

Sustainable Rural-Based Energy Security in Katsina State, Nigeria: Challenges and Community Responses

Yahaya Sani¹, Abdu Yaro² and Ibrahim Danladi Sule³

^{1,2,3}Department of Environmental Resource Management, Federal University Dutsin-Ma, Katsina State, Nigeria

Received: 11.05.2026 | Accepted: 18.06.2026 | Published: 20.06.2026

*Corresponding Author: Yahaya Sani

DOI: [10.5281/zenodo.20771440](https://doi.org/10.5281/zenodo.20771440)

Abstract

Case Studies

This study examines the critical issue of energy poverty in rural sub-Saharan Africa, with a specific focus on Nigeria, a nation experiencing profound energy scarcity. The study meticulously examines the adaptive strategies employed by rural communities in Katsina State to achieve energy security. It aims to delineate the primary coping mechanisms utilized by households, ascertain the socio-economic factors influencing the adoption of these strategies, and assess their subsequent impact on household well-being. Employing a mixed-methods approach, the research integrated data from structured questionnaires distributed to 384 households randomly selected from three Local Government Areas (Dutsi, Kankia and Danja), alongside semi-structured interviews with 20 key informants, including community leaders and energy business operators. The findings underscore the pervasive nature of energy poverty, with a substantial majority (82.1%) of respondents classified as energy-poor, experiencing limited electricity access (less than four hours daily for 67.7%), and predominantly relying on firewood for cooking (89.1%). Households have developed a range of coping mechanisms, such as fuel stacking (82.1%), consciously minimizing electricity usage (57.8%), exclusively employing rechargeable lighting (52.9%), and leveraging social networks for resource sharing (45.1%). Furthermore, the study highlights the considerable socio-economic and health implications associated with these community responses, including increased respiratory ailments (48.2%), negative effects on children's education (56.5%), and reduced opportunities for productive activities (63.1%). The study concludes that rural households in Katsina State exhibit significant resilience and adaptive capabilities in the face of energy deprivation. Consequently, it advocates for focused policy interventions, such as promoting off-grid renewable energy initiatives, bolstering community energy cooperatives, and embedding energy access within comprehensive rural development frameworks.

Keywords: Energy Security, Coping Strategy, Rural Electrification, Energy Poverty, Fuel Stacking.

Copyright © 2026 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0).

1. Introduction

1.1 Background of the study

The provision of energy is intrinsically linked to the advancement of sustainable development, impacting key sectors such as economic output, public health, educational opportunities, and ecological preservation. The international community, through the United Nations'

Sustainable Development Goal 7 (SDG 7), has established a clear objective to guarantee universal access to equitable, dependable, sustainable, and contemporary energy services by the year 2030 (Angela, et al, 2024).

Despite global efforts, sub-Saharan Africa continues to face significant energy poverty challenges. Research indicates that despite the availability of diverse energy resources in remote

rural locales within sub-Saharan Africa, the populace experiences substandard energy quality and limited accessibility (Ekengoue, et al, 2025; Agoundedemba, et al, 2023 and Onyeausi, 2025). Electrification rates in these rural areas are notably low, averaging approximately 16%, a stark contrast to the near-universal access in North African nations (99%) and the significantly higher rate in South Africa (71%). Consequently, an estimated 900 million individuals across sub-Saharan Africa depend on traditional biomass for their domestic energy needs, including cooking and heating (Anteneh, 2020).

Nigeria, characterized by its substantial population and the largest economy in Africa, exhibits a complex and contradictory energy situation. Notwithstanding its considerable reserves of oil and gas, alongside considerable potential for renewable energy sources, the nation contends with pervasive energy poverty. Scholarly investigations underscore that Nigeria experiences one of the most acute levels of energy poverty globally, profoundly influencing both quotidian existence and enduring economic trajectories (Obileke, 2026; Ozughalu, et al, 2019).

While urban areas in Nigeria report approximately 85% access to electricity, this figure plummets to between 25% and 35% in rural regions. Given that nearly half of Nigeria's populace inhabits these rural areas, fewer than 30% benefit from dependable electrical access. Compounding these challenges, the national electricity grid is widely recognized for its unreliability, compelling approximately 60% of all households to depend on electricity generated by privately owned petrol and diesel generators (Pepple, 2024).

Katsina State, situated in Nigeria's northwestern semi-arid zone, serves as a pertinent case study of the energy challenges prevalent in rural areas. The state, largely populated by an agrarian community, grapples with substantial infrastructural shortcomings, recurrent failures of the national electricity grid, and inadequate expansion of power infrastructure into its rural settlements. In addressing this ongoing energy insecurity, households have devised a variety of adaptive strategies to ameliorate the effects of an

inconsistent energy supply. Consequently, this research investigates these rural-focused coping mechanisms within Katsina State, analyzing their frequency, underlying causes, and resultant impacts.

1.2 Statement of the Problem

Energy insecurity in the rural areas of Katsina State represents a persistent and enduring challenge rather than a transient issue. The provision of official electricity is marked by frequent interruptions, diminished voltage levels, and extended periods of darkness, compelling households to pursue alternative methods for fulfilling their fundamental energy requirements for illumination, culinary purposes, and the operation of small electrical devices.

Despite the state government's implementation of several significant initiatives, such as the creation of Nigeria's inaugural Ministry of Power, Renewable Energy and Energy Security, and the development of a 1-megawatt mini-hydropower project in Danja, the disparity between energy supply and demand persists considerably.

The existing literature concerning energy poverty in Nigeria has predominantly concentrated on national or broader regional contexts, frequently neglecting the distinct local circumstances and the ingenious coping strategies employed by rural households (Obileke, 2026; Tornel-Vazquez et al, 2024; Ozughalu, et al, 2019). While studies (Yatzkan, et al, 2025; Song et al., 2024) have explored energy transitions especially in urban environments. This research aims to fill this void by presenting empirical data on how these rural households manage energy insecurity, a crucial element for the formulation of policies that are both contextually appropriate and effective.

1.3 Research questions

This study seeks to investigate the primary energy security coping mechanisms utilized by rural households within Katsina State. Furthermore, it aims to identify the socio-economic and demographic variables that shape the selection of these strategies. The research also examines the resultant socio-economic,

health, and environmental consequences of these coping mechanisms on household well-being. Finally, the study explored potential policy interventions designed to bolster energy security and foster sustainable coping strategies in rural Katsina State.

1.4 Significance of the study

This study enhances the existing academic dialogue surrounding energy poverty and adaptive capabilities in rural sub-Saharan Africa. It offers original, empirical evidence that can guide the Katsina State Government's extensive energy initiatives, the Rural Electrification Agency's project execution, and the efforts of international development partners dedicated to achieving Sustainable Development Goal 7. By meticulously documenting the coping strategies employed at the community level, this research elevates the perspectives of rural populations, thereby ensuring that policy development is responsive to actual needs and grounded in local realities. The outcomes of this investigation are equally significant for non-governmental organizations engaged in rural development, public health, and the advancement of women's empowerment, particularly in light of the gendered dimensions inherent in energy poverty.

2.0 Literature Review

2.1 Conceptual Framework

Energy security within rural households is a complex construct, extending beyond basic access to encompass affordability, reliability, quality, and long-term sustainability of energy sources. Disruptions to energy security compel households to implement coping strategies, which are defined as intentional actions and behavioral modifications undertaken to manage, alleviate, and adapt to a sustained deficit in dependable and economical energy. A key framework for comprehending these adaptive behaviors in rural Nigeria is "energy stacking," wherein households integrate various traditional energy sources to satisfy daily requirements. Empirical evidence indicates that, irrespective of their socio-economic standing, families frequently utilize wood and charcoal in conjunction with renewable energy alternatives

such as solar and bio-energy, even when financial capacity allows for exclusive reliance on renewables (Pepple, 2025). This practice, also termed fuel switching, illustrates that a straightforward progression up the "energy ladder" is not a guaranteed outcome in the Nigerian setting. Energy choices are dynamic, with households oscillating between different energy sources influenced by factors of availability, cost, and cultural inclinations.

2.2 State of Energy Access in Rural Nigeria

Access to reliable and affordable energy remains a critical challenge in rural Nigeria, hindering socioeconomic development and perpetuating poverty. Despite the nation's vast natural resources, a significant portion of its rural population relies on traditional biomass fuels like firewood and charcoal for cooking and lighting, leading to adverse health and environmental consequences (Adewumi et al., 2019). This reliance also limits productivity, educational attainment, and overall quality of life, creating a cycle of underdevelopment.

The existing literature highlights several key factors contributing to this persistent energy poverty. Infrastructure deficits, characterized by a lack of grid extension and inadequate distribution networks, are a primary obstacle. Even where grid access exists, it is often unreliable, with frequent power outages and voltage fluctuations (Odeyemi et al., 2020). Furthermore, the high cost of conventional energy sources and the limited purchasing power of rural households make them inaccessible for many. While renewable energy technologies, such as solar and mini-grids, present promising alternatives, their widespread adoption is hampered by high upfront costs, a lack of technical expertise for maintenance, and insufficient policy support and financing mechanisms (Emodi & Okafor, 2021).

Addressing the energy access gap in rural Nigeria requires a multi-faceted approach. Research emphasizes the need for increased investment in both grid infrastructure and decentralized renewable energy solutions. Policies that incentivize private sector participation, promote local manufacturing of renewable energy components, and provide

targeted subsidies for low-income households are crucial (Olakunle et al., 2022). Capacity building for local technicians and entrepreneurs is also vital for the sustainable operation and maintenance of energy systems. Ultimately, a concerted effort involving government, private sector, and international partners is necessary to unlock Nigeria's energy potential and ensure equitable access for all its citizens.

2.3 Empirical Review of Coping Strategies

Existing research conducted throughout Nigeria offers a foundational understanding of household energy coping mechanisms. In Adamawa State, investigations identified common strategies such as the utilization of generators (37.3%), rechargeable lamps (29.1%), and solar power (24.4%), alongside a conscious effort to decrease electricity usage (44%) (Climate Scorecard, 2025). Within rural Kano State, an analysis utilizing the Multidimensional Energy Poverty Index indicated that a substantial proportion of households experience energy poverty, which adversely affects their health and educational attainment. A nationwide survey observed that households opt for renewable energy sources due to the prohibitive cost of generator fuel and the inherent unreliability of the national grid (Pepple, 2025). Furthermore, an evaluation of solar energy projects in Southwestern Nigeria pinpointed critical factors contributing to project failures, including vandalism, insufficient technical expertise, inadequate project design, and a deficient maintenance culture (Amole, et al., 2026). These collective findings are instrumental in shaping our methodological approach by illuminating prevalent coping strategies and underscoring the necessity of evaluating localized constraints.

3. Methodology

3.1 Study Area

The study was conducted in Katsina State, a

region located in the northwestern part of Nigeria. Geographically, the state is located between latitudes 11⁰08'N and 13⁰22'N and longitudes 6⁰52'E and 9⁰20'E., covering an approximate area of 24,000Km². The state political boundaries are shared with Kaduna State to the south, Jigawa and Kano states to the east, Zamfara to the west and the Republic of Niger to the north.

Based on seasonal patterns, Katsina State exhibits two distinct climatic zones: tropical continental and semi-arid continental. The state experiences a hot, dry season from March to May, followed by a warm, wet season from June to September. A less defined season is observed with reduced rainfall and a gradual temperature decline during October and November. The period from December to February is characterized by a cold, dry season, commonly referred to as the harmattan.

3.2 Research Design

This research employed a mixed-methods approach, specifically utilizing a convergent parallel design. This design integrated quantitative data gathered through household questionnaires with qualitative insights obtained from key informant interviews. By combining these distinct data streams, the study was able to pinpoint its findings, thereby achieving a more thorough and detailed comprehension of household coping strategies than would have been possible through the exclusive use of a single methodology.

This investigation was carried out in Katsina State, Nigeria, with the purposive selection of three Local Government Areas (LGAs); they are Dutsi, Kankia and Danja as indicated in figure 1. Within each selected LGA, three rural communities were randomly selected, leading to a total of nine investigated communities across the three sampled LGAs in Katsina state as illustrated in table 1.

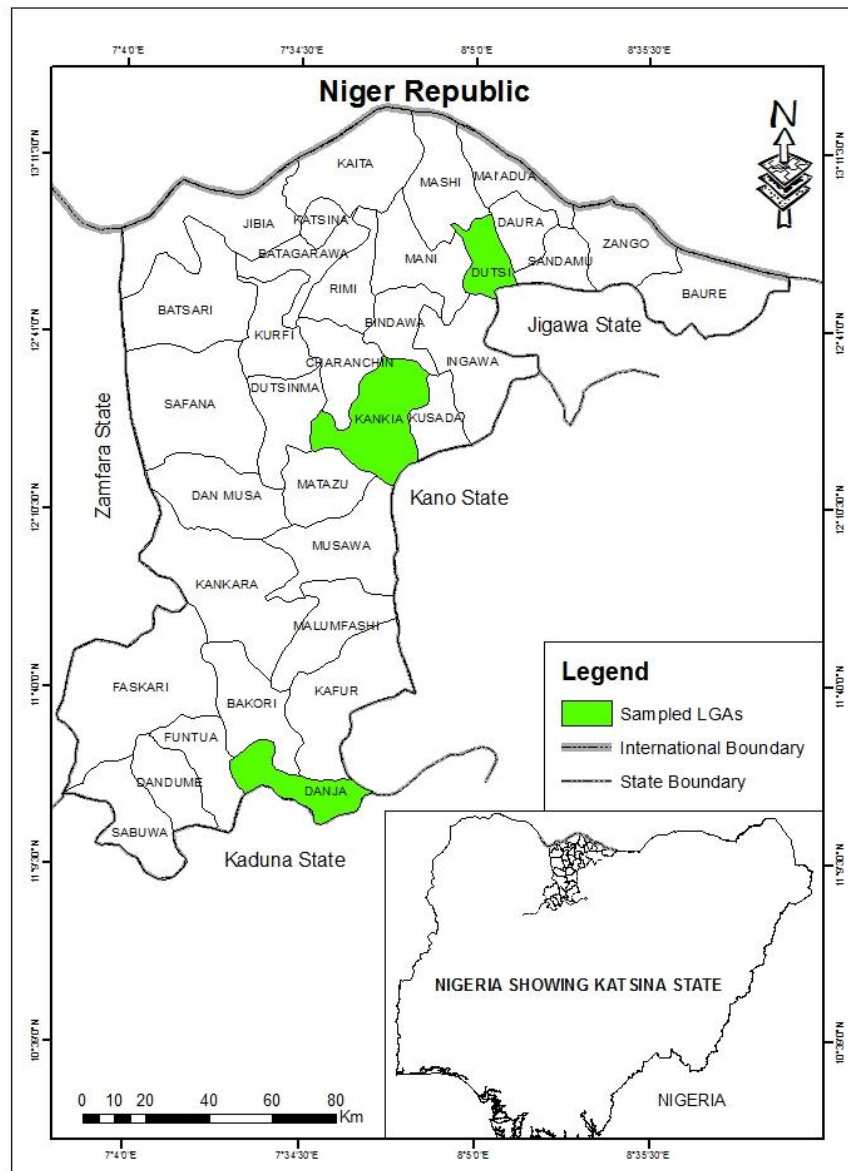


Figure 1: Map of Katsina state showing sampled Local Government Areas

3.3 Sampling and Sample Size

The study focused on rural households within the designated Local Government Areas (LGAs). To establish the sample size for the quantitative survey, Yamane's formula was applied, aiming for a 95% confidence level and a 5% margin of error. Utilizing an estimated number of rural households, a sample size of 384 households was

determined. The sampling methodology involved multiple stages: first, the purposive selection of LGAs; second, the random selection of villages within these LGAs; and third, systematic random sampling of households within each village, selecting every *n*th household until the allocated quota for each village was met.

Table 1: Questionnaire distribution format

Local Government Area	Rural Sampled Community	No. of Questionnaire Administered (n)	Proportion of Questionnaire Administered (%)
Dutsi	Yamel	43	11.3
	Dan'aunai	42	11.0
	Kayawa	42	11.0
Kankia	Gachi	43	11.3
	Kunduru	41	10.1
	Kafin-Soli	42	11.0
Danja	Jiba	42	11.0
	Tandama	43	11.3
	Dabai	43	11.3
Total		381	100

For the qualitative aspect, 20 key informants were purposefully chosen from the study villages. This group included village heads (n=3), leaders of women's groups (n=6), youth leaders (n=3), small business owners (n=4), and energy entrepreneurs/dealers (n=4). These individuals were selected due to their extensive understanding of local energy-related issues.

3.4 Data Collection Instrument

A structured questionnaire was developed as the primary instrument for data collection, organized into four distinct sections. The first section, Section A, focused on gathering socio-demographic information from respondents, encompassing details such as age, gender, household size, educational attainment, occupation, and income levels. Section B delved into energy access and usage patterns, querying participants about their primary sources of lighting and cooking fuel, the duration of electricity access, and their expenditures related to energy consumption. Section C presented a checklist of fifteen potential coping strategies, informed by existing literature, which included practices like fuel stacking, the use of generators, adoption of solar lamps, and efforts to reduce energy consumption. Finally, Section D explored the perceived impacts and implications of energy access, soliciting self-reported data on health issues, the effects on children's education, and

overall economic productivity. Prior to its main deployment, the questionnaire underwent a pre-testing phase involving 30 households in a village not part of the primary study to ensure clarity and assess its reliability, which was confirmed by a Cronbach's alpha value of 0.82.

A semi-structured interview guide was also employed to facilitate in-depth exploration of participants' experiences. This guide featured open-ended questions designed to elicit detailed responses concerning the rationale behind the selection of specific coping strategies. It also aimed to uncover the obstacles encountered, such as issues of affordability and availability, and to understand the social dimensions of energy use, including the division of labour in fuel collection and decision-making processes within households. Furthermore, the guide sought to capture participants' perceptions regarding the effectiveness and nature of government interventions in the energy sector.

3.5 Data Collection Procedure

Data collection spanned a duration of two weeks. A team of five locally recruited research assistants, proficient in both Hausa and English, conducted face-to-face questionnaire administration with household heads or their spouses. Simultaneously, the principal investigator facilitated 20 key informant interviews. All interviews were audio-recorded,

following the acquisition of informed consent, and subsequently transcribed verbatim.

3.6 Data Analysis

Quantitative data derived from the questionnaires underwent coding and entry into SPSS version 26 for analysis. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were utilized to summarize the data. Inferential statistics, specifically Chi-square tests, were employed to investigate potential associations between socio-demographic variables and the selection of coping strategies. Qualitative data from the interviews were subjected to thematic analysis.

This process involved repeated reading of the transcripts, followed by coding and the subsequent categorization of codes into overarching themes that directly addressed the research questions.

4. Results

4.1 Socio-demographic characteristics of respondents

The study achieved a high response rate, with 381 valid questionnaires returned, accounting 99.2% of those distributed. Table 2 outlines the main socio-demographic characteristics of the respondents.

Table 2: Socio-demographic Profile of Respondents (n=381)

Variable	Category	Frequency (n)	Proportion (%)
Gender of Household Head	Male	312	81.9
	Female	69	18.1
Age Group (years)	18-35	91	23.9
	36-55	218	57.2
	56+	72	18.9
Household Size	1-4	42	11.0
	5-8	214	56.2
	9+	125	32.8
Education Level	No formal education	208	54.6
	Primary	99	26.0
	Secondary	53	13.9
	Tertiary	21	5.5
Primary Occupation	Farming	286	75.1

Variable	Category	Frequency (n)	Proportion (%)
Monthly Income (₦)	Trading	48	12.6
	Artisan	21	5.5
	Other	26	6.8
	< 20,000 (< \$15)	168	44.1
	20,000 - 49,999	147	38.6
	50,000 - 99,999	46	12.1
	≥ 100,000	20	5.2

Source: Field survey, 2025

The demographic profile indicates a population representative of a rural agrarian community. The majority of households are male-headed, with individuals in the working-age bracket of 36-55 years. These households are characterized by a significant number of dependents, limited formal education, and notably low-income levels. Specifically, 82.7% of households reported a monthly income below ₦50,000 (approximately \$30), underscoring the pervasive poverty within this group.

4.2 Energy Access and Usage Patterns

The survey findings highlight a severe deficit in energy access. A mere 13.6% of households reported connection to the national electricity grid, and among this subset, a substantial 94.2% experienced recurrent daily power interruptions. On average, households received only 2.4 hours of grid-supplied electricity per day. Table 3 delineates the predominant energy sources utilized by households for illumination and culinary purposes.

Table 3: Primary Sources of Energy

Energy Service	Primary Source	Percentage (%)
Lighting	Kerosene lamps	42.3
	Rechargeable lamps/torches	32.8
	Small petrol/diesel generators	15.5
	Solar home systems (SHS)	7.1
	Grid electricity	2.3

Energy Service	Primary Source	Percentage (%)
Cooking	Firewood (collected)	67.2
	Firewood (purchased)	21.9
	Charcoal	8.9
	Kerosene/Gas (LPG)	2.0

Source: Field survey, 2025

These findings are congruent with national research indicating a significant dependence on biomass resources. Analysis of the respondents' perceptions of overall energy security revealed that 82.1% were categorized as energy-poor. This classification was determined by a multidimensional index that integrated metrics of energy access, affordability, and reliability. Such a high prevalence of energy poverty is consistent with a reported figure of 71.5% in Adamawa State.

4.3 Predominant Coping Strategies

The study investigated the coping mechanism employed by households in response to energy insecurity. Participants were presented with a predefined list of strategies and asked to identify those they routinely utilized. Given the practice of energy stacking or the concurrent use of multiple energy sources, is prevalent, household commonly reported employing a combination of strategies. Table 3 details the most frequently adopted methods for addressing energy insecurity.

Table 3: Prevalence of Coping Strategies (n=381)

Coping Strategy	Frequency (n)	Proportion (%)
Fuel stacking (using ≥ 3 different fuel sources)	292	76.6
Deliberate reduction of electricity consumption (e.g., using fewer bulbs, turning off appliances)	220	57.8
Exclusive use of rechargeable lamps/torches (avoiding grid lighting entirely)	201	52.9
Participation in local social networks for resource pooling (e.g., borrowing a generator, sharing fuel)	172	45.1
Reliance on petrol/diesel generators (≥ 1 hour/day)	156	41.0

Coping Strategy	Frequency (n)	Proportion (%)
Using unapproved electrical connections	28	7.4
Total	381	100

Source: Field survey, 2025

A particularly noteworthy finding from the study is the near-ubiquitous adoption of fuel stacking with 76.6% of respondents utilizing this practice. This phenomenon, where multiple fuel sources are employed concurrently, was further illuminated by the insight of key informant, a shopkeeper in Kankia, the interviewee described their energy strategy as one of diversification, noting, *"I cannot depend on just one thing. For my shop, I have the generator for the freezer. But for my home, we use the lantern mostly. When there is fuel, I use the generator for two hours for the children to read. It is a constant calculation of cost and what is available."* This implies a careful management of resources, employing a generator for essential commercial needs like refrigeration, while relying on lanterns for domestic lighting, and selectively using the generator for educational purposes when fuel is accessible, all within a framework of constant cost-benefit analysis.

A significant proportion of households, precisely 57.8%, indicated that they intentionally decreased their electricity consumption through measures such as reducing the number of light bulbs in use, disconnecting appliances, and limiting the operational time of devices like fans. This practice, termed "energy conservation," was characterized not as a voluntary environmental initiative, but rather as a necessary adaptation driven by external pressures. This observation was further contextualized by a statement from a female household head in Dutsi, the respondent conveyed a narrative of stringent resource management, stating, *"We have learned to live with less. We cook with firewood even though it is dirty. We put the children to bed early because the torch battery will die. We pray for the day we*

will have our own solar panel." This statement illustrates a profound adaptation to scarcity, wherein daily activities like cooking are conducted with less convenient methods (firewood), and domestic routines, such as children's bedtime, are dictated by the limitations of available power sources (torch batteries). The expression of hope for a solar panel signifies a desire for a more sustainable and less constrained energy future.

4.4 Socio-economic Determinants of Coping Strategy Choice

Chi-square tests were conducted to examine the association between key socio-demographic variables (income, education, household size) and the adoption of specific coping strategies (generator use, solar adoption, fuel stacking).

Analysis revealed a significant correlation between monthly income and the utilization of generators, as indicated ($\chi^2= 18.45$ ($p < 0.001$)). Households situated in the highest income tier (\geq N100,000) demonstrated a propensity to own or consistently use generators at a rate exceeding five times that of households in the lowest income bracket ($<$ N20,000). In contrast, the most economically disadvantaged households predominantly relied on kerosene and rechargeable lamps.

Furthermore, a significant association was observed between the educational attainment of the household head and the adoption of solar home systems, with a chi-square value of ($\chi^2= 10.32$, $p < 0.05$). Individuals possessing secondary or tertiary education were found to be more inclined towards owning solar panels, even

modest systems intended for charging phones and providing lighting, when compared to those without any formal education.

A significant relationship was identified between the number of individuals within a household and the practice of fuel stacking, evidenced by a chi-square value of ($\chi^2= 9.87$ ($p < 0.05$)). Households comprising nine or more members exhibited a greater tendency to utilize a combination of fuel sources, including firewood, kerosene, and generator power. This diversified approach appears to be driven by the increased and varied energy requirements for essential activities such as cooking and lighting, as well as for leisure purposes.

4.6 Implications of Coping Strategies

The adoption of coping strategies, though critical for survival, imposes substantial burdens, as evidenced by respondents' reports of significant negative repercussions across multiple dimensions.

Health Implications: A considerable percentage of households (48.2%) indicated that members suffered from chronic health conditions, including persistent coughing, ocular irritation, and respiratory distress, which they directly linked to exposure to smoke from firewood and kerosene lamps. This correlation is consistent with established data from the World Health Organization regarding the detrimental health effects of indoor air pollution stemming from biomass fuel consumption (Tornel-Vazquez et al).

Educational Implications: Among households with school-aged children, 56.5% reported that the available study time for these children was severely restricted due to inadequate lighting conditions. This often-necessitated studying during daylight hours or congregating around a single, smoke-filled kerosene lamp in the evenings, environments not conducive to focused academic work.

Economic Implication: A majority of respondents (63.1%), particularly those operating small-scale businesses such as tailoring or food processing, noted that energy insecurity directly reduced their productive working hours. For instance, individuals reliant on electricity or affordable fuel for their

operations frequently had to decline customer requests when energy was unavailable.

Environmental and Societal Impacts: The collection of firewood for domestic use was overwhelmingly shouldered by women and girls, as reported by 88.4% of respondents. This labor-intensive activity significantly encroaches upon the time available for income-generating activities, educational pursuits, and necessary rest.

5. Discussion

This study reveals profound energy insecurity within rural households in Katsina State, characterized by the development of complex and resource-intensive coping mechanisms. These findings not only corroborate but also expand upon the existing body of knowledge concerning energy poverty in Nigeria and the wider sub-Saharan African context.

A pivotal observation is the widespread implementation of "fuel stacking," where households utilize multiple energy sources concurrently. This practice, which aligns with previous national surveys (Pepple, 2024) indicating that energy choices in Nigeria are dynamic and do not follow a linear progression up an "energy ladder," sees households in Katsina employing generators for appliances like freezers, solar lamps for illumination, and firewood for cooking, often within the same day. Rather than representing a transitional phase, this approach is a pragmatic adaptation to an unreliable and costly energy infrastructure. Additionally, the findings aligns with other studies (Tshotsho, 2024). Examined fuel stacking of firewood and use of LPG in rural communities of Bhutan. He found that rural households use different cooking fuels simultaneously, indicating a continued use of fuelwood and other energy sources.

The significant reliance on generators, even in rural settings (41%), is noteworthy. While this figure is below the national average, it still imposes a substantial financial strain on rural farmers and traders, primarily driven by the high cost of petrol and diesel. The finding coincided with Price, et al, (2025), who analysed the World Bank's Multi-Tier Framework survey data

concerning energy access and cooking practices in Cambodia, Myanmar, and Zambia. Its novel approach uses fuel expenditure data to group urban households according to the intensity of biomass consumption (wood, charcoal) relative to modern fuel consumption (electricity, gas). The study further explored how different fuel-stacking contexts are associated with factors related to household finances, composition, experiences of electricity, and attitudes towards modern fuels. Furthermore, the prevalence of rechargeable lamps and torches as the main lighting source for over half the respondents underscores the inadequacies of the national grid and the limited penetration of solar home systems. For many, the comparatively lower expense of charging a lamp at a local vendor proves more economical than operating a generator. The research also brings to light the gendered nature of energy coping strategies, with women disproportionately bearing the responsibility for firewood collection and cooking. This exposes them to heightened health risks and time poverty, reinforcing findings from other studies in northern Nigeria and sub-Saharan Africa that advocate for gender-sensitive energy interventions and the empowerment of women in decision-making processes (Tornel-Vazquez et al, 2025).

The policy ramifications of this research are substantial. While the Katsina State Government's initiatives, including mini-hydro projects, solar photovoltaic (PV) installations, and the establishment of a new ministry, represent positive strides, the study's findings suggest that a singular focus on large-scale, top-down infrastructure development will not adequately address the prevailing energy crisis. The observed coping strategies highlight a clear demand for decentralized, cost-effective, and dependable energy solutions. For instance, the extensive use of rechargeable lamps points to a significant unmet market for high-quality, affordable solar home systems (SHS) that incorporate flexible financing options. Moreover, the persistent reliance on generators indicates an opportunity for the state to expedite the deployment of solar-powered battery charging stations and mini-grids.

6. Conclusion and Recommendation

6.1 Conclusion

This investigation reveals that rural households within Katsina State are subjected to persistent and multifaceted energy poverty, compelling them to continuously adapt their circumstances. Their current adaptive mechanisms—which include the combined use of various energy sources, conservation efforts, reliance on generators, and dependence on traditional biomass—demonstrate considerable ingenuity. However, these strategies are ultimately insufficient and impose significant financial burdens. The repercussions are severe, negatively impacting health outcomes, educational attainment, economic productivity, and gender equality, thereby perpetuating a cycle of poverty within these communities.

While the government's recent endeavors are praiseworthy, they have not yet yielded discernible benefits for the majority of the rural populace. A paradigm shift is imperative, transitioning away from a centralized, infrastructure-centric model towards a decentralized, community-focused, and demand-responsive approach. Effectively reconciling policy aspirations with the realities on the ground represents the primary obstacle to achieving comprehensive energy security in Katsina State.

6.2 Recommendation

In light of the study's findings, the following recommendations are put forth:

1. **Amplify and Prioritize Off-Grid Solar Deployments:** The Rural Electrification Agency (REA) and the newly established Katsina State Ministry of Power, Renewable Energy, and Energy Security should expedite the implementation of solar home systems (SHS) and mini-grids. This strategic shift should move away from an overemphasis on unreliable grid extensions. Crucially, these solutions must be accessible through pay-as-you-go (PAYG) financing mechanisms to circumvent the impediment posed by substantial initial expenditures.
2. **Institute Community Energy Cooperatives:** To effectively tackle challenges

related to maintenance and foster local stewardship, governmental support should be directed towards establishing energy cooperatives at the village level. These entities would assume ownership and management responsibilities for local mini-grids or SHS distribution points, ensuring the remuneration of locally trained technicians for ongoing upkeep.

3. Advance Clean Cooking Technologies: Recognizing the predominant reliance on firewood, which stands at 89%, a significant initiative is imperative to advocate for cleaner cookstoves and alternative energy sources such as biogas. This undertaking should encompass financial incentives for improved cookstoves, targeted awareness campaigns spearheaded by women to highlight the health implications of biomass smoke, and backing for the localized production of fuel briquettes derived from agricultural byproducts.

4. Embed Energy Considerations within Comprehensive Rural Development Strategies: Energy accessibility must be established as a foundational element across all rural development sectors, including healthcare, education, and agricultural extension services. Illustratively, healthcare facilities should be designated for priority solar power installation, educational institutions should be equipped with solar lighting to facilitate evening study sessions, and agricultural producers should receive support in the form of solar-powered cold storage solutions.

5. Enhance Subnational Technical Prowess: Collaboration between the state administration and technical educational institutions is recommended to institute vocational training programs tailored for solar technicians, mini-grid operators, and generator maintenance personnel. This initiative is projected to generate localized employment opportunities within the green economy and bolster the long-term viability of energy infrastructure.

6. Pursue Additional Scholarly Inquiry: Subsequent research endeavors ought to concentrate on longitudinal investigations designed to meticulously document the practical ramifications of the Danja mini-hydro project and analogous undertakings. Furthermore, a comprehensive cost-benefit analysis comparing

diverse adaptive strategies, such as generator utilization versus solar home systems (SHS), would yield critical economic data instrumental for informing policy formulation.

References

- Adewumi, O. S., Ojo, O. O., & Ojo, A. O. (2019). Energy access and rural development in Nigeria: A review. *Renewable and Sustainable Energy Reviews*, 107, 42-52.
- Agoundedemba, M., Kim, C. K., & Kim, H.-G. (2023). Energy Status in Africa: Challenges, Progress and Sustainable Pathways. *Energies*, 16(23), 7708. <https://doi.org/10.3390/en16237708>
- Anteneh, G. D., Andries F. H., Paul, L. L., and Detlef P. (2020). Scenario analysis for promoting clean cooking in Sub-Saharan Africa: Costs and benefits. *Energy*, vol. 192. <https://doi.org/10.1016/j.energy.2019.116641>
- Amole, A. O., Tafa, A. O., and Bamido, O. A. (2026) Assessment of solar-powered projects' functionality and failures in selected remote locations of southwestern Nigeria. *Soc. Impacts*, 7:100171. <https://doi.org/10.1016/j.socimp.2026.100171>
- Angela, M.M., Samira, G., Christopher, W., Velma, M., Jhud, M. A., Amanda, A., Jaise, K., Carlos, G., Alejandro, G. and Sarah M. (2024). Advancing Sustainable Development Goals through energy access: Lessons from the Global South. *Renewable and Sustainable Energy Reviews*, vol, 199. <https://doi.org/10.1016/j.rser.2024.114457>
- Climate Scorecard. (2025). Nearly half of Nigeria's population resides in rural areas, yet fewer than 30% have access to reliable electricity.
- Ekengoue, C.M., Dikko, J. T. de Dieu Bokoyo, V., Fendji, M.D., de Paul Fotso, V., Kenfack-Sadem, C., Akana, Nguimdo and Ngoukwa, G. (2025). Energy poverty alleviation through improvement of access to electricity in Nsanke and neighboring villages: A road towards rural electrification project for sustainable development. *Sustainable Energy Technologies and Assessments*, vol 82

- Emodi, C. E., & Okafor, C. N. (2021). Challenges and prospects of renewable energy adoption in rural Nigeria. *Journal of Cleaner Production*, 295, 126398.
- Nuhu Wali, H., Dutta, T., Sani, B., & Isak, J. M. S. (2025). Impact of energy poverty on human capital: a cross-sectional analysis of the rural households in Kano State, Nigeria. *Cogent Economics & Finance*, 13(1), 2469785.
- Obileke, K. (2026). Energy Poverty in Nigeria: A Review. *Sustainability*, 18(5), 2387. <https://doi.org/10.3390/su18052387>
- Odeyemi, O. T., Olawole, O. O., & Adewumi, J. O. (2020). Rural electrification in Nigeria: An assessment of grid extension and off-grid solutions. *Energy for Sustainable Development*, 55, 112-121.
- Olakunle, O. S., Ojo, O. O., & Adewumi, J. O. (2022). Policy and financial frameworks for enhancing energy access in rural Nigeria. *International Journal of Energy Research*, 46(3), 3033-3046.
- Onyeanusi, N.B. (2025). Energy Access Implications for Unserved Communities in Sub-Saharan Africa: Challenges and Opportunities. In: Narra, MM., Narra, S. (eds) African Green Transition Through Innovative Pathways. World Sustainability Series. Springer, Cham. https://doi.org/10.1007/978-3-031-87043-9_9
- Ozughalu, U.M., Ogwumike, F.O. (2019) Extreme Energy Poverty Incidence and Determinants in Nigeria: A Multidimensional Approach. *Soc Indic Res* 142, 997–1014. <https://doi.org/10.1007/s11205-018-1954-8>
- Pepple, D. G., & Pokubo, D. (2024). Assessing the energy sources of households in Nigeria. *ESI Africa*.
- Price, M., Barnard-Tallier, M., & Troncoso, K. (2021). Stacked: In Their Favour? The Complexities of Fuel Stacking and Cooking Transitions in Cambodia, Myanmar, and Zambia. *Energies*, 14(15), 4457. <https://doi.org/10.3390/en14154457>
- Song, J.S., Pondie, T.M. & Njoya, L. (2024). Urbanization in Africa: Does Energy Poverty Matter?. *J Knowl Econ* 15, 11750–11783. <https://doi.org/10.1007/s13132-023-01539-8>
- Tshotsho. (2024). Fuel Stacking of Firewood and Use of LPG in Conservation Restricted Villages: Evidence from a Natural Experiment in Bhutan. *Hum Ecol* 52, 1285–1295 <https://doi.org/10.1007/s10745-024-00559-5>
- Tornel-Vazquez, R., Iglesias, E., and Loureiro, M.L. (2025). Adoption of nature based solution for energy transition in rural household of Northern Nigeria. *Sci Rep*, 15, 7296. <https://doi.org/10.1038/s41598-025-91637-1>
- Yatzkan, O., Cohen, R., Yaniv, E., & Rotem-Mindali, O. (2025). Urban Energy Transitions: A Systematic Review. *Land*, 14(3), 566. <https://doi.org/10.3390/land14030566>