adopting the final rounds of DHS data for each country is that these are the phases of surveys that often encompass the parameters employed in the research - indicators necessary for the indices, instruments, and covariates used in studying the various paths. All nationally representative DHS data publicly available was appended with the sample for every country recorded over distinct time periods. For example, the latest survey year was reported by Cameroon is 2018, but that of Kenya was recorded in 2022.

Across the nations, the intended sample includes women in partnerships (married or living together with a partner) between the ages of 15 to 49. The emphasis on women in this age cohort is underlined principally by the consistency by which the anthropometric results of this age group are assessed throughout the 33 nations chosen for the research. Real per capita GDP was derived for every single nation that matches the year of interview from the WDI as the macroeconomic covariate. The final sample utilised for the analysis is 132,143 women 15-49 years who are married or living together

with a partner, after the data was cleaned and missing observations were accounted for.

Sampling Design for DHS

The usual sample methodology for all nations under the Demographic and Health Surveys (DHS) program involves a two-stage stratified sampling process. In DHS surveys, the findings are stratified based on variables such as urban vs rural domicile, distinct administrative or geographic areas, or differing educational levels of respondents to produce sample strata. Each participating nation picked a sample frame of Enumeration Areas (EAs) from its most recent population census. An EA is a specified geographic region that encompasses numerous houses, aiding efficient enumeration during the census.

Enumeration Areas (EAs) were sampled independently within each stratum through a two-stage process. To achieve implicit stratification and proportional allocation, the sampling frame in each stratum was arranged by administrative divisions, and EAs were selected using a probability proportional to size (PPS) method. In the first phase, a fixed number of EAs were drawn from each stratum, with the probability of selection based on the number of residential households reported in the national census. In the second phase, a household listing was conducted within the selected EAs to create a frame from which households were then sampled.

To decrease the burden in highly inhabited EAs, big EAs were partitioned, and one segment was selected for the survey using probability proportional to segment size. Household listing was then undertaken specifically in the specified parts. As a consequence, a DHS cluster is defined

as either a whole enumeration area or a section of it. In the second step, a specific number of homes within each cluster was systematically picked with equal probability within the freshly formed domiciliary list. Survey teams visited only the pre-selected families, with no replacements or substitutes permitted to reduce bias.

The poll targeted all females aged 15-49 who were either typical occupants of the chosen houses or who had slept there the night before the survey. Based on the study's aims and the characteristics of interest, a total of 132,143 women who were cohabiting or married were chosen from an original sample of 310,177 women across 33 nations.

Data Validity and Reliability

Validating secondary data is a well-known method of guaranteeing a dataset's accuracy and integrity. While reliability necessitates that the data be precise, meaning that measured variables can be re-measured to yield exact outcomes *ceteris paribus*, validation guarantees the accuracy of measurements of covariates utilised for the evaluation and the suitability of the dataset. To confirm that the original coding used for the DHS survey, which was mostly focused on the conventions and the intended usage of the data was adequate for the study, the researcher first evaluated by summarising the variables. All critical variables required for the analysis of the data have been independently examined and validated according to the codebook's description. Following this, is the recoding of certain parameters to suit the goal of the study and to guarantee correctness and conciseness as well as interrogation for likely outliers that may impact the conclusion.

Data Collection Instrument

The user interaction menu was created to offer selection choices and buttons whenever feasible to speed the registration process, while yet allowing for the entry of open-ended replies where required. To accelerate the interview procedure and limit the danger of possible mistakes, identity data for chosen houses were pre-loaded into each enumerator's device. Additionally, the Computer-Assisted Personal Interviewing (CAPI) software was designed to contain all the key logic operations, guaranteeing that relevant replies and actions could be quickly carried out during data collection.

Data Analysis Procedures

Investigation into women empowerment and energy poverty is conducted based on three main objectives as noted in chapter one. The following sections outline the data analysis processes for each of the three objectives of the study, which were all constructed using data from DHS data. The unit of analysis for every single inquiry was individual women in households aged 15 to 49. The Appendices present specifics about parameter descriptions, metrics, and a-priori predictions. The Stata econometric software package was used for all analyses.

Variables Description

Energy Poverty

In studies on energy poverty, both objective and subjective criteria are often applied. One objective way is the energy income-expenditure methodology, which calculates the percentage of a household's income spent on fuel or energy expenses. The bigger this fraction, the more severe the amount of energy deprivation (Boardman, 2013; Churchill & Smyth, 2020). A

frequently used benchmark in this regard is the 10% cut-off, where families who spend more than 10% of their income on energy are defined as energy poor (Boardman, 2013; Bouzarovski & Petrova, 2015). Subjective assessments of energy poverty concentrate on the household's inability to afford appropriate heating, particularly during colder seasons. This is commonly recorded as a binary indicator: “1” if the family has trouble paying for heating owing to lack of cash, and “0” otherwise (Churchill & Smyth, 2020).

These classic indicators are generally utilised in research from developed nations, where thorough data on household fuel expenditures and heating-related difficulties are easily accessible. However, in the context of emerging economies, a more comprehensive methodology is required to reflect the intricacies of energy poverty. This research adopts the Multidimensional Energy Poverty Index (MEPI), which incorporates both objective and subjective indicators to account for financial restrictions and the speed of green energy adoption (Churchill & Smyth, 2020; Nussbaumer et al., 2013). Consistent with prior studies in developing nations (Adusah-Poku & Takeuchi, 2019; Crentsil et al., 2019), the study employs a multidimensional energy poverty measure which is representative of SSA utilising data from the Demographic and Health Surveys (DHS).

The MEPI covers five domains with six indicators: cooking, lighting, home appliances, entertainment/education, and communication (Adusah-Poku & Takeuchi, 2019; Crentsil et al., 2019; Nussbaumer et al., 2013). This index is based on the Oxford Poverty and Human Development Initiative's multidimensional poverty assessment methodology (Alkire & Foster, 2011)

and relies on Amartya Sen’s capabilities approach to poverty. Each of the five domains is normally weighted equally, with a weight of 0.2 applied to each. However, owing to their crucial role in energy poverty, cooking and lighting are given somewhat larger weights. Specifically, the lighting dimension is awarded a weight of 0.20, whereas the two indications relating to cooking are allotted a combined weight of 0.205. The other categories are each allocated a weight of 0.13. Indicators employed in Appendix A1 represent deprivations and are used to calculate household energy deprivation scores, which range from 0 to 1. These values indicate the weighted average of deprivations suffered by each family, offering a thorough evaluation of energy poverty.

$$d_i = w_1I_1 + w_2I_2 + \dots + w_nI_n \dots \dots \dots (1)$$

where d_i is the household energy deprivation score, " $I_i = 1$ if a household is deprived in indicator I " and " $I_i = 0$ if otherwise". w_i is the weight associated with an indicator i with $\sum_{i=1}^d w_i = 1$. In accordance with Nussbaumer et al. (2013), the study employs a threshold of 0.33, indicating that a family is considered energy deprived if their energy deprivation score is no less than 0.33. Also, for sensitivity and robustness checks 0.5, 0.6, 0.7, and 0.8 cut-offs were used to confirm the consistency of the results. The current DHS data employed for this study show that the share of energy-poor families in SSA is about 89 percent.

Women Empowerment

The measure of women's empowerment in this research leverages the approach created by the Oxford Poverty and Human Development Initiative (OPHI) as stated by Alkire & Foster (2011) for comprehending multidimensional phenomena such as poverty. This technique finds women

experiencing multidimensional empowerment across four critical dimensions: autonomy (involvement in family decision-making), education and literacy, resource ownership, and freedom from domestic abuse. The research adopts the conventional multidimensional cut-off of 0.33, as suggested by (Alkire & Foster, 2011; Alkire & Roche, 2012), to define women as empowered or not based on their accomplishments across these dimensions.

The empowerment cut-off k ("dimension-specific") characterises the multifaceted empowered woman as a woman powerful in at least $1/3$ of the dimensions out of the four. The research additionally used a cut-off of 0.5, 0.6, 0.7 and 0.8 which are superior to the suggested traditional multidimensional cut-off of 0.33 as a sensitivity and robustness assessment. Appendix A2 displays the four major equally weighted characteristics of empowerment (autonomy, education and literacy, resource ownership, and freedom from domestic abuse) with well-defined cut-offs. Equation (1) specifies the empowerment profile of women with the corresponding cut-offs. $\gamma_i = w_1 l_1 + w_2 l_2 + \dots + w_n l_n \dots \dots (2)$. Whereas γ_i denotes women's empowerment score, $l_i = 1$ if the woman records autonomy in indicator i and $l_i = 0$ if the reverse is the case in that order. Additionally, w_i is the weight assigned to indicator i with $\sum w_i = 1$. Equation 1 thus estimates a multidimensional women empowerment score which ranges from 0 to 1.

Based on the multidimensional cut-off of $k=0.3$, we assign the value 1 to a woman if her multidimensional empowerment score is greater than 0.3 and 0 if otherwise. The variable list in Appendix A2 is captured to reflect the various dimensions and used to derive the empowerment scores.

Estimation Techniques and Model Specification

According to the information acquired from connected ideas and current publications, an econometric framework was created defining the function that links multidimensional energy poverty. Given the continuous character of our dependent variables (multidimensional energy poverty), the ordinary least square (OLS) approach is applied to assess the connection between women empowerment and energy poverty as a baseline model.

$$MEPI_{iqrt} = \alpha + \beta WoE_{iqrt} + \delta MAT_{qrt} + \varphi HH_{qrt} + \Upsilon COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \varepsilon_{it} \dots \dots \dots (1)$$

$$MEPI_{iqrt} = \alpha + \beta Aut_{iqrt} + \delta MAT_{qrt} + \varphi HH_{qrt} + \Upsilon COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \varepsilon_{it} \dots \dots \dots (2a)$$

$$MEPI_{iqrt} = \alpha + \beta Edulit_{iqrt} + \delta MAT_{qrt} + \varphi HH_{qrt} + \Upsilon COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \varepsilon_{it} \dots \dots \dots (2b)$$

$$MEPI_{iqrt} = \alpha + \beta Res_{iqrt} + \delta MAT_{qrt} + \varphi HH_{qrt} + \Upsilon COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \varepsilon_{it} \dots \dots \dots (2c)$$

$$MEPI_{iqrt} = \alpha + \beta GV_{iqrt} + \delta MAT_{qrt} + \varphi HH_{qrt} + \Upsilon COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \varepsilon_{it} \dots \dots \dots (2d)$$

$$MEPI_{iqrt} = \alpha + \beta WoE_{iqrt} + \pi WoEEnt_{iqrt} + \delta MAT_{qrt} + \varphi HH_{qrt} + \Upsilon COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \varepsilon_{it} \dots \dots \dots (3)$$

While i, q, r , represents women aged 15-49 years, household of dwelling, and country-level characteristics that affect household multidimensional energy poverty, t denotes the period that the data was collected for each of the 33 countries. From equation (1), $MEPI$ is the main dependent variable of the study representing the multidimensional energy poverty index. WoE is the

main independent variable of the study representing women's empowerment in equations (1) and (3) respectively. *Aut, Edulit, Res and GV* which denotes Autonomy, Education and Literacy, Resource ownership, and attitude to Gender-Based violence are the disaggregated components of women empowerment which constitute the main independent variables in equations (2a) to (2d) respectively. *MAT* is a vector of maternal/women variables which includes mass media exposure, wealth quintile, number of live offsprings a woman has, age of woman, and partner's occupation. On the other hand, *HH* is a vector of household characteristics comprising of the age of the household head, household size, housing quality, and location of the household. *COUNT* constitute country and year of survey dummies. The log of the real gross domestic product per capita of each country is represented by $\ln RGDP^P$ which corresponds to the period in which data was collected for each of the 33 countries. The choice of the control variable is dictated by their observations in existing studies and energy poverty models (Ahmed, 1998; Oosthuizen, 2020; Yeboah, 2020) among others.

Potential Endogeneity

There is a probable endogenous link between women's empowerment and energy poverty. This endogeneity may come from the bidirectional interaction between the two variables. While this research mainly attempts to analyse the effect of women's empowerment on energy poverty, it is also feasible that energy poverty impacts the sovereignty status of females. This is reasonable, given that women in energy-poor homes generally spend substantial time on tasks like as fuel collection and cooking, which may restrict their educational and economic chances, therefore limiting their

empowerment. Additionally, the dependence on solid fuels creates health concerns to women and children, as emphasised by Dutta et al. (2017), which may further drain resources required for enhancing women's empowerment.

If not correctly handled, this endogeneity problem might influence the computed coefficient (β). To alleviate this problem, the research adopts the Two-Stage Least Squares (TSLS) approach, following the strategy utilised by Lu et al. (2012). This technique entails utilising the “neighbourhood women's empowerment prevalence rate” as an instrument for the TSLS estimate. For the instrument to be legitimate, it must fulfil the criteria of relevance (i.e., it should be connected with women's empowerment) and exclusion limitation (i.e., it should not directly influence energy poverty other than via its effect on empowerment). This technique enables a more accurate assessment by resolving any biases coming from the endogenous character of the variables.

Regarding relevance, it can be argued intuitively that the neighborhood women empowerment prevalence rate engenders empowerment tendencies among individual women. Thus, in neighborhoods where the prevalence of women empowerment is high, as the empowered women interact with other women by sharing experiences and information, the other women have the likelihood to exhibit empowerment attributes compared to neighborhoods with relatively low women empowerment prevalence. In terms of the exclusion restriction, the research obviates the likelihood that neighborhood women empowerment prevalence rate will have an immediate impact on energy poverty except it is implicitly transmitted via individual women's empowerment.

In light of the aforementioned, we then assess the influence of empowering the female gender on energy deprivation using a TSLS model. Equation (4) shows the first stage which is used to estimate women's empowerment (WoE) as a function of neighborhood women empowerment prevalence (EMP_PREV) including the control variables.

$$WoE = \gamma + \phi WoE_PREV_{iqrt} + \delta MAT_{qrt} + \phi HH_{qrt} + \gamma COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \epsilon_{it} \dots \dots \dots (4)$$

Equation (4) is estimated using the OLS model after which \widehat{WoE} is predicted. It is worth noting that \widehat{WoE} is composed of \widehat{Aut} , \widehat{EduLit} , \widehat{Res} , \widehat{GV} in its disaggregated form. In the second stage of the TSLS model, \widehat{WoE} in equation (4) and its disaggregated dimensions is substituted with the predicted value in equations (1), (2a), (2b), (2c), (2d) and (3) respectively.

$$MEPI_{iqrt} = \alpha + \beta \widehat{WoE}_{iqrt} + \delta MAT_{qrt} + \phi HH_{qrt} + \gamma COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \epsilon_{it} \dots \dots \dots (5.1)$$

$$MEPI_{iqrt} = \alpha + \beta \widehat{Aut}_{iqrt} + \delta MAT_{qrt} + \phi HH_{qrt} + \gamma COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \epsilon_{it} \dots \dots \dots (5.2a)$$

$$MEPI_{iqrt} = \alpha + \beta \widehat{EduLit}_{iqrt} + \delta MAT_{qrt} + \phi HH_{qrt} + \gamma COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \epsilon_{it} \dots \dots \dots (5.2b)$$

$$MEPI_{iqrt} = \alpha + \beta \widehat{Res}_{iqrt} + \delta MAT_{qrt} + \phi HH_{qrt} + \gamma COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \epsilon_{it} \dots \dots \dots (5.2c)$$

$$MEPI_{iqrt} = \alpha + \beta \widehat{GV}_{iqrt} + \delta MAT_{qrt} + \phi HH_{qrt} + \gamma COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \epsilon_{it} \dots \dots \dots (5.2d)$$

$$MEPI_{iqrt} = \alpha + \beta \widehat{Woe}_{iqrt} + \pi WoeEnt_{iqrt} + \delta MAT_{qrt} + \varphi HH_{qrt} + \Upsilon COUNT_{rt} + \Omega \ln RGDP_{rt}^p + \varepsilon_{it} \dots \dots \dots (5.3)$$

To make causal attributions of β in equation (5), it is required that EMP_PREV in equation (4) to be exogenous. That is does not have a direct relationship with $MEPI$.



CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter includes a detailed analysis and discussion of the study results on the influence of female empowerment on energy poverty in Sub-Saharan Africa (SSA). The research investigated three main hypotheses: (A) Women's empowerment lowers energy poverty, (B) Different aspects of feminine empowerment have diverse impacts on energy poverty, and (C) Entrepreneurship strengthens the impact of women's empowerment on decreasing energy poverty. To explore these assumptions, the research applied diverse estimate methodologies, including Ordinary Least Squares (OLS) and Two-Stage Least Squares (2SLS).

The econometric analysis is preceded by a graphical comparison of the poverty status for the complete sample of households across key chosen covariates, followed by a display of summary data for the variables utilised in the estimations. This early research serves as a validation check, offering insights into the level of energy poverty among families in SSA. The results establish a rigorous foundation for understanding how empowering women may play a vital role in relieving energy poverty, especially when paired with entrepreneurial ventures.

Graphical Representation of Key Variables

Figure 6 below provides the energy poverty indices of empowered and non-empowered women for the total sample. The data reveal that empowered women had a lower energy poverty index than their counterparts (non-empowered). Thus, women who are empowered have roughly 12.7 (97.8 -

85.1) percentage points lower energy poverty rate than those who are not empowered. These findings reinforce the assertion that women's empowerment is closely linked to efforts aimed at alleviating energy poverty.

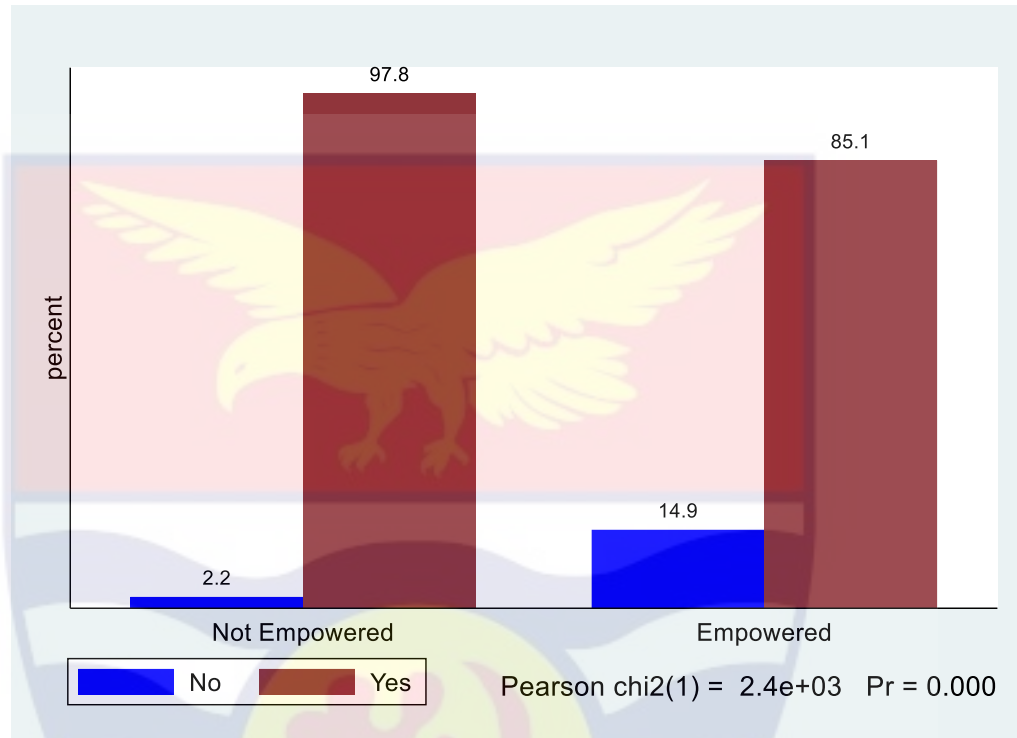


Figure 6: Energy poverty across empowerment rate
Source: Agbozo (2025)

The graph below (Figure 7) gives the prevalence of energy poverty across geographic areas (rural and urban). From the standpoint of rural-urban residency and ecological zones, the evidence that women in urban families are better off than those in rural households is further noticed. The graph illustrates that urban families are 25.1 (96.5 – 71.4) percentage points less energy-poor compared to their rural counterparts. The chi-square reveals that this distribution is statistically significant. Therefore, it seems natural that women in urban families would score lower on energy poverty than women in rural areas given their high levels of empowerment. This association coincides with study undertaken by Ahmad et al. (2016) and Yeboah (2020).

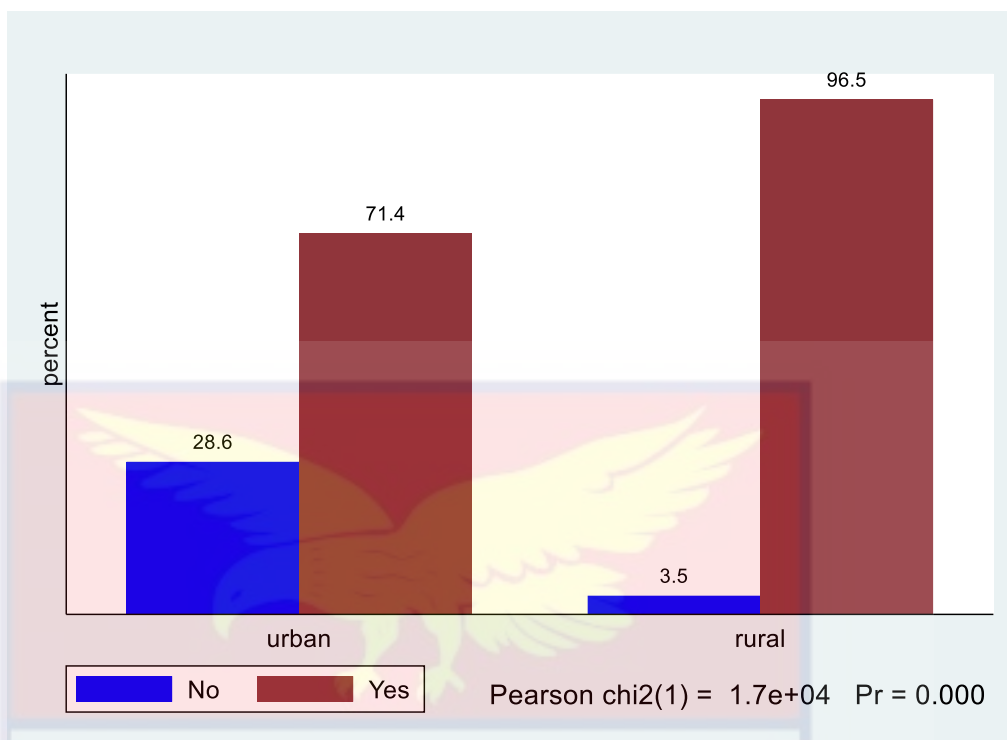


Figure 7: Proportion of energy poverty across geographic location
Source: Agbozo (2025)

Figure 8 illustrates home energy poverty based on dwelling quality proxied by materials used for the floor. From the figure, it can be observed that families that employ obsolete materials like dirt, sand, and manure are more energy-poor compared to those using contemporary floor materials. Thus, families using obsolete floor materials are projected to be 92 percent energy-poor. This suggests that housing factors, such as the kind of flooring, might impact household energy choice, all other things being equal. Numerous researches have proven how poor housing materials have a considerable influence on energy poverty (Burlinson, 2018; Chen, 2022; Streimikiene, 2023).

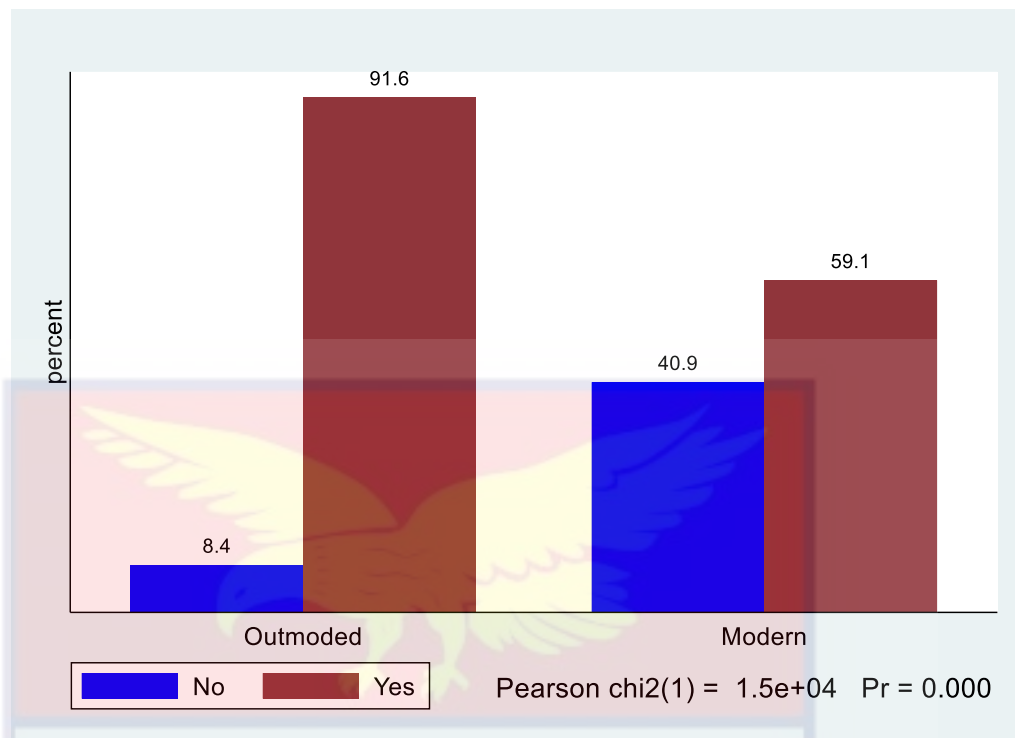


Figure 8: Proportion of energy poverty by housing quality
Source: Agbozo (2025)

Mass media exposure also plays a role in energy poverty reduction. Thus, families who have little exposure to media are more energy-poor than their counterparts. As indicated in Figure 9 families with no media exposure are 98.3 percent energy poor. The conclusion is that households become more aware of and informed about the detrimental impacts of dependency on filthy fuel on their general development and well-being via media exposure (listening to the radio or watching television among others). This unfavorable association is substantiated by the studies of (Bandyopadhyay, 2014; Bandyopadhyay, 2005; Ferrara & Ferrara, 2015; Sills, 2012) who identified a negative correlation between media exposure and poverty reduction.

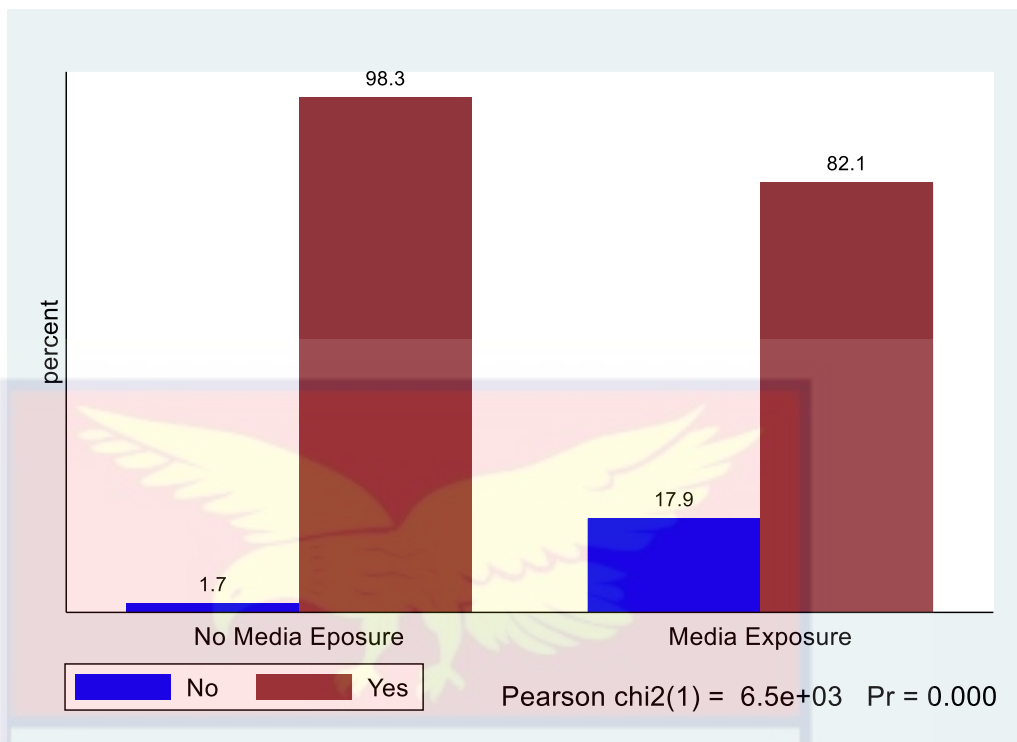


Figure 9: Proportion of energy poverty across mass media exposure
Source: Agbozo (2025)

Figure 10 reveals that there is a locational dependency between women's empowerment and place of residence at a 1 percent significant level. A higher rate of empowerment is seen among metropolitan women when contrasted with their rural counterparts. Women who are urban inhabitants had a 7.7 (90 - 82.3) greater percentage of empowerment than those in rural settings. This shows that women in urban centers have greater possibilities for self-development such as education and literacy, resource ownership, and more involvement in decision making among other things which are significant drivers of empowerment.

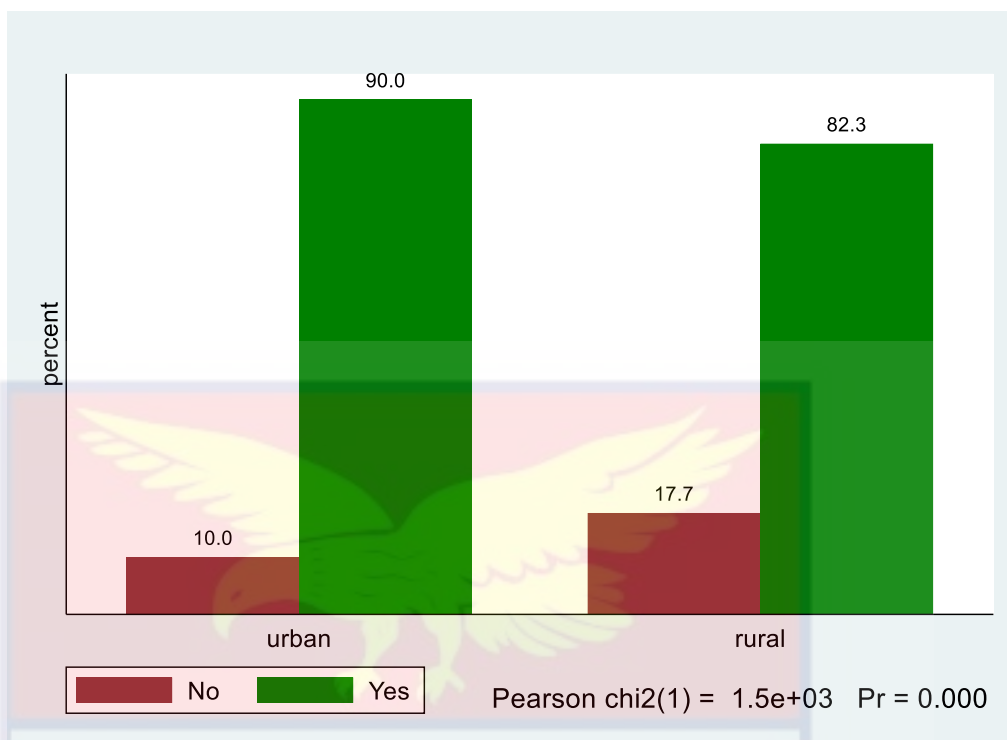


Figure 10: Proportion of women empowered across geographic location
Source: Agbozo (2025)

Figure 11 depicts the empowerment rate in families depending on housing circumstances. Housing conditions are proxied by the major materials utilised for the floor. From the figure, it can be deduced that the empowerment rate is rather high in SSA irrespective of the housing circumstances. However, women in contemporary houses are 7.6 (91.7 - 84.1) percentage points more empowered than those experiencing bad living circumstances. This link between housing conditions and empowerment is statistically relevant at a 1 percent alpha level (p-value < 0.01).

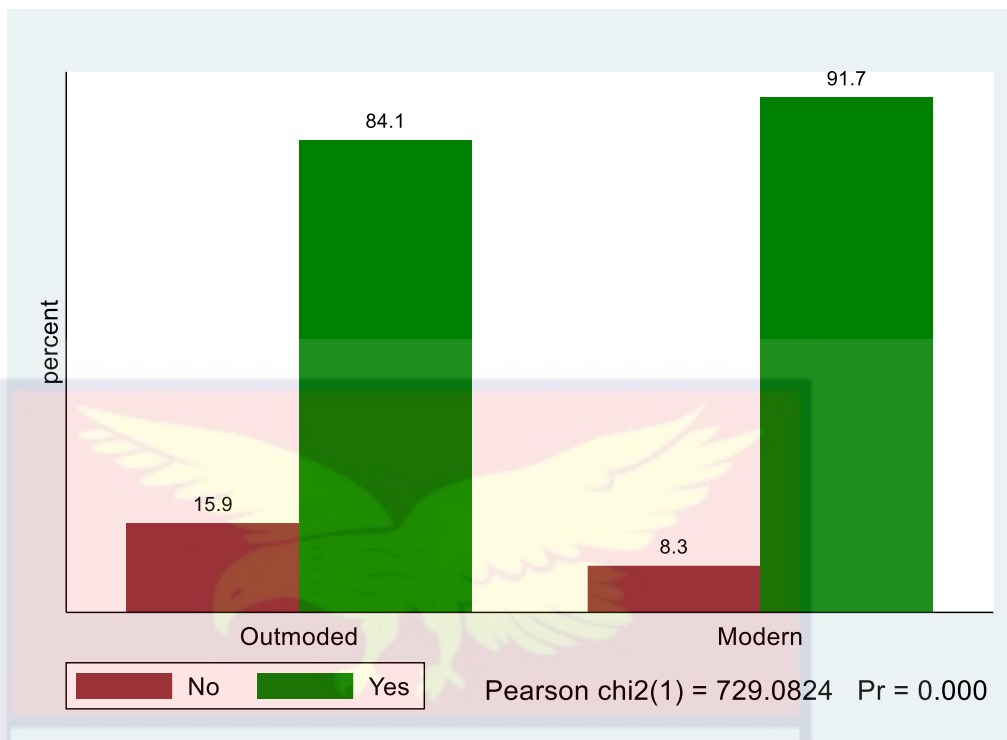


Figure 11: Empowerment rate by housing quality
Source: Agbozo (2025)

The influence of mass media exposure serves as a catalyst for women's empowerment, as illustrated in Figure 12 below. From the figure, one can infer that women who engage with media (such as listening to radio or watching television) exhibit a significantly higher rate of empowerment compared to those who lack such exposure. This relationship demonstrates a statistically significant correlation at the 1 percent level. This shows that women in homes who have access to media have the potential to learn more information on significant life topics which may help to boost their growth and translate to empowerment. Studies demonstrate that women's empowerment is favorably influenced by mass media, notably television, in numerous ways (Dasgupta, 2019; Seidu et al., 2020)

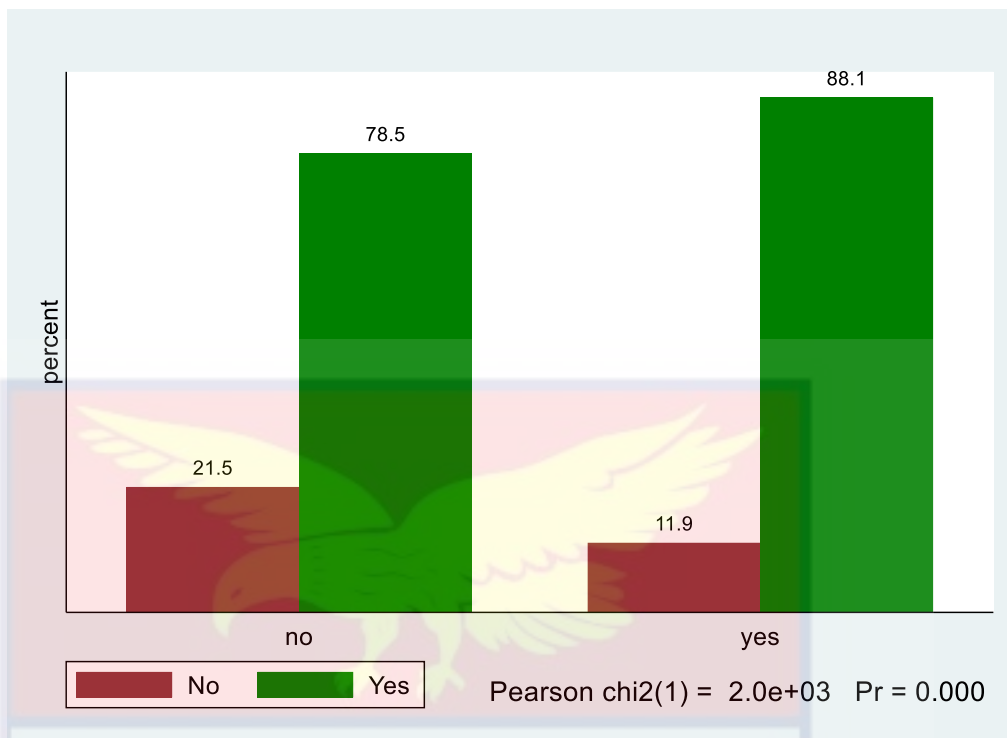


Figure 12: Empowerment rate by media exposure
Source: Agbozo (2025)

Figure 13 shows a geographical depiction of the energy poverty level across the 33 nations utilised in the research. The energy poverty rate is quite high across all the examined nations in SSA. The nations with no data are represented by white color whereas those with data have a shade of red, the darker the color, the greater the frequency. The nations with extremely deep shade have a high prevalence rate of energy poverty from 98.6 to 100 percent. Also, the lighter shade implies lower energy poverty rates. For example, it can be extrapolated that nations like Burundi, Chad, Congo Democratic Republic, Liberia, Uganda, Mali, Gambia, Guinea, Benin, Niger and Tanzania among others have a high frequency of energy poverty. The percentage of energy poverty in these nations reaches beyond 90 percent.

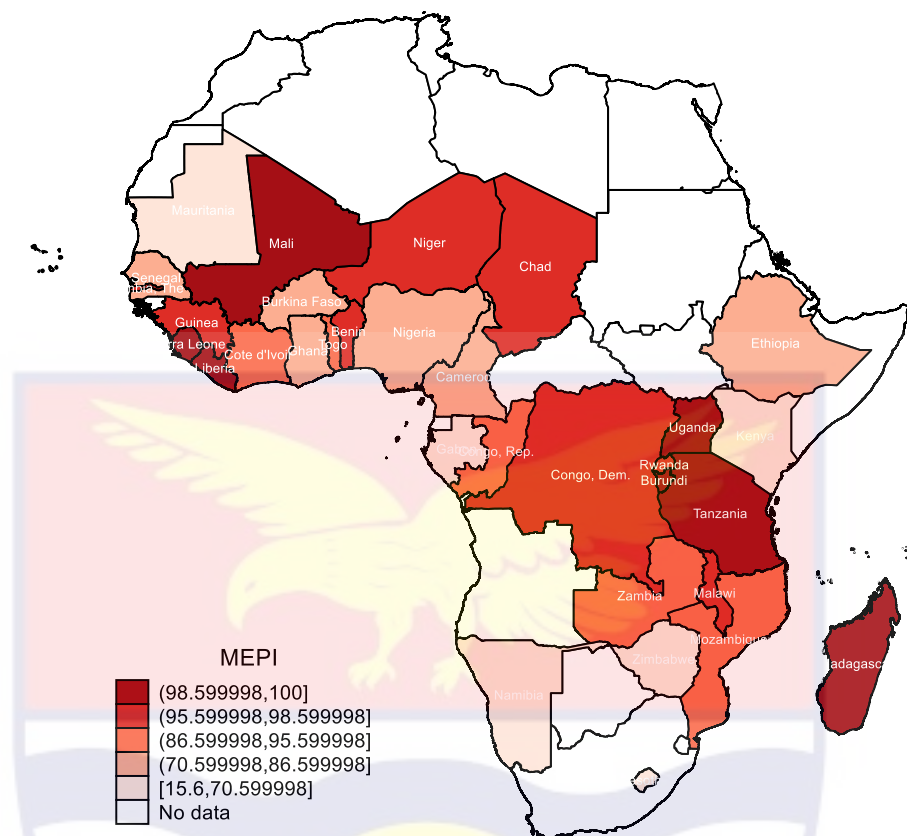


Figure 13: Energy poverty rate across 33 SSA economies
 Source: Agbozo (2025)

The map of the empowerment rate in the chosen nations is also given in Figure 14 below. The legend reflects the empowerment rate of nations with accessible data. The vacant or white-colored zones are for nations lacking empowerment statistics. From the map, Lesotho is found to have the greatest empowerment rate of almost 100 percent and this correlates to a reduced energy poverty rate of roughly 40.8 percent. This shows that the empowerment rate has a considerable influence on the energy poverty rate in Lesotho. Similarly, Gabon’s empowerment rate of approximately 96 percent correlates to a reduced energy poverty rate of roughly 16 percent. Also, nations such as Kenya, Comoros, Zimbabwe, and Namibia among others have empowerment rates exceeding 90 percent. Relatively, a greater empowerment



94.75 percent of women are participating in decision-making. Thus autonomy (decision-making) scores the highest, followed by non-justification of gender-based violence, education and literacy, and resource ownership. Moreover, there were significant demographic and socioeconomic variations among selected women which are worth noticing. For instance, mainstream media exposure accounted for roughly 70 percent. Also, around 44 percent of women are in the highest wealth quintile, 19 percent in the middle, and 37 percent in the lowest wealth quintile. Most homes in SSA are male-headed (85%) while just (15%) are female-headed. Housing conditions are exceedingly bad throughout the area; roughly 86 percent of families utilise very low-quality housing materials such as soil, sand, and wood plunks among others for their flooring. The majority of women were found to be inhabitants in rural places accounting for approximately 62 percent.

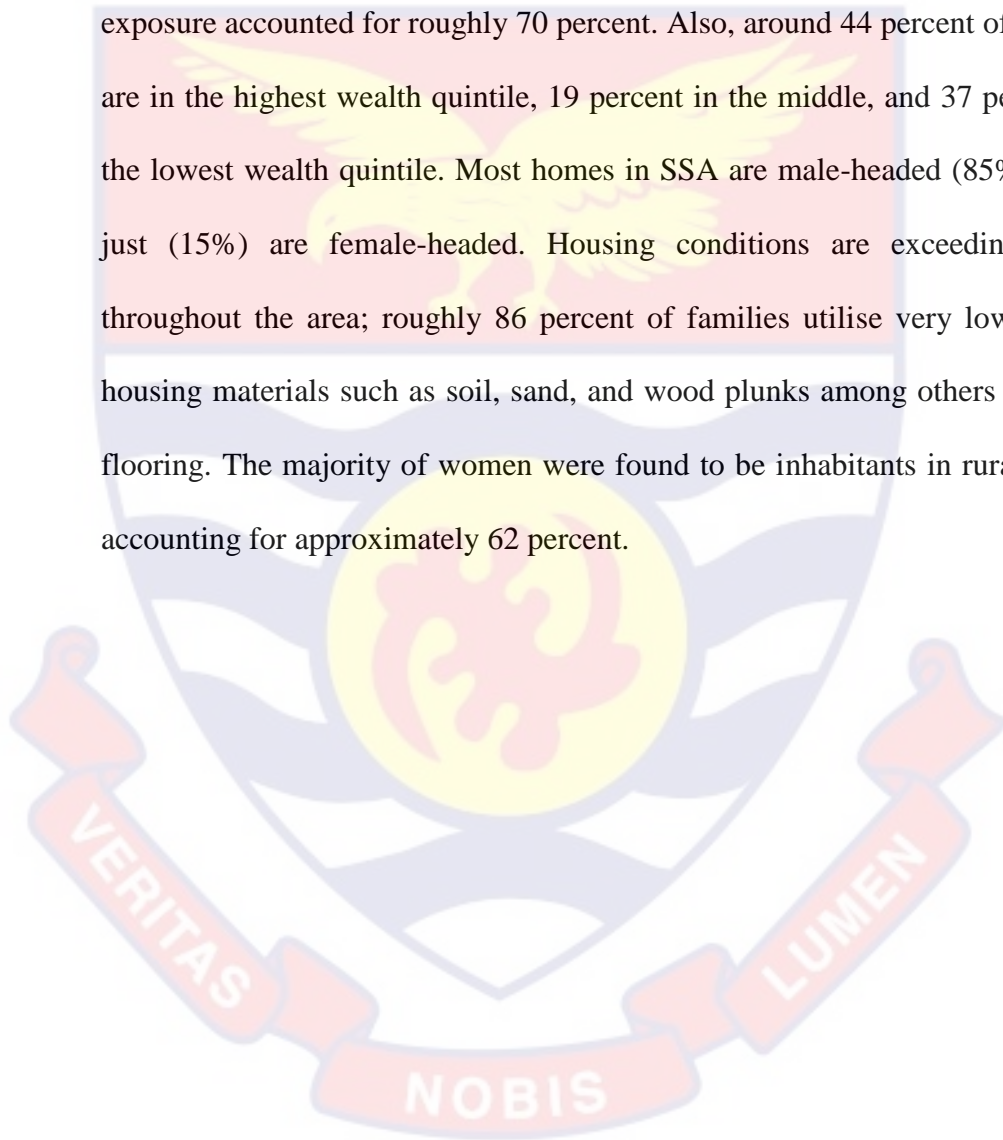


Table 1: Summary Statistics for Variables

<i>Continuous Variables</i>	Obs	Mean	Std. Dev.	Min	Max
Energy Poverty Score	132143	0.665	0.29	0	1
Women Empowerment Score	132143	0.596	0.228	0	1
Age of Woman	132143	32.79	8.132	15	49
Number of Children	132143	3.432	2.183	0	15
Age of Household Head	132143	41.784	12.241	13	95
Household Size	132143	6.562	4.481	1	99
Year of Survey	132143	2017.126	3.325	2008	2023
GDP per Capita (ln)	132143	6.983	0.691	5.491	8.926
<i>Categorical Variables</i>		<i>Frequency (%)</i>			
Energy Poverty Dummy					
No		17213		13.030	
Yes		114930		86.970	
		132143		100.000	
Women Empowerment Dummy					
No		19556		14.800	
Yes		112587		85.200	
		132143		100.000	
Autonomy (Decision Making)					
Not Involved		6966		5.270	
Involved		125177		94.730	
		132143		100.000	
Education and Literacy					
No		42460		32.130	
Yes		89683		67.870	
		132143		100.000	
Resource Ownership (House/Land)					
Does not own		68415		51.770	
Owns		63728		48.230	
		132143		100.000	
Gender-Based Violence					
Justified		12783		9.670	
Not Justified		119360		90.330	
		132143		100.000	
Mass Media Exposure					
No		39941		30.230	
Yes		92202		69.770	
		132143		100.000	
Wealth quintile					
Low		49425		37.400	
Middle		25297		19.140	
High		57421		43.450	
		132143		100.000	
Sex of Head of Household					
Male		112058		84.800	
Female		20085		15.200	
		132143		100.000	
Partner's Occupation					
Not working		1097		0.830	

Non-Agriculture	81726	61.850
Agriculture	49320	37.320
	132143	100.000
Housing Quality (Floor)		
Outmoded	113448	85.850
Modern	18695	14.150
	132143	100.000
Location		
Urban	50137	37.940
Rural	82006	62.060
	132143	100.000

Source: Agbozo (2025)

Table 2 displays the statistics of the bivariate analysis, indicating a typically negative correlation between women's empowerment and energy poverty, *ceteris paribus*. The data suggest that a one-unit rise in women's empowerment is connected with a 0.304-unit decrease in energy poverty, *ceteris paribus*. This shows that as women become more empowered, they obtain higher knowledge and awareness about their well-being, including health, time allocation for economic activities, and personal development. As a result, women who are empowered tend to adopt cleaner and more environmentally sustainable energy sources more readily than those with lower levels of empowerment. This conclusion accords with recent empirical research, such as Burney et al. (2017) and Day (2020), which have revealed that empowering women leads to lowering energy poverty.

In addition to women's empowerment, the investigation addressed additional variables that may impact energy poverty. The findings reveal that variables such as mass media exposure, income level, gender of the family head, age of the woman, partner's employment, home quality, age of the household head, and GDP per capita all contribute to lowering energy poverty, keeping other parameters constant. However, some characteristics were shown to worsen energy poverty, notably an upsurge in the number of offspring a

woman has and living in rural regions. All the parameters investigated were statistically significant at the 1% alpha level, underlining their relevance in understanding the dynamics of energy poverty.

Table 2: Bivariate Analyses on the effect of Women Empowerment and other Covariates on Energy Poverty in SSA

Energy Poverty Index	MEPI Coef (SE)
<u>Main Independent Variable</u>	
Women empowerment score	-0.304 (0.003) ***
<u>Women Characteristics</u>	
Mass Media Exposure (base = no)	
Yes	-0.280 (0.002) ***
Wealth Quintile (base = low)	
Middle	-0.130 (0.002) ***
High	-0.398 (0.001) ***
Sex of household head (base = male)	
Female	--0.052 (0.002) ***
Age of woman	-0.003 (0.000) ***
Number of living children	0.025 (0.000) ***
Husband's Occupation (base = not working)	
Non-Agriculture	-0.156 (0.008) ***
Agriculture	0.111 (0.008) ***
<u>Household Characteristics</u>	
Age of household Head	-0.001 (0.000) ***
Household Size	0.004 (0.000) ***
Housing Quality (base = Outmoded)	
Modern	-0.347 (0.002) ***
Location of household (base = urban)	
Rural	0.319 (0.001) ***
<u>Country Characteristics</u>	
GDP per Capita (ln_GDPpc)	-0.149 (0.001) ***
Country Dummies	Yes
Year of Survey	Yes
Cluster-level standard errors in parentheses	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Agbozo (2025)

Effect of Women's Empowerment on Energy Poverty

This section summarizes the results relating to the primary aim of the investigation. Tables 3 and 4 exhibit the Ordinary Least Squares (OLS) and

Instrumental Variables (IV) findings on the influence of women's empowerment on energy poverty. The varied impacts of several components of female empowerment on energy poverty are discussed in Table 5, while Table 6 offers evidence on how entrepreneurship mediates the link between feminine empowerment and energy destitution.

The multivariate findings suggest that the substantial association between female empowerment and decreased energy dearth remains statistically robust even after adjusting for other predisposing characteristics that potentially impact energy poverty. According to the OLS estimates in Table 3, the hypothesis that women's empowerment lowers energy poverty is validated. Specifically, empowered women have a 0.114-unit lower energy poverty score than their non-empowered counterparts, indicating that a one-unit increase in the empowerment score reduces energy poverty by approximately 0.1 units, even after accounting for country and time-fixed effects in the third model.

However, it is crucial to highlight that the OLS estimates may not completely represent the influence of women's empowerment on energy poverty owing to endogeneity difficulties. The coefficients generated using the OLS model is possibly skewed, since they may not sufficiently address the endogenous character of women's empowerment in connection to energy poverty. Therefore, although OLS gives first insights, it may not provide the most accurate forecasts. To solve this restriction, the Two-Stage Least Squares (TSLS) technique is applied in the following section to give a more robust analysis, minimising the bias produced by endogeneity.

Table 3: Multivariate Analyses of the Effect of Women Empowerment on Energy

	(1-OLS) Coef (SE)	(2-OLS) Coef (SE)	(3-OLS) Coef (SE)
<i>Main independent variable</i>			
Women empowerment score	-0.114 (0.004)***	-0.094 (0.004)***	-0.114 (0.004)***
<i>Women Characteristics</i>			
Mass Media Exposure (base = no)			
Yes	-0.080 (0.001)***	-0.088 (0.002)***	-0.080 (0.001)***
Wealth Quintile (base = low)			
Middle	-0.080 (0.002)***	-0.079 (0.002)***	-0.080 (0.002)***
High	-0.263 (0.002)***	-0.252 (0.003)***	-0.263 (0.002)***
Sex of household head (base = male)			
Female	0.015 (0.002)***	0.004 (0.002)**	0.015 (0.002)***
Age of woman	-0.003 (0.000)***	-0.003 (0.000)***	-0.003 (0.000)***
Number of living children	0.012 (0.000)***	0.014 (0.000)***	0.012 (0.000)***
Husband's Occupation (base = not working)			
Non-Agriculture	-0.026 (0.005)***	-0.042 (0.005)***	-0.026 (0.005)***
Agriculture	0.002 (0.005)	-0.002 (0.005)	0.002 (0.005)
<i>Household Characteristics</i>			
Age of household Head	0.001 (0.000)***	0.000 (0.000)***	0.001 (0.000)***
Household Size	-0.000 (0.000)	-0.002 (0.000)***	-0.000 (0.000)
Housing Quality (base = Outmoded)			
Modern	-0.102 (0.003)***	-0.117 (0.003)***	-0.102 (0.003)***

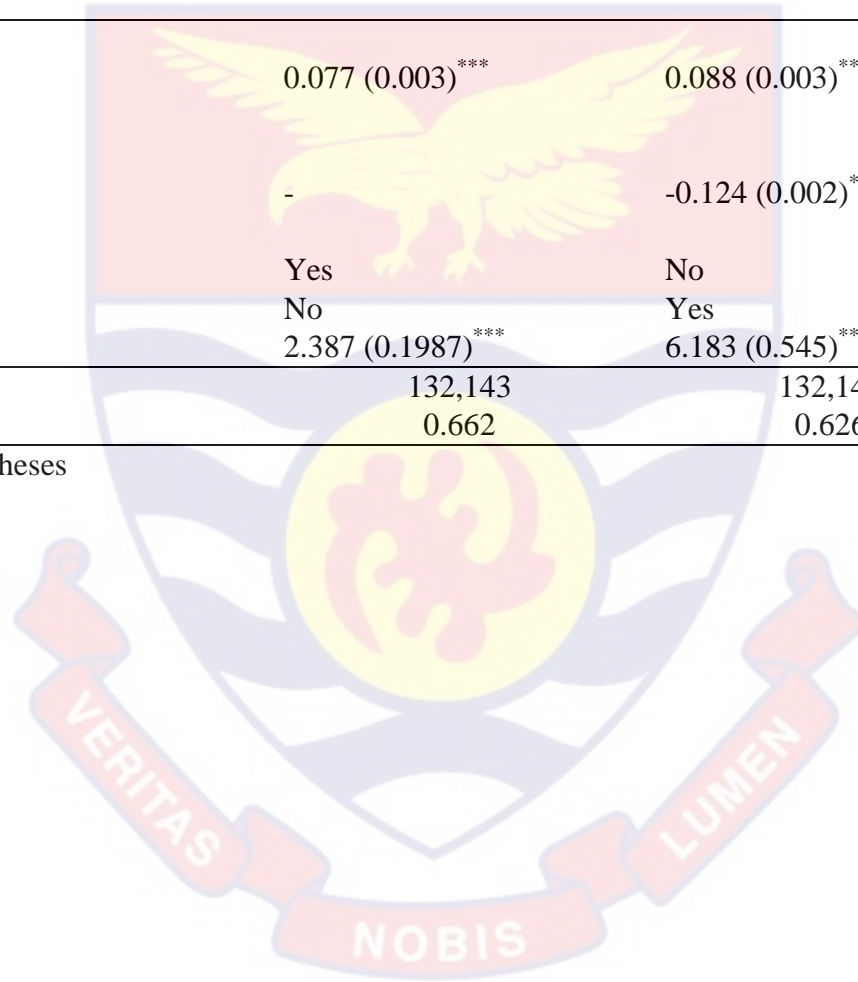
Table 3 continued

Location of household (base = urban)			
Rural	0.077 (0.003) ^{***}	0.088 (0.003) ^{***}	0.077 (0.003) ^{***}
<i>Country Level Characteristics</i>			
Log of GDP per capita	-	-0.124 (0.002) ^{***}	-0.370 (0.044) ^{***}
Country Dummies	Yes	No	Yes
Year of Survey	No	Yes	Yes
Constant	2.387 (0.1987) ^{***}	6.183 (0.545) ^{***}	26.701 (5.088) ^{***}
N	132,143	132,143	132,143
R ²	0.662	0.626	0.663

Cluster-level standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Agbozo (2025)



Endogeneity Corrected Estimates

The Two-Stage Least Squares (TSLS) estimates presented in Table 4 indicate a negative relationship between women's empowerment and energy poverty. Models 1 and 2 omit time and country fixed effects, respectively, while Model 3 incorporates both. The observed relationship is statistically significant at the 1% level. Specifically, a one-point increase in the women's empowerment score is associated with reductions in household energy poverty by 0.434, 0.101, and 0.431 units in Models 1, 2, and 3, respectively. These results suggest that households with disempowered women are more likely to experience higher levels of energy poverty. The consistency of these outcomes across different model specifications provides strong evidence supporting the role of women's empowerment in mitigating energy poverty in Sub-Saharan Africa.

The findings imply that when women's empowerment rises across several dimensions such as autonomy, education, literacy, access to resources, and rejection of domestic abuse; their negotiating power, knowledge, and self-awareness also improve. This, in turn, results into improved decision-making regarding home energy consumption. Since women are often the major consumers of home energy, improved knowledge of the health dangers connected with solid fuel consumption, as well as the time-saving advantages of contemporary fuels, may promote a transition toward cleaner energy sources.

For example, Sills (2012) observed that supplying energy to communities may boost gender parity, increase women's empowerment, and broaden their access to education, healthcare, and work possibilities.

Furthermore, rural electrification programs typically encourage gender-sensitive measures by giving access to electricity-powered amenities such as lights, television, and appliances, which may boost women's quality of life.

The results are further reinforced by Nguyen et al. (2021), who suggested that eliminating energy poverty is connected to higher economic and social empowerment for women, resulting in more job prospects, especially in the industrial and service sectors. This correlates with the findings of Munien and Ahmed (2012), Burney et al. (2017), and Day (2020), who all affirm that female empowerment has a large negative influence on energy poverty. By empowering women, families are more likely to choose renewable energy solutions, thus lowering household energy deprivation and enhancing overall well-being.

Other Covariates correlated with Energy Poverty

The research adjusted for other variables that may be related with energy poverty. The control variables include mass media exposure, income quintile, sex of household head, age of the woman, number of living children, partner's employment, age of household head, family size, home quality (conditions), and household location. Other nation-level characteristics such as real Gross domestic product per capita, country dummies, and year of survey were also accounted for.

Mass media Exposure

The emergence of mass media as a vital component of contemporary society's information access has been phenomenal. Access to knowledge is vital for efficient choice-making by individuals and consumers (Bandyopadhyay, 2014; Stigler 1961, Stiglitz 2000). Research shows that

exposure to mass media, notably via newspaper circulation, radio, and TV, may have a good influence on lowering poverty and inequality (Bandyopadhyay, 2014; Bandyopadhyay, 2005). From Table 4, it can be noted that families who are exposed to mass media had 0.064 reduced energy poverty compared to their counterparts with no media exposure (model 3). The first and second models demonstrate similar links. This is because when members of different households are exposed to the media via television stations or listening to the radio, they grow more educated and aware of problems affecting their general well-being and development of which energy poverty is not an exception. These pieces of knowledge on the pros and cons of dependency on and use of ecologically harmful energy assist people in making effective and sustainable energy choices. This suggests that aside other household elements that might contribute to energy poverty reduction, one cannot dismiss the significance of mass media in gearing up this cause.

These results are verified by (Bandyopadhyay, 2014; Bandyopadhyay, 2005; Ferrara & Ferrara, 2015; Sills, 2012) who discovered a negative link between media exposure and poverty alleviation. This indicates that while a person watches TV programs, he/she becomes exposed to a variety of items, lifestyles, and information about people, locations, or behaviors which will eventually alter their choices. Thus, having access to television and or radio may enhance understanding of the negative impacts of overdependence on solid fuel and inefficient energy-generating equipment. This understanding of the hazards and health effects of unsafe energy consumption will progressively influence family decision making towards choosing more efficient energy choices.

Wealth Quintile

The research additionally adjusted for the wealth quintile as a potential factor that might impact energy decisions at the home level. The findings reveal that moving across the different higher classes of wealth is related with a reduced energy poverty score at a 1 percent alpha level. As demonstrated in Table 4, medium and higher wealth quintiles are related with 0.067 and 0.239 reductions in energy poverty correspondingly (model 3). This is logical since movement across a higher wealth quintile denotes an improvement in the quality of life of a person, hence an increase in procurement power; consequently, the individual may purchase better and clean energy services.

This is a congruent finding that demonstrates that above a minimal income, household power usage climbs linearly with revenue levels, especially with utility use (Hasan & Mozumder, 2017; Yeboah, 2020). The argument is verified by (Asiedu, 2022; Garba, 2021) that families in the lower wealth quintiles are more likely to face greater energy poverty. This illustrates that the wealthier a family is, the fewer chances its members would be energy-deprived.

Sex of household head

The sex of the family head as indicated in model 3 is found to have a positive correlation with energy poverty. Consequently, compared to male-headed families, female headship exacerbates energy poverty. This suggests that female-headed families have 0.02 higher energy poverty ratings than their male counterparts. This may be explained by the uneven time allocation between men and women in homes, and the economy which has a harmful

influence on women's capacity to exercise financial independence (Munien & Ahmed, 2012).

This is further supported by Chant (2003), who contended that female leadership roles may perpetuate poverty. Females several roles-productive, fertility, and communal involvement-constrict their time and resources, they encounter prejudice in the job market, and they are unable to benefit from the "dual-earner" position as the sole provider for their households, which serves as a buffer against the pressures associated with neo-liberal economic overhaul.

Age of the woman

The age of the lady was shown to be statistically significant at the 1% alpha level. The results imply that each extra year of a woman is related with a decline in energy dearth by 0.002 units in Model 1 and 0.003 units in Model 2; however, Model 3 demonstrates a positive connection. This implies that as women age, they tend to gather experience and information on critical life problems, which might strengthen their decision-making skills and perhaps lessen energy poverty. However, the degree to which a woman's age adversely effects energy poverty was not extensively addressed in this research.

Contradictory results have been reported in the literature. For example, Oosthuizen (2020) discovered that elderly women are more sensitive to energy poverty. This shows that the association between age and energy poverty is not clear. Therefore, there is a need for more study to establish a threshold age beyond which a woman's growing age may begin to worsen energy poverty. Understanding this threshold might drive targeted actions to help women more successfully as they age.

Number of living children

The number of living children is defined as the total number of children born alive who are still under the care of their parents or mother. According to Table 4, the number of alive children is highly related with energy poverty. Specifically, the data reveal that for each extra kid a woman has, home energy poverty increases by 0.010 units (as indicated in the third model). This shows that a growth in the number of children imposes pressure on family income, assuming that the income stays constant. As a consequence, resources may need to be redirected to suit the demands of the new kid, which may lower the finances available for other costs, such as energy use.

This suggests that an increasing number of children might strain restricted family budgets, making it more tough to acquire greener energy sources for home usage. Oosthuizen (2020) notes that women living in disadvantaged metropolitan settings, who generally have more children, are especially susceptible owing to their increased energy demands. This difficulty is further worsened by the detrimental effect of rising birth rates on family income and welfare participation, as highlighted by Caceres-Delpiano (2012). These results underscore the larger consequences of family size on energy poverty, particularly in low-income countries.

Partner's Occupation

From Table 4, it can be noticed that a partner's work (non-agriculture) has a negative connection with energy poverty. The data reveal that women whose husbands are working are 0.024 less energy deprived compared to their peers whose spouses are not working (column 3). This means a partner's profession, which translates into an increase in household resources or income

equally influences household decision making and energy choices. As the family disposable income improves, their buying power increases, ergo they may devote resources to satisfy fundamental household demands which include more improved energy use. Therefore, families with dual-income spouses are likely to have a greater quality of living compared to their counterparts. This corresponds with Yeboah (2020), who proved that a raised welfare level correlates with a lower chance of energy poverty. This means that a partner's profession enhances the welfare of families owing to an increase in family income, and this will have a favorable influence on lessening energy poverty.

Age of Household Head

Across all three models, the age of the family head was shown to be positively connected with energy poverty. This suggests that a one-unit increase in the age of the household head is connected with a higher level of energy poverty, demonstrating that homes headed by older adults endure larger degrees of energy deprivation. It is crucial to highlight that age was regarded as a continuous variable in this research, meaning the study did not specify a particular age at which energy poverty considerably worsened.

These results correspond with recent study by Nie (2021) and Ashagidigbi (2020), which identified age as a critical factor driving energy poverty, showing that older household heads are more sensitive to greater levels of energy deprivation. However, this link is not completely agreed upon, since Kebede (2022) discovered a positive correlation between age and increased energy availability, indicating that older family heads could be less energy deprived in certain settings. Thus, the available literature on the

connection between family head's age and energy poverty remains ambiguous, highlighting the need for future study to elucidate these dynamics.

Household size

The size of the family proxied as the number of members of the household indicates a negative connection with energy poverty as demonstrated in all the models of Table 4. The implication is that larger households experience reduced energy poverty. From the table, each additional family member results in a 0.001, 0.002, and 0.001 decrease in energy poverty (models 1, 2, and 3). A possible reason is that, if there are more working persons in a home, their income level will cumulatively be greater leading to an improvement in household welfare and this may translate into lower energy poverty levels.

However, if there are more dependents in the larger house, there is likely to be pressure on the family resources which can worsen energy poverty. For instance, Yeboah (2020) observed that households with more members in Ghana were far less probable to experience energy poverty, while Chen (2022) and Scheier (2022) reported the opposite in China and the United States respectively, with larger households more likely to be subjected to energy poverty. These findings illustrate that the connection between family size and energy poverty is complicated and may fluctuate across varied circumstances.

Housing Quality/Housing Conditions

Housing quality, measured based on the kind of material used for flooring, was shown to be statistically significant. This shows that the kind of housing material might affect household energy poverty. As seen in the three

models in Table 4, families with contemporary flooring materials had lower energy poverty ratings compared to those with obsolete or inferior floor materials. In other words, leaving all other parameters constant, dwelling attributes notably the quality of flooring materials might affect household energy decisions.

A considerable amount of research emphasises the major influence of insufficient house materials on energy poverty. For instance, Burlinson (2018) and Streimikiene (2023) underlined that housing circumstances are a crucial aspect in the multifaceted character of energy poverty. Similarly, Chen (2022) showed that older, poorly insulated dwellings are more likely to be linked with greater levels of energy poverty. These results underline the necessity of improving housing quality as part of efforts to eliminate energy poverty.

Location of household

The analysis also accounted for the site of residence, differentiating between rural and urban families. The findings reveal that dwelling in a rural location is positively related with energy poverty and is statistically significant at the 1% alpha level. These data show that persons in rural locations have much greater degrees of energy deprivation compared to those in urban environments. Specifically, the data demonstrate that rural families are 0.079 units more energy deprived than their urban counterparts, as stated in Model 3.

This observation fits with results from previous empirical research, which reveal a greater incidence of energy poverty in rural locations compared to urban areas (Cyrek, 2022; Yeboah, 2020). The difference emphasises the persisting obstacles in energy access that disproportionately impact rural

people, underlining the need for focused efforts to alleviate energy inequality in these regions.

Country level Characteristics

The study also controlled for year of survey, country dummies and real GDP per capita as a macro level variable. Model 3 of Table 4 reveals a percentage rise in Per Capita GDP would lead to a 0.098 decrease in energy poverty across families in SSA. This means that families in countries that have faster economic development are unlikely to be energy-deprived than their counterparts who have lower growth rates. This also suggests that, aside from other domestic factors that might have a major influence on energy poverty, one cannot disregard the importance of economic development as a key contributor to energy poverty decrease.

Essentially, when an economy improves, there is an anticipated increase in the eminence of life of residents. This rise in the standard of life connotes better welfare choices of which energy choice is not an exception. Hence it is projected that a rise in per capita GDP would result in a reduction in energy destitution as illustrated in model 2 and 3 respectively (see Appendix D). This negative association between energy poverty and GDP per capita is corroborated by several writers (Garba, 2021; Yakubu, 2017)

Table 4: Multivariate Analyses of the Effect of Women Empowerment on Energy (IV Results)

	(1-IV) Coef (SE)	(2-IV) Coef (SE)	(3-IV) Coef (SE)
<u>Main independent variable</u>			
Women empowerment score	-0.434 (0.027)***	-0.101 (0.019)***	-0.431 (0.027)***
<u>Women characteristics</u>			
Mass Media Exposure (base = no)			
Yes	-0.064 (0.002)***	-0.087 (0.002)***	-0.064 (0.001)***
Wealth Quintile (base = low)			
Middle	-0.066 (0.002)***	-0.078 (0.002)***	-0.067 (0.002)***
High	-0.238 (0.003)***	-0.252 (0.003)***	-0.239 (0.003)***
Sex of household head (base = male)			
Female	0.020 (0.002)***	0.004 (0.002)**	0.020 (0.002)***
Age of woman	-0.002 (0.000)***	-0.003 (0.000)**	0.002 (0.000)***
Number of living children	0.010 (0.000)***	0.014 (0.000)***	0.010 (0.000)***
Husband's Occupation (base = not working)			
Non-Agriculture	-0.024 (0.006)***	-0.042 (0.005)***	-0.024 (0.006)***
Agriculture	0.003 (0.006)	-0.003 (0.005)	0.003 (0.006)
<u>Household Characteristics</u>			
Age of household Head	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***

Table 4 continued

Household Size	-0.001 (0.000)***	-0.002 (0.000)***	-0.001 (0.000)***
Housing Quality (base = Outmoded) Modern	-0.091 (0.003)***	-0.116 (0.003)***	-0.091 (0.003)***
Location of household (base = urban) rural	0.079 (0.003)***	0.088 (0.003)***	0.079 (0.003)***
<u>Country Level Characteristics</u>			
ln_GDP per capita	0.002 (0.034)	-0.124 (0.002)***	-0.098 (0.052)***
Country Fixed Effects	Yes	No	Yes
Time Fixed Effects	No	Yes	Yes
Constant	0.988 (0.232)***	6.124 (0.575)***	16.696 (5.603)***
First stage			
Neighborhood prevalence of women empowerment	0.002 (0.000)***	0.002 (0.000)***	0.002 (0.000)***
N	132,143	132,143	132,143
R ²	0.6233	0.626	0.624
Weak identification test (Cragg-Donald Wald F statistic):	6261.321	8398.390	6206.514

Cluster-level standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Agbozo (2025)

Differential effects of the Dimensions of Women's Empowerment on Energy Poverty

This section addresses the varying implications of the aspects of women's empowerment on energy poverty. Four indicators were utilised to capture women's empowerment: (a) Autonomy, (b) Education and literacy, (c) Resource ownership, and (d) Attitude towards Gender-based violence. Autonomy of the woman is a binary variable (1 = engaged in decision making 0 = not involved in decision making) that represents the degree of power the woman has in deciding things involving vital household choices. Education and Literacy are assessed as (1 = woman has at least elementary education and or can read and write 0 = lady has no education and or cannot read and write. It is believed that women who are enlightened would have more negotiating power in the family which would transfer into making better household energy decisions.

Resource ownership is measured as (1 = woman owns a home and or land 0 = woman does not own a house or land). Access to and control over resources is considered an enhancement in women's economic empowerment. This suggests that a woman who possesses such resources has a larger negotiating power and consequently may influence decisions and choices made at the family level. Attitude to gender-based violence assessed as whether the beating is justifiable if a woman/wife neglects significant home chores is recoded as binary ("1 = Beating Not Justified" "0 = Beating Justified"). The existence of domestic violence denotes a lack of empowerment, so if the woman faces any form of violence in the house, then she is unempowered. On the other side, her degree of empowerment improves

if she does not meet any abuse in the household. This is considering violence committed against women in the home diminishes their ability to negotiate; accordingly, their empowerment grows when they are free from such abuse, which influences crucial household decisions like the production and use of energy. The next paragraph summarizes the conclusions of these four empowerment dimensions, and then goes on to clarify other elements that were included in the research.

Autonomy in Decision Making of the Woman

A woman's engagement in the home decision-making process is assessed by whether she participates in choices about her healthcare, significant household purchases, everyday household requirements, visits to family or relatives, and how to handle her partner's wages. This indicator is statistically significant at the 1% alpha level. The numbers from Table 5 demonstrate that women's engagement in decision-making greatly lowers family energy poverty. Specifically, families where women are actively participating in decision-making exhibit a 2.594-unit lower energy poverty score compared to households where women are not engaged in such choices.

These results imply that a woman's autonomy is connected with a decrease in family energy poverty. The findings confirm the premise that a woman's agency in making family decisions might be a key factor in optimizing family energy choices, hence decreasing energy poverty. This result accords with earlier research by Ahmad et al. (2016) and Sills et al. (2012), who suggested that families where women wield higher decision-making power are typically better off than those where women have less or no decision-making authority. Thus, empowering women in home decision-

making is expected to lower poverty levels and promote overall household well-being.

Education and Literacy

The second column of Table 5 gives the estimates relating to the education and literacy component of feminine empowerment employed in this research. The data demonstrate that education and literacy are negatively related with energy poverty, with findings being statistically significant at the 1% alpha level. The inference is that a woman who has at least a basic education or can read and write is better positioned to make educated judgments about energy choices at the family level. As demonstrated in Model 2, each extra year of schooling, or merely being literate, is connected to a 0.311-unit fall in the household's energy poverty score.

It is vital to note that when a woman attains greater levels of education, she obtains access to better options, such as higher-paying employment, which considerably boost her empowerment. This enhanced empowerment immediately enhances her bargaining and buying power, effectively affecting family choices. Empirical investigations by several authors have similarly proven that education has a detrimental influence on multidimensional poverty (Roy & Alam, 2021) and energy poverty (Ahmad et al., 2016; Polemis & Soursou, 2021). For example, Yeboah (2020), in his research on “An Economic Assessment of Energy Poverty and Households’ Welfare in Ghana,” observed that the influence of educational attainment on decreasing energy destitution improves as the education level of the household head grows. Thus, the more educational progress a family head accomplishes, the lower the household’s energy poverty circumstances.

Resource Ownership

Numerous scholars have underlined that holding assets whether financial, humanitarian, or social is a necessary precondition to empowerment, since assets strengthen an individual's capacity to make decisions (Kabeer, 1999; Singh & Singh, 2020). In the current study, access to and control over resources was one of the important markers of women's empowerment. The data indicate that this factor is statistically significant at the 1% alpha level. Specifically, as indicated in column 3 (model 3) of Table 5, a one-unit increase in resource ownership leads to a 0.482-unit decrease in multidimensional energy poverty within families.

The possession of resources, such as land or a house, shows a woman's economic position, so empowering her monetarily and economically. This shows that a woman with control over these assets is more likely to be autonomous in decision-making owing to the enormous bargaining and buying power that such ownership gives. From another viewpoint, a woman who is economically and financially independent is better positioned to influence home choices compared to her colleagues who lack access to such resources. Thus, resource ownership not only promotes economic security but also strengthens women's autonomy within their homes.

Attitude to Gender-Based Violence

Gender-based violence is the fourth component of female empowerment included in the research. This metric is equally significant at a 1 percent level of significance. In model 4 of Table 5, the data demonstrate an inverse connection between the acceptability of gender-based violence and energy poverty. This means that an improvement in empowerment (non-

acceptance of domestic abuse) is connected with a decline in energy deprivation in families by 0.727 units. A probable explanation is that women who do not suffer from violence in their homes have the freedom to share their opinions on vital household matters and hence may participate in household decision making which includes energy choices. Thus, women being the principal users of energy at the residential level, and having the foreknowledge of the merits and demerits of energy choices, would be able to share their thoughts on the need to adopt a better and environmentally friendly energy devoid of any fear.

Other covariates

The subsequent paragraph discusses other control variables used in the estimations. It is worth noting that the same covariates used in the main model (Tables 3 and 4) are employed in the analyses of the differential effects of women's empowerment dimensions on energy poverty.

Women Characteristics

In all four models, it was revealed that mass media exposure was adversely connected with energy impoverishment. The results imply that a household's exposure to mass media has a substantial influence on lowering energy poverty at a 1 percent level of significance. Indicating that families with access to mass media are less energy-poor compared to their counterparts who are not in models 1, 2, 3, and 4. This is verified by other authors (Bandyopadhyay, 2014; Sills, 2012) who argued that exposure to mass media has a major influence on alleviating energy poverty.

Another crucial covariate employed in the estimate is the wealth quintile defined as low, medium, and high levels. The findings reveal that

relative to the base (low wealth quintile), at the one percent significance level, rising a quintile is connected to a reduced energy poverty score. However, model 3 displays a positive coefficient for the middle wealth quintile at a 5 percent alpha level. Column 1 of Table 5 reveals that medium and high-wealth quintile classifications are connected with a drop in domestic energy poverty by 0.066 and 0.238 units correspondingly (see Appendix D). Models 2, 3, and 4 also indicate a similar pattern in reducing energy deprivation when one upgrades to a higher wealth quintile. This assumption is backed by investigations from various authors as mentioned in the primary model (Asiedu, 2022; Garba, 2021).

At a 1 percent alpha level, the family head's gender was determined to be statistically significant. From Table 5, the findings demonstrate that female-headed families aggravate energy poverty in models 1, 2, 3 and 4. Thus, compared to male-headed families, female-headed households are 0.052, 0.023, 0.007, and 0.018 more energy-poor in models 1, 2, 3, and 4 correspondingly. This shows that female headship itself causes poverty (Chant 2003). Similarly, every extra kid a woman delivers likewise exacerbates home energy poverty in all four scenarios. The total number of offspring a mother has may greatly affect her susceptibility to energy poverty (Caceres-Delpiano, 2012; Oosthuizen 2020).

The age of a woman and partner's work was shown to have a decreasing influence on energy poverty in all models except model 3. All the coefficients in the models are statistically significant. This means that as a woman matures, residential energy poverty reduces (Models 1, 2, and 4). This inverse association might be linked to the fact that the woman obtains more

knowledge and experience as she matures and, thus can make appropriate judgments that will benefit the welfare of her home. However, the threshold to which this increase in age might negatively affect energy poverty levels is not addressed in this research.

Moreover, the negative link between a partner's profession and energy poverty proves that spouses who are working contribute to the household resources and consequently drawing these resources together helps to increase family well-being. In a nutshell, an increase in family welfare (Yeboah, 2020) will be reflected in making better energy choices hence lowering energy poverty in the home.

Household characteristics

The location of the home and the age of the family head were shown to have been positively connected with dirty energy utilisation at a 1 percent level of significance. Columns 1, 2, 3, and 4 in Table 5 suggest that each extra age of a family head worsens energy poverty (Appendix D). This is similar to the results of other writers (Ashagidigbi 2020; Nie, 2021). The positive association between home location and energy poverty also means that rural inhabitants are worse off, compared to urban dwellers. As indicated in Table 5, families in rural areas are 0.045, 0.066, 0.130, and 0.061 units more energy poor than their urban counterparts in models 1, 2, 3, and 4 accordingly. This statement supports other empirical investigations (Cyrek, 2022; Yeboah, 2020).

The data also suggest that household size is adversely related to energy poverty except model 3 which has a positive connection. This shows that families with higher members have lower levels of energy poverty. The

empirical works (Yeboah, 2020) support this claim. Housing circumstances (housing quality) proxied by the kind of floor material used also demonstrated a negative correlation with energy poverty. Table 5 depicts that, the usage of contemporary floor materials such as tiles is connected to decreased energy poverty levels compared to the use of obsolete floor materials like dung or soil. The data show that families with superior quality dwelling materials are more likely to employ efficient and contemporary energy equipment such as LPG and electric stoves among others which are ecologically safe to use considering the design of the house. However, individuals living in dwellings made with clay, or bushes are less likely to adopt these energy-safe devices even if they can afford them because most of them cook in the open area or beneath a shade. This argument is underscored by the works of (Burlinson, 2018; Chen, 2022; Streimikiene, 2023)

Country level variables

The study also controlled for year of survey, country dummies and real GDP per capita as a macro level variable. From all the models, GDP per capita is seen to have an inverse link with energy poverty, however, the coefficients in models 1 and 2 are statistically invalidated. Thus, a percentage increase in GDP per capita ceteris paribus will result in a 0.151 and 0.480 decrease in energy poverty in models 3 and 4 respectively. The finding is consistent with the works of (Garba, 2021; Yakubu 2017).

Table 5: Differential effect of Women Empowerment Dimensions on Energy Poverty (IV RESULTS)

	(1) Coef (SE)	(2) Coef (SE)	(3) Coef (SE)	(4) Coef (SE)
<i>Main Independent Variables</i>				
Autonomy (Decision Making)	-2.594 (0.519)	-	-	-
Education and Literacy	-	-0.311 (0.022) ^{***}	-	-
Resources Ownership	-	-	-0.482 (0.043) ^{***}	-
Gender-Based Violence	-	-	-	-0.727 (0.070) ^{***}
Women Characteristics	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Log of GDP per capita	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
First stage				
Neighborhood prevalence of women empowerment	0.0003208 (0.000) ^{***}	0.00268 (0.000) ^{***}	0.00173(0.000) ^{***}	0.001115 (0.000) ^{***}
N	132143.000	132143.000	132143.000	132143.000
R ²	-3.096	0.539	0.129	0.181
Weak identification test (Cragg-Donald Wald F statistic):	111.240	2620.625	779.375	840.661

Cluster-level standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Agbozo (2025)

Dominance Analysis

The findings from the differential analysis suggest that diverse components of women's empowerment have varying and substantial implications on energy poverty. However, it is vital to establish which of these elements has the largest effect on decreasing energy poverty. To create this comparison, dominance analysis (DA) was undertaken to identify which particular aspect of feminine empowerment is the most influential. In multiple regression, DA is used to analyse the relative relevance of variables by comparing the extra R^2 contributions of each predictor across all subgroup models (Azen & Budescu, 2006). This technique offers a full assessment of the impact of predictors in a multivariate setting by extending R^2 to situations with multiple response variables.

The results from the DA, as given in Table 6, demonstrate that education and literacy are the most significant variables in alleviating energy poverty. The second most important predictor is resource ownership, followed by views against gender-based violence, and lastly, autonomy. These findings underline the essential significance of education in reducing energy poverty. Specifically, the better a woman's educational attainment, the more likely she is to switch to clean energy sources, hence lowering household energy deprivation. This emphasises the need for policies that concentrate on empowering women through education and literacy as a crucial method for decreasing energy poverty in homes throughout Sub-Saharan Africa.

Table 6: Dominance Analysis

Energy Poverty	Dominance statistics	Standardized Dominance statistics	Ranking
Autonomy (Decision Making)	0.002	0.023	4
Education and Literacy	0.048	0.737	1
Resource Ownership	0.008	0.121	2
Gender-Based Violence	0.008	0.120	3
N	132143.000		
Overall Fit Statistics	0.0648		

Source: Agbozo (2025)

Mediation role of Entrepreneurship on Energy Poverty

Existing research publications demonstrate that women's entrepreneurship greatly influences creativity, job creation, and the generation of wealth globally (Brush & Cooper 2012). According to Dutta et al. (2017) women reinvest roughly 90% of their earnings in their families and societies hence women participating in entrepreneurial activities would increase their economic empowerment which will have a multiple influence on other crucial economic indicators such as energy poverty. The mediation study below highlights the importance of entrepreneurship in boosting female empowerment and its combined influence on energy poverty. From Table 7, women empowerment is observed to have an inverse connection with the outcome variable, energy poverty and this is substantial at 1 percent alpha level.

Moreover, entrepreneurship is regarded to have an excellent connection with women's empowerment. This means that entrepreneurship boosts female empowerment by 0.183 units. The impact of the mediator while controlling for the treatment (women empowerment) in the third row suggests

that both the mediator (entrepreneurship) and treatment (women empowerment) variables have an inverse connection with energy poverty. Row 4 provides the linear IV mediation analysis findings. From the table, women empowerment via entrepreneurship (indirect effect) has 0.306 units lowering effect on energy poverty. Also, the direct effect of empowerment on energy poverty is -0.051. This suggests that women's empowerment directly lowers energy poverty by 0.051 units. Finally, the overall impact of women empowerment on energy poverty with the mediation function of entrepreneurship is -0.357. This suggests that women's empowerment via business (total effect) leads to 0.357 units decline in energy poverty.

In summary, the mediator variable has 85.60% explanatory power on the treatment variable in predicting the changes in energy poverty. Thus, 85.60 percent of the disparities in energy poverty could be attributed to the aggregate effect of entrepreneurship on women's empowerment.

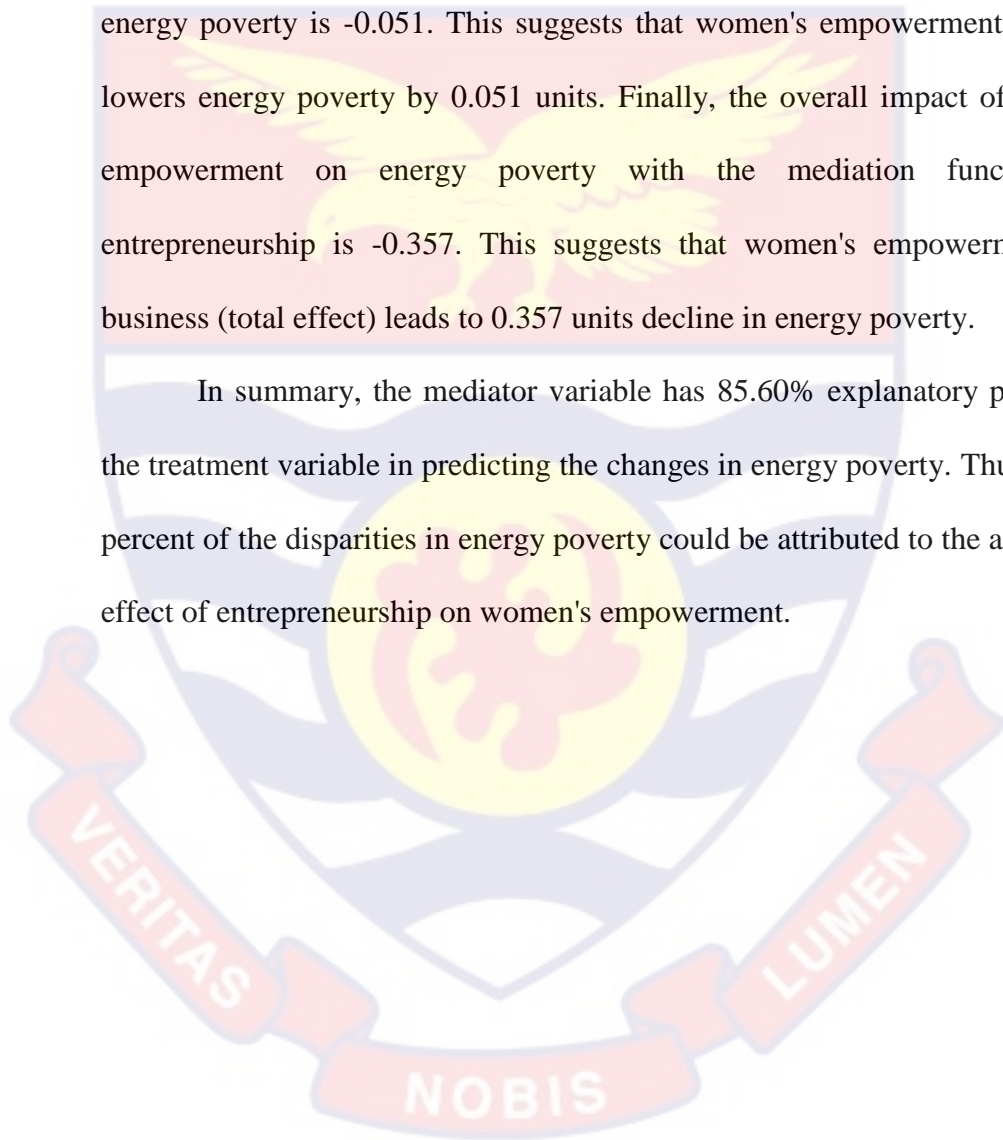


Table 7: Entrepreneurship as a Mediator

Outcome: Energy Poverty Dummy	
Treatment: Women empowerment dummy	
Mediator: Entrepreneurship	
<hr/>	
Effect of the treatment on the outcome	(1)
Women empowerment dummy	-0.183 (.008)***
<hr/>	
Effect of the treatment on the mediator	
Women empowerment dummy	0.183 (0.016)***
<hr/>	
Effect of the mediator on the outcome, controlling for the treatment	(2)
Women empowerment dummy	-0.051 (.003)
Entrepreneurship	-1.675 (0.151)
<hr/>	
Linear IV Mediation Analysis	(3)
Total effect	-0.357 (0.011)***
Direct effect	-0.051 (0.003)***
Indirect effect	-0.306 (0.007)***
<hr/>	
N	129850.000
<hr/>	
Explanatory Power of Mediator (Entrepreneurship) on the total effect.	85.60%
F-statistic for excluded instruments in	
- first stage one (T on Z): 9533.319	
- first stage two (M on Z T): 895.347	
<hr/>	
Cluster-level standard errors in parentheses	
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$	
Source: Agbozo (2025)	

Sensitivity Analyses

In this portion, multiple robustness tests are undertaken to examine the dependability of the estimations. First, the model is re-specified by changing both the dependent and independent variables into binary (dummy) variables. The multidimensional energy poverty index is classified as "1 = Yes" if a household is energy poor, and "0 = No" if a family is not. Similarly, the multidimensional women's empowerment index is graded as "1 = Yes" if a

woman is empowered, and "0 = No" if she is not. The instrumental variable (IV) findings offer a comprehensive study of the link between women's empowerment and energy poverty.

As seen in Table 8, the data consistently suggest a negative link between female empowerment and energy destitution across all models. This suggests that both aggregate female empowerment and its individual facets have a mitigating influence on household energy poverty. Specifically, column 1 reveals that in families where women are empowered, energy poverty is decreased by 0.357 units compared to households where women are not empowered. Additionally, the findings for the autonomy component imply that women active in household decision-making enjoy a 3.872-unit decrease in energy poverty compared to their counterparts who are not involved. Similar relationships are evident for the components of education and literacy, resource ownership, and attitudes toward gender-based violence. These discoveries are consistent with the early OLS results and the endogeneity-corrected estimates, which treated feminine sovereignty and energy deprivation as continuous variables (see Tables 3 and 4).

Secondly, Table 9 offers the sensitivity analyses of feminine empowerment and energy poverty in regard to conventional cutoff values. The research employed cutoffs of 0.5, 0.6, 0.7, and 0.8 to scrutinise the influence of women's empowerment on energy poverty. The statistics demonstrate that higher thresholds for empowerment correlate to lower energy poverty indices.

However, beyond the 0.5 threshold, the impact of women's empowerment on energy poverty stays rather steady. In summary, the results obtained using the cutoffs of 0.5, 0.6, 0.7, and 0.8 correspond with the prior

findings, suggesting that the outcomes are resistant to varied metrics of energy poverty. This consistency emphasises the credibility of the study's results about the favourable influence of empowering the female gender on diminishing energy poverty.



Table 8: Re-specification of the effect of Women Empowerment on Energy Poverty as a dummy (IV RESULTS)

	(1) Coef (SE)	(2) Coef (SE)	(3) Coef (SE)	(4) Coef (SE)	(5) Coef (SE)
Women Empowerment Dummy	-0.357 (0.023) ^{***}	-	-	-	-
Autonomy (Decision Making)	-	-3.872 (0.772) ^{***}	-	-	-
Education and Literacy	-	-	-0.464 (0.033) ^{***}	-	-
Resources Ownership	-	-	-	-0.719 (0.065) ^{***}	-
Gender-Based Violence	-	-	-	-	-1.085 (0.104) ^{***}
Women Characteristics	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes
Log of GDP per capita	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
First stage					
Neighborhood prevalence of women empowerment	0.00387 (0.00004) ^{***}	.00039 (0.00003) ^{***}	0.00414 (0.00005) ^{***}	0.00135 (0.00005) ^{***}	0.00129 (0.00003) ^{***}
N	132143.000	132143.000	132143.000	132143.000	132143.000
R ²	0.293	-5.868	0.146	-0.487	-0.426
Weak identification test (Cragg-Donald Wald F statistic)	6169.614	111.240	2620.625	779.375	840.661

Cluster-level standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Agbozo (2025)

Table 9: Sensitivity Analyses of the effect of Women Empowerment on Energy Poverty in SSA using 0.5 to 0.8 cutoffs (IV RESULTS)

	(1)	(2)	(3)	(4)
Energy poverty	Coef (SE)	Coef (SE)	Coef (SE)	Coef (SE)
<i>Main Independent Variable</i>				
Women empowerment score	-0.431 (0.027)***	-0.441 (0.028)***	-0.441 (0.028)***	-0.441 (0.028)***
			Yes	Yes
Women Characteristics	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Log of GDP per capita	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
First stage				
Neighborhood prevalence of women empowerment	0.00231 (0.00003)***	0.0023 (0.00003)***	0.0019 (0.00005)***	0.0019 (0.00005)***
N	132143.000	127489.000	127489.000	127489.000
R ²	0.6243	0.6227	0.6227	0.6227
Weak identification test (Cragg-Donald Wald F statistic):	6206.514	6073.027	6073.027	6073.027

Cluster-level standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Agbozo (2025)

Heterogeneity Analyses

The present section summarises the findings for rural-urban disparities, and mass media exposure subsamples to highlight any locational, and media-related heterogeneity linked with female empowerment and energy deprivation. This study aligns with the United Nations' Sustainable Development Goal (SDG) commitment to “leave no one behind,” which encourages scholars to engage in disaggregated research (Koomson et al., 2021; World Health Organization, 2016). Table 10 presents instrumental variable (IV) estimates disaggregated by urban and rural residence. According to column 1, higher levels of women's empowerment are associated with a 0.543-unit reduction in energy poverty in urban areas. In rural settings, women's empowerment is linked to a 0.303-unit decline in energy poverty. These results suggest that while women's empowerment contributes to reducing energy poverty in both urban and rural contexts, its impact appears to be more pronounced in urban environments.

The stronger effect found in urban contexts is likely owing to improved access to opportunities such as education, well-paying employment, and resources, which strengthen women's empowerment. As a consequence, women with greater empowerment ratings in urban areas likely to face lower levels of energy poverty compared to those in rural regions. According to Ahmad et al. (2016), although rural women have made substantial contributions to poverty reduction, they typically confront constraints such as limited education, poor earnings, restricted asset ownership, less mobility, and constricted decision-making authority. Similarly, Yeboah (2020) showed that families in urban areas are less likely to face energy poverty compared to

those in distant locations. These outcomes are steady with earlier studies suggesting that geographical distribution effects energy availability, leading to greater levels of energy deprivation in particular rural regions (Bhattacharyya, 2006; Mirza & Kemp, 2009).

The research similarly evaluated the influence of women's empowerment on energy poverty by evaluating a subsample based on mass media exposure. Column 3 of Table 10 demonstrates that for women exposed to mass media, empowerment decreases energy poverty by 0.540 units. Although women without mass media exposure also benefitted from empowerment in terms of decreased energy poverty, the impact was less. In summary, the results reveal that the association between women's empowerment and energy poverty is varied among distinct categories, with variances detected depending on geographic location and media exposure.

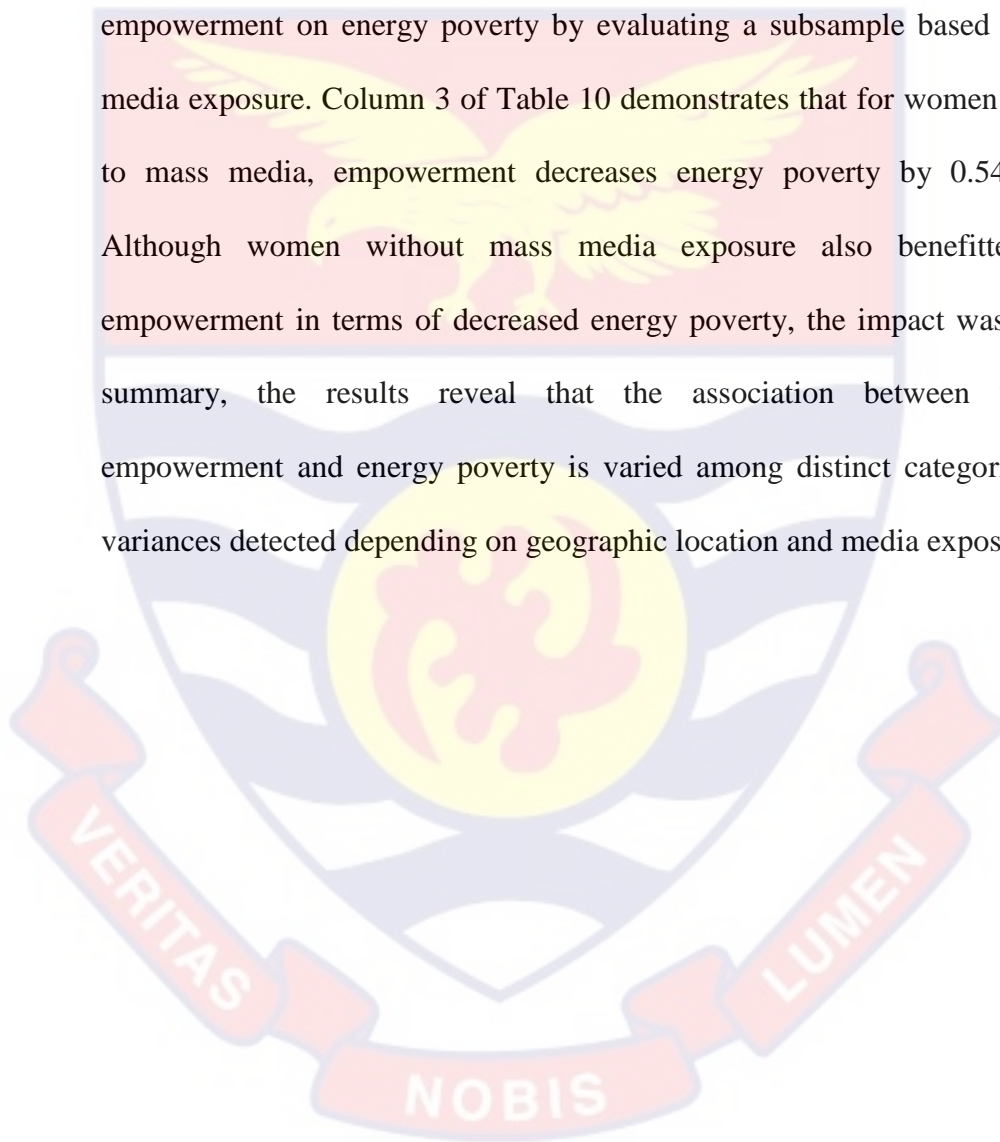


Table 10: Locational effect of Women Empowerment on Energy Poverty (IV RESULTS)

	(1) Urban	(2) Rural	(3) Mass Media (Yes)	(4) Mass Media (No)
<i>Main Independent Variable</i>				
Woman Empowerment score	-0.543 (0.072) ^{***}	-0.303 (0.026) ^{***}	-0.540 (0.038) ^{***}	-0.173 (0.023) ^{***}
Women Characteristics	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Log of GDP per capita	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
First stage				
Neighborhood prevalence of women empowerment	0.00139 (0.00009) ^{***}	0.00206 (0.00006) ^{***}	0.00161(0.00005) ^{***}	0.00224 (0.00008) ^{***}
N	50137.000	82006.000	92202.000	39941.000
R ²	0.530	0.516	0.560	0.435
Weak identification test (Cragg-Donald Wald F statistic):	1117.860	4342.092	2967.888	2468.379

Cluster-level standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Agbozo (2025)

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

Despite several worldwide attempts by international organisations and governments to eliminate energy poverty among households in Sub-Saharan Africa, statistics demonstrate that energy poverty remains ubiquitous in the area. According to the International Energy Agency (IEA, 2018), over 80% of the population in Sub-Saharan Africa still depends on solid fuels for cooking. Recent data from the Demographic and Health Surveys (DHS) utilized in this research reveal that about 89.5% of women in households throughout the area face energy poverty. This reveals that many households in Sub-Saharan Africa continue to suffer from significant levels of energy deprivation, underlining the continuous obstacles in tackling this problem.

Given this backdrop, the difficulties connected with energy poverty have emerged as a key concern. This study intended to examine how female empowerment may assist relieve energy poverty in Sub-Saharan African nations. The findings are provided in this chapter, which includes a brief evaluation of the study's results, conclusions, and practical suggestions. The chapter also proposes possibilities for future study, highlighting the necessity for methods that promote feminine empowerment as a roadmap to tackling the continuing problem of energy poverty in the area.

Summary

Empowering women is not only a buzzword but a requirement for unleashing the full potential of families, society, countries, and the planet. This research intends to analyse the effect of women's empowerment on

energy poverty in Sub-Saharan Africa using multidimensional metrics. It presents actual information on how female empowerment helps in eliminating energy poverty in the area. The research evaluated three important hypotheses: (1) Women's empowerment lowers energy poverty, (2) Various aspects of female empowerment have varying impacts on energy poverty, and (3) Entrepreneurship boosts the impact of female empowerment on decreasing energy poverty. The study employed data from the Demographic and Health Surveys program across 33 Sub-Saharan African nations, including a sample of 132,143 females who were married or cohabiting. The study utilized descriptive statistics, bivariate analysis, ordinary least squares (OLS), and two-stage least squares (2SLS) econometric techniques.

To evaluate the link between women's empowerment and energy poverty, the research included numerous parameters identified following an exhaustive literature analysis. The results indicated that the total women's empowerment score has a key impact in lowering household multidimensional energy poverty. The research analysed four elements of empowerment—autonomy, education and literacy, resource ownership, and attitudes toward gender-based violence—and found that each was statistically significant and inversely connected with energy poverty. Among them, education and literacy emerged as the most significant component. The findings imply that concentrating on boosting education and literacy for women may be especially successful in reducing household energy poverty in Sub-Saharan Africa.

Furthermore, the study indicated that women's empowerment might decrease energy poverty by extending entrepreneurial options, allowing women to increase their economic and social skills. This highlights the

significance of empowering women not just for decreasing energy poverty but also for supporting sustainable economic growth. The research implies that targeted interventions, notably in education and entrepreneurship, might be essential in achieving considerable reductions in energy poverty and promoting sustainable development objectives throughout the area.

Conclusions

Empowering women is not only a truism but a requirement for reaching the entire potential of families, communities, countries, and eventually establishing a sustainable world. This study intends to analyse the influence of women's empowerment on energy poverty in Sub-Saharan Africa using multidimensional metrics. The paper includes factual information on how female empowerment helps to eliminating energy poverty in the area.

The study utilised data from the Demographic and Health Surveys (DHS) program, covering 33 countries in Sub-Saharan Africa and encompassing a sample of 132,143 women who were either married or cohabiting. To assess the effect of women's empowerment on energy poverty, the analysis employed descriptive statistics, bivariate analysis, ordinary least squares (OLS), and two-stage least squares (2SLS) regression techniques. The relationship between women's empowerment and energy deprivation was explored using a set of indicators selected through a comprehensive review of existing literature. The findings suggested that an aggregate women's empowerment score was a key factor in lowering household multidimensional energy poverty. All four characteristics of empowered women: autonomy, education and literacy, resource ownership, and attitudes towards gender-based violence were shown to be statistically significant, with negative

relationships to energy poverty. Among them, education and literacy appeared as the most crucial determinants for decreasing energy poverty, exhibiting the principal and most substantial influence. The research also found that women's empowerment promotes energy poverty reduction via entrepreneurial possibilities, allowing women to enhance their economic and social capacities.

These results show the significance of concentrating female empowerment will engender energy poverty alleviation in Sub-Saharan Africa.

Recommendations

Beyond offering solid evidence of an inverse association between women's empowerment and energy poverty, this thesis underlines the potential significance of these results as a strategic tool for planners, developers, and humanitarian campaigners. The insights gathered may assist build successful ways for empowering women to relieve energy poverty in Sub-Saharan Africa, with possible applicability in comparable locations. Establishing policies that actively target women's empowerment might play a vital role in eliminating energy poverty. Furthermore, government and non-governmental groups should expand family planning services while concentrating on strengthening women's economic presence and decision-making capacity in society. Educational programs must also focus on establishing gender parity in educational achievements.

In addition, governments should adopt policies that support women's entrepreneurship, since it acts as a catalyst for empowerment and, therefore, has a substantial influence on alleviating energy poverty. Empowering women is not merely an issue of fairness but is also crucial for expediting progress toward poverty eradication, especially in the energy industry. By tackling

these areas, it is feasible to reverse the poor rate of development in reaching the Sustainable Development Goals (SDGs) in low-income nations. Women's empowerment, therefore, stands as a major tool in fostering sustainable development and poverty reduction throughout the area.



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APPENDICES

Appendix A: Measurement of multidimensional Energy Poverty Index

Dimensions	Indicator (weight)	Variables	Deprivation cut-off (energy poor if....)
Cooking	Modern cooking fuel (0.205) Indoor pollution (0.205)	Type of cooking fuel	Any fuel use besides electricity, LPG, kerosene, natural gas, or biogas. True
Lightening	Electricity access (0.20)	Has access to electricity	False
Services provided by means of household	Household appliance ownership (0.13)	Has a fridge	False
Appliances Entertainment/ education	Entertainment/ education appliance ownership (0.13)	Has a radio OR television	False
Communication	Telecommunication means (0.13)	Has a phone land line OR mobile phone	False

Appendix B: Measurement of the dimensions of women empowerment

Dimensions	Indicators	Weights	A-priori
1. Autonomy (Involved in Decision Making) (0.25)		0.25	-
	A. Person who usually decides how to spend respondent's earnings	0.05	
	B. Person who usually decides on respondent's health care	0.05	
	C. Person who usually decides on large household purchases	0.05	
	D. Person who usually decides on visits to family or relatives	0.05	
	E. Person who usually decides what to do with money husband earns	0.05	
2. Education and Literacy (0.25)		0.25	-
a. Literacy	Can read at least part of a sentence	0.125	
b. Education	At least Primary Education	0.125	
3. Access to and Control over Resources (0.25)		0.25	-
	A. Owns a House	0.125	
	B. Owns land	0.125	
4. Gender-Based Violence (Not Justified) (0.25)		0.25	-
	A. Beating justified if wife goes out without telling husband	0.05	
	B. Beating justified if wife neglects the children	0.05	
	C. Beating justified if wife argues with husband	0.05	
	D. Beating justified if wife refuses to have sex with husband	0.05	
	E. Beating justified if wife burns the food)	0.05	

Appendix C: Measurement of other covariates

	Description	Measurement	A-priori
<u>Maternal Variables</u>			
Variables	How often one watches television or listens to the radio	Binary (0 = no, 1 = yes)	+/-
Wealth Quintile	It's a measure of the individual's financial status (from poorest to richest)	Categorical (1=low, 2=middle, 3=high)	-
Sex of Household Head	Whether the head of the household is a female or a male	Categorical ("1=male", "2=female")	+/-
Woman's age	Measured in years (15-49 years)	Continuous	+/-
Number of living children	Number of children a woman has (0-15)	Continuous	+/-
<u>Household Variables</u>			
Age of head of household	Measured in years (15-95 or above)	Continuous	+/-
Household Size	Number of household members (1-98)		+/-
Housing Quality	Type of floor material used	Categorical (0 = Outmoded, 1 = Modern)	-
Location of Household	Type of place of residence	Categorical (1 = rural, 2 = urban)	+/-
<u>Country Level Variables</u>			
GDP per capita	Per capita GDP for each country corresponding to the year of survey	Continuous	-
Country dummies	Accounts for number of countries used in the survey (33 countries)		
Year of Survey	The year each countries survey was conducted		

Appendix D: Observations validation chart

S/N	Country Name	Code	Raw IR (Women File)	Recoded	Appended	Estimation Sample
1	Burkina Faso	BF8	12868	12868	12868	3544
2	Benin	BJ7	11170	11170	11170	7532
3	Burundi	BU7	9559	9559	9559	3985
4	Congo Democratic Rep.	CD6	12448	12448	12448	8007
5	Congo	CG6	6750	6750	6750	4653
6	Cote D'Ivoire	CI6	6453	6453	6453	3512
7	Cameroon	CM7	8060	8060	8060	3826
8	Ethiopia	ET7	9824	9824	9824	1888
9	Gabon	GA7	5598	5598	5598	1822
10	Ghana	GH8	8811	8811	8811	5634
11	Gambia	GM7	8083	8083	8083	3636
12	Guinea	GN7	7812	7812	7812	2789
13	Kenya	KE8	18312	18312	18312	7465
14	Comoros	KM6	3291	3291	3291	830
15	Liberia	LB7	4654	4654	4654	1938
16	Lesotho	LS6	3609	3609	3609	856
17	Madagascar	MD7	11637	11637	11637	7231
18	Mali	ML7	8332	8332	8332	2949
19	Mauritania	MR7	9759	9759	9759	1476
20	Malawi	MW7	15952	15952	15952	3788
21	Mozambique	MZ6	8956	8956	8956	1659
22	Nigeria	NG7	28888	28888	28888	16962
23	Niger	NI6	9509	9509	9509	2404
24	Namibia	NM6	3803	3803	3803	1292
25	Rwanda	RW7	7290	7290	7290	3947
26	Sierra Leone	SL7	9837	5933	9837	3278
27	Senegal	SN7	5933	5933	5933	1918
28	Chad	TD6	13439	13439	13439	3537
29	Togo	TG6	6360	6360	6360	3876
30	Tanzania	TZ7	8189	8189	8189	3530
31	Uganda	UG7	11379	11379	11379	6603
32	Zambia	ZM7	7597	7597	7597	3230
33	Zimbabwe	ZW7	6015	6015	6015	2465
	Total		310177	310177	310177	132143

Appendix E: Multivariate Analyses of the Differential effect of Women Empowerment dimensions on Energy Poverty (IV Estimates)

	(1) Coef (SE)	(2) Coef (SE)	(3) Coef (SE)	(4) Coef (SE)
<u>Main Independent Variables</u>				
Autonomy (Decision Making)	-2.594 (0.519)***			
Education and Literacy		-0.311 (0.022)***		
Access to and Control over Resources			-0.482 (0.043)***	
Gender-Based Violence				-0.727 (0.070)***
<u>Women Characteristics</u>				
Mass Media Exposure (base = no)				
Yes	-0.044 (0.009)***	-0.046 (0.003)***	-0.075(0.003)***	-0.067 (0.003)***
Wealth Quintile (base = low)				
Middle	-0.066 (0.007)***	-0.052 (0.003)***	-0.087 (0.003)***	-0.070 (0.003)***
High	-0.238 (0.010)***	-0.213 (0.005)***	-0.297 (0.004)***	-0.244 (0.004)***
Sex of household head (base = male)				
Female	0.052 (0.009)***	0.023 (0.002)***	0.007 (0.003)**	0.018 (0.002)***
Respondent's current age	-0.001 (0.001)*	-0.004 (0.000)***	0.002 (0.000)***	-0.002 (0.000)***
Number of living children	0.014 (0.001)***	0.006 (0.001)***	0.015 (0.001)***	0.011 (0.001)***
Husband's Occupation (base = not working)				
Non-Agriculture	0.042 (0.026)	-0.014 (0.007)*	-0.030 (0.009)***	-0.023 (0.007)***
Agriculture	0.037 (0.023)	-0.005 (0.006)	0.026 (0.009)***	-0.002 (0.008)
<u>Household Characteristics</u>				
Age of household head	0.001 (0.000)***	0.000 (0.000)***	-0.000 (0.000)	0.001 (0.000)***
Household Size	-0.001 (0.001)*	-0.002 (0.000)***	0.000 (0.000)	-0.001 (0.000)***
Housing Quality (base = Outmoded)				
Modern	-0.108 (0.006)***	-0.090 (0.003)***	-0.087 (0.004)***	-0.091 (0.003)***
rural	0.045 (0.009)***	0.066 (0.003)***	0.130 (0.006)***	0.061 (0.003)***

Country Level Characteristics

Log of GDP per capita	-0.021 (0.166)	-0.041 (0.057)	-0.151 (0.071)**	-0.480 (0.060)***
Country Fixed Effects	0.000	0.000	0.000	0.000
Time fixed effects	-0.007	-0.007**	-0.013***	-0.018***
First stage				
Neighborhood prevalence of women empowerment	0.0003208 (0.000)***	0.00268 (0.000)***	0.00173(0.000)***	0.001115 (0.000)***
Constant	16.597 (20.205)	14.803 (6.130)**	28.583 (8.102)***	40.632 (8.236)***
N	132143.000	132143.000	132143.000	132143.000
R ²	-3.096	0.539	0.129	0.181
Weak identification test (Cragg-Donald Wald F statistic):	111.240	2620.625	779.375	840.661

Cluster-level standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$