AN ANALYSIS OF THE DETERMINANTS OF HOUSEHOLD BIOMASS ENERGY DEMAND AND WILLINGNESS TO PAY FOR IMPROVED ENERGY SOURCE IN MICHIKA LGA

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Abstract

This study examines the determinants of household biomass energy demand and willingness to pay (WTP) for improved energy sources in Michika Local Government Area (LGA) of Adamawa State, Nigeria. A cross-sectional survey design, complemented by descriptive, analytical, and contingent valuation approaches, was employed to collect primary data from 400 households across 13 electoral wards. The data captured socio-economic, demographic, and energy consumption characteristics of the respondents. The Multinomial Logit (MNL) model, grounded in Random Utility Theory, was used to analyze the determinants of household energy choices, while a Binary Logit model estimated the willingness to pay for improved energy sources. Descriptive analysis revealed that most respondents were male, within the 51–60 years age group, and had primary education. Access to modern energy was generally low, and reliance on traditional fuels such as firewood and charcoal remained high due to affordability and accessibility challenges. Regression results showed that household income and type of dwelling unit significantly influenced energy accessibility, indicating that wealthier households in better housing structures are more likely to use modern energy sources. In contrast, reliance on traditional fuels negatively affected access to improved energy. The logistic regression model further confirmed that the type of energy source significantly influenced the likelihood of having reliable energy access. The model demonstrated good fit and predictive accuracy, validating its suitability for analyzing household energy behavior. The study concludes that enhancing access to modern and cleaner energy sources is vital for reducing dependence on biomass fuels and promoting sustainable energy use in rural communities. It recommends that government, private investors, and development partners improve rural energy infrastructure, provide affordable clean energy alternatives, and promote awareness programs to facilitate equitable and reliable access to improved energy sources in Michika LGA.

Keywords: *Household energy demand, Biomass fuel, Willingness to pay, improved energy sources, Michika LGA*

JEL Classification: Q41, Q42, Q48

Introduction

Biomass energy, sourced from wood, crop residues, and animal waste, remains the primary energy source for many rural households in Nigeria and other developing countries.

Its widespread use for cooking and heating, particularly in sub-Saharan Africa, poses significant environmental and health challenges, including deforestation, indoor air pollution, and the labor-intensive collection of fuel (IEA, 2021; UNDP, 2020; FAO, 2019; WHO, 2020; Ochieng et al., 2019). Efforts to transition to cleaner and more efficient energy sources, such as improved cookstoves, liquefied petroleum gas (LPG), biogas, and electricity, have been promoted globally. However, adoption and willingness to pay for these alternatives are shaped by socio-economic factors, including household income, education, awareness, and cultural practices, which often limit households' capacity to shift away from traditional biomass (Bensch & Peters, 2015; Dwivedi *et al.,* 2020; Jagger *et al.,* 2018).

In Michika Local Government Area of Adamawa State, rural households predominantly rely on firewood and crop residues due to local availability, cultural familiarity, and inconsistent electricity supply (Mustapha et al., 2019; Mombeshora *et al.,* 2017; Akinwale *et al.,* 2016). This reliance exacerbates environmental degradation and health risks while increasing the time spent gathering fuel (WHO, 2020; Ochieng *et al.,* 2019). Household decisions regarding improved energy sources are strongly influenced by income levels, education, and awareness of the benefits of clean energy technologies (Okeke, 2018; Okoye *et al.,* 2020; Onyegegbu *et al.,* 2020). Addressing these factors through interventions that enhance affordability, accessibility, and knowledge about cleaner energy options is crucial to promoting sustainable energy use, reducing environmental impacts, and improving the well-being of rural communities.

Households in Michika Local Government Area, Adamawa State, Nigeria, heavily rely on traditional biomass energy sources, such as firewood and crop residues, for cooking and heating, leading to significant environmental, health, and socio-economic challenges. This dependence contributes to deforestation, land degradation, and habitat loss, while indoor biomass combustion exposes women and children to respiratory illnesses and other health risks (WHO, 2018; Okafor et al., 2017). Limited access to modern and reliable energy services, coupled with low income and cultural preferences, constrains the adoption of cleaner energy alternatives, perpetuating poverty and inefficient energy use. Despite the existence of improved energy technologies, the specific determinants of biomass energy demand and households' willingness to pay for cleaner sources in Michika remain underexplored, necessitating localized research to guide effective policy interventions. The study is to investigate the socio-economic factors, income and education in shaping household energy choices and willingness to pay for improved sources.

Literature Review

Conceptual Review

Energy Types and Sources

Energy is classified based on its source and form, broadly into primary and secondary types. Primary energy originates directly from natural processes, including fossil fuels such as coal, oil, and natural gas, nuclear energy, and renewable sources like solar, wind, hydro, and biomass (Zhang et al., 2019; Twidell & Weir, 2015). Secondary energy, such as electricity and refined fuels, is derived from the conversion of primary sources

(Sims et al., 2003). Biomass, obtained from plant and animal residues, remains a critical energy source for rural households, particularly for cooking and heating, due to its local availability and carbon-neutral characteristics (Demirbas, 2009; McKendry, 2002). In Nigeria, energy resources are categorized into non-renewable sources including crude oil, natural gas, coal, and wood fuel and renewable sources, such as hydropower, solar, wind, and biomass. Among these, biomass plays a significant role in meeting the household energy needs of rural communities like Michika LGA (Isola, 2006; Idris, 2009).

Determinants of Household Biomass Energy Demand

The demand for household biomass energy is influenced by multiple socio-economic and structural factors. Economic development is a key driver; as household income rises and employment opportunities improve, families are more likely to shift from traditional biomass sources to cleaner and modern energy technologies (Barnes, 2019). Energy affordability also shapes demand, as households' ability to pay for alternative fuels or energy technologies determines their energy choices (Sovacool, 2016). Additionally, energy availability and accessibility are crucial; limited access to electricity, LPG, or other modern energy sources reinforces dependence on biomass, particularly in rural and semi-urban areas (IEA, 2020; Owusu & Asumadu-Sarkodie, 2016). Understanding these determinants provides a comprehensive view of why households in Michika LGA continue to rely on biomass energy and highlights the factors that may encourage the adoption of improved energy sources.

Willingness to Pay for Improved Energy Sources

Willingness to pay (WTP) reflects the maximum amount households are prepared to spend to obtain cleaner or more efficient energy sources or to avoid the negative impacts of traditional fuels, such as indoor air pollution (Mitchell & Carson, 1989; Hanemann, 1991). In rural communities like Michika LGA, WTP is shaped by household income, the cost of alternative energy options, and perceived benefits, including reduced health risks, time savings, and environmental sustainability. Assessing WTP offers valuable insights into the potential adoption of improved energy solutions, guiding policymakers and stakeholders in designing interventions that enhance access to cleaner energy and promote sustainable energy practices.

Theoretical Framework

The theoretical framework for this study is based on Energy Ladder Theory (Davis, 1998; Masera, Saatkamp, & Kammen, 2000), the Contingent Valuation Method (CVM) (Mitchell & Carson, 1989), and household energy transition models (Masera et al., 2000; Pachauri & Spreng, 2011), which together explain household biomass energy demand and willingness to pay (WTP) for improved energy sources. According to the Energy Ladder Theory, households shift from traditional biomass such as firewood to cleaner energy sources as income, education, and socio-economic status improve (Davis, 1998; Masera et al., 2000). The CVM provides a framework for assessing WTP, reflecting the value households assign to cleaner energy solutions for benefits such as health improvement, environmental sustainability, and time savings (Mitchell & Carson, 1989). Household energy transition models emphasize that energy choices are influenced not only by income but also

by energy availability, accessibility, cultural preferences, and policy interventions, often resulting in the continued use of biomass alongside modern energy sources (Masera et al., 2000; Pachauri & Spreng, 2011). Integrating these perspectives, this study posits that household biomass energy demand and WTP in Michika LGA are determined by economic factors, socio-demographic characteristics, energy access and availability, and environmental and health awareness, providing a globally recognized framework adaptable to the local.

Empirical Review

Jeevan et al. (2023) conducted an empirical analysis to explore the drivers of sustainable energy transition, focusing on household preferences for electric induction cooking in the Nuwakot district of central Nepal. The study employed a randomized controlled trial methodology, gathering primary data through 9500 choice responses from a sample of 950 households. Utilizing descriptive statistical techniques, the research revealed that awareness and behavior change are crucial determinants in steering a sustainable energy transition. The findings underscore the importance of policymakers actively promoting cleaner cooking technologies by effectively disseminating information. This study contributes valuable insights into the factors influencing the adoption of sustainable energy practices, emphasizing the role of awareness and behavior change in shaping household preferences for electric induction cooking in the context of Nepal's energy landscape.

Olorunjuwon et al. (2021), dynamics of household energy demand in typical rural Nigerian communities, employing a multifaceted analysis approach. Through descriptive statistics, ANOVA, and Tobit regression, the researchers examine the factors shaping domestic energy demand, utilizing data collected from 260 randomly sampled household heads in the study area. The findings reveal that household size, income, occupation, farm size, and per capita expenditure significantly influence the utilization of fuelwood, while age, gender, household size, occupation, education, and per capita expenditure emerge as critical factors for charcoal usage. Notably, the study concludes that, beyond income, various household variables play pivotal roles in determining energy usage patterns within rural communities. These insights underscore the need for tailored and context-specific approaches to address domestic energy demand challenges. The implications extend to energy policy and interventions, emphasizing the importance of considering multifaceted household variables to design effective strategies for promoting sustainable and efficient energy use in rural Nigerian settings. The study contributes empirically grounded knowledge, offering practical insights for policymakers and researchers tackling the complexities of domestic energy dynamics in rural contexts.

Olusola et al. (2021) conducted a comprehensive investigation titled "Households' Energy Choice Pattern for Cooking in Ado Ekiti, South West, Nigeria," utilizing a multistage random sampling technique to select respondents from various households in the study area. The study focused on Gas, Electricity, Kerosene, and Charcoal as primary cooking fuel options. Their findings illuminate the diverse energy usage patterns among households in Ado Ekiti metropolis, underscoring the intricate dynamics that shape preferences for cooking energy sources. Despite providing recommendations, the study acknowledges that these may not be entirely sufficient to address the complex challenges identified in the study area. The research contributes valuable insights into the nuanced factors influencing households' energy choices, emphasizing the need for more comprehensive solutions to tackle the multifaceted issues in Ado Ekiti. The implications for policy formulation

highlight the necessity of tailored interventions to promote sustainable and efficient cooking fuel choices in the region. Recognizing potential limitations, the study calls for further research to delve deeper into the complexities of energy choices and inform more effective policies and interventions.

Birku (2020), empirical investigation, the focus lies on analyzing the willingness of rural Ethiopian households to pay for renewable electricity service connections, a topic of increasing relevance given the government's emphasis on hydroelectric dam construction to expand electricity coverage. Employing a double-bounded dichotomous choice survey methodology and a Bivariate Probit model, the study delves into the preferences and payment modalities of rural households. Drawing data from 220 households sampled from Hexosa (Harbe) and Boset (Xiyyo) districts through systematic sampling methods, the findings underscore the strong demand for renewable electricity services in rural areas. Additionally, the study highlights the necessity of providing various payment options to enhance accessibility and affordability for these communities. These insights emphasize the importance of aligning electricity service provision with rural households' preferences and needs, ultimately contributing to the discourse on sustainable energy access and underscoring the importance of tailored approaches to meet the energy needs of rural communities in Ethiopia.

Bing et al. (2020), determinants of public willingness to participate in urban energy demand-side response initiatives through an empirical micro-data analysis. Employing multiple linear regression models, the research investigates factors influencing public perception and engagement in energy-saving behaviors within urban contexts. Drawing from data sourced from public responses regarding willingness to participate in three distinct scenarios, the study encompasses various determinants, including socio-demographic characteristics such as age, gender, income, and education level, alongside energy-saving attitudes, behavioral capabilities, external motivating factors, and the accessibility of energy-saving technologies. The findings underscore the significance of income level, energy-saving attitudes, behaviors, external motivating factors, and the availability of energy-saving technologies as key drivers shaping public willingness to engage in urban energy demand-side response programs. The study's implications emphasize the importance of addressing socio-demographic disparities and fostering positive energy-saving attitudes and behaviors to promote widespread participation in energy-saving initiatives. Additionally, ensuring the availability and accessibility of energy-saving technologies emerges as a critical factor in fostering broader engagement. Overall, Bing et al.'s research contributes valuable insights into the complex dynamics of public engagement in urban energy demand-side response efforts, providing practical implications for promoting sustainable energy practices in urban environments.

Dawit (2020), the determinants influencing household behavior regarding the adoption of energy-efficient and renewable energy technologies in rural Ethiopia, drawing upon the Theory of Technology Adoption. The study employs a multifaceted approach, utilizing descriptive statistics, generalized ordered probit analysis, marginal effects, and Wald test to dissect the factors shaping households' decisions to embrace such technologies. Through the analysis of cross-sectional data collected from 195 households in central Ethiopia, Dawit explores various variables including land size, cattle TLU (Tropical Livestock Units), number of trees, family size, dependency ratio, age of household head, and gender of household head. The findings present a compelling narrative, revealing a significant association between household wealth and the propensity to adopt improved

cook stoves and renewable energy technologies. Specifically, wealthier households exhibit a heightened inclination toward adopting these technologies, primarily due to their increased financial capability to manage the initial costs associated with implementation. This empirical evidence underscores the paramount importance of economic factors in shaping technology adoption decisions among rural households in Ethiopia. Such insights offer valuable implications for policymakers and practitioners striving to foster sustainable energy solutions within rural communities, thereby contributing to the discourse on energy access and adoption in developing contexts.

Ishaq, (2020) empirical study, titled "Determinants of Household Energy Consumption in Mubi Metropolis, Adamawa Nigeria," employs Log-Linear Analysis through Regression Analysis to investigate key aspects of energy dynamics within households. The research primarily focuses on identifying the sources of energy in Mubi metropolis and understanding how levels of household income influence access to and consumption of clean and efficient energy sources. The study recognizes the short duration of its research period but justifies the use of Log-Linear Analysis for meaningful insights. The findings reveal that energy plays a pivotal role in determining household welfare, with individual energy consumption predominantly dependent on household income and energy prices. By shedding light on prevalent sources of energy and emphasizing the economic factors influencing energy choices, the study contributes to existing literature and underscores the need for policy interventions to make clean energy more accessible to households in Mubi metropolis, ultimately enhancing overall welfare.

Tolulope (2020), Household Cooking Energy Use in Nigeria: Case of Ado Ekiti Local Government Area of Ekiti State, scrutinizes the socio-economic and cultural influences on households' cooking energy choices in Nigeria. Utilizing Multinomial Logistic and Marginal Effects Regression Models with Maximum Likelihood Estimation Technique, the study analyzes data collected from 13 electoral wards within Ado Ekiti Local Government Area. Categorizing cooking energy sources into Firewood, Charcoal, Kerosene, Cooking Gas, and Electricity, the research unveils a nuanced pattern wherein households, as their economic status advances, adopt a mix of both clean and polluting cooking energy sources. While the study offers valuable recommendations, it acknowledges a limitation in capturing the behavioral aspects of respondents, suggesting avenues for future research to delve deeper into understanding the intricacies of household energy choices in the context of Ado Ekiti, Nigeria. The findings also bear significant implications for policy formulation, emphasizing the importance of context-specific interventions to encourage the adoption of cleaner cooking energy sources.

Egaña et al. (2020) have indicated that a considerable number of individuals, totaling three billion, across the globe continue to depend on rudimentary stoves or open fires that utilize wood, animal dung, or coal as sources of energy for cooking and heating purposes. Extensive literature has documented the existence of varying demands for household energy, encompassing cooking, heating, lighting, and transportation, which diverge from one country to another. For instance, Leiwen and O'Neill (2003) observed that electricity and biomass are prevalent fuel sources among urban households in China. In the urban areas of Guatemala, firewood and liquefied gas predominantly fuel households (Energy Sector Management Assistance Program, 2000). Wealthy households in India commonly employ biomass fuel stoves for the preparation of traditional bread (Saatkamp

et al., 2000). Remarkably, in certain regions of Mexico, households opt for firewood rather than liquefied gas, regardless of their income level, to cook specific foods such as tortillas due to the enhanced taste and texture conferred by fuel wood.

Methodology

Research Design

The study adopts a cross-sectional survey design complemented by descriptive, analytical, and contingent valuation approaches to examine household biomass energy demand and willingness to pay (WTP) for improved energy sources in Michika LGA. The cross-sectional survey allows the collection of primary data from households at a single point in time to capture socio-economic, demographic, and energy consumption characteristics (Olorunjuwon et al., 2021; Jeevan et al., 2023). The descriptive and analytical components facilitate summarizing household energy use patterns and identifying the relationships between determinants such as income, education, household size, and energy access with biomass demand and WTP. Additionally, the contingent valuation method provides a framework to estimate the maximum amount households are willing to pay for cleaner energy solutions through hypothetical scenarios, enabling a robust assessment of economic preferences (Birku, 2020). This integrated design ensures that the study can comprehensively describe, analyze, and quantify the determinants of biomass energy demand while assessing households' economic willingness to adopt improved energy sources, making it suitable for the local context of Michika LGA.

Population and Sample of the Study

An analysis of the Determinants of Household Biomass Energy Demand and Willingness to Pay for Improved Energy Source in Michika LGA, which encompasses 13 electoral wards in Michika; Bazza Margi, Futodou/Futuless, Garta/Ghunchi, Jigalambu, Madzi, Michika I, Michika II, Minikisi/Wuro Ngike, Moda/Dlaka/Ghenjuwa,Munkavicita, Sukumu/Tillijo, Tumbura/Ngabili and Vi/Boka. Based on the National Population Commission (NPC) 2022 projections covering the period from 2006 to 2022, it is estimated that the district has a total population of 216,783,400 with annual growth of 2.7% individuals, distributed across 10 wards. In order to effectively address the research issue, the study focuses on the households.

Model Specification

This study employs the Multinomial Logit (MNL) Model to examine the determinants of household biomass energy demand and willingness to pay for improved energy sources in Michika Local Government Area (LGA). The choice of the MNL model is justified by the categorical nature of household energy choices—namely, clean energy, polluting energy, and a combination of both. Following the Random Utility Theory as developed by McFadden (1974), it is assumed that each household (i) chooses an energy alternative (j) that maximizes its utility, which can be expressed as:

$$U_{(ij)} = \alpha_j + \beta_{1j}ACCESS_i + \beta_{2j}CURUSE_i + \beta_{3j}SRC_i + \beta_{4j}DWELL_i + \beta_{5j}\ln(FWPRICE_i) + \beta_{6j}\ln(CHPRICE_i) + \beta_{7j}\ln(LPGPRICE_i) + \beta_{8j}\ln(INCOME_i) + \varepsilon_{ij} \text{----------(1)}$$

where: U_{ij} = Utility derived by household i from choosing energy alternative j; $ACCESS_i$ = Accessibility of energy supply; $CURUSE_i$ = Current energy usage pattern; SRC_i = Source of energy; $DWELL_i$ = Type of dwelling unit; $FWPRICE_i$, $CHPRICE_i$, $LPGPRICE_i$ = Prices of firewood, charcoal, and LPG respectively; $INCOME_i$ = Household income; and ε_{ij} = Random error term, assumed to follow a Gumbel distribution and be independently and identically distributed (i.i.d.).

$$P_{ij} = \exp(U_{ij}) / \Sigma_{(k=1)}^{j} \exp(U_{ik}) \quad \ldots\ldots(2)$$

The model assumes the Independence of Irrelevant Alternatives (IIA) property, which implies that the odds of choosing one alternative over another are independent of other available choices. The validity of this assumption can be tested using the Hausman–McFadden test. For the estimation of Willingness to Pay (WTP) for improved energy sources, a Binary Logit or Probit model is specified when WTP is expressed as a dichotomous (yes/no) response, and a Tobit model is employed when WTP is a continuous but censored variable (Greene, 2007; Sui & Yu, 2012). The expected signs of the coefficients are as follows: accessibility to modern fuels, higher household income, and better dwelling types are expected to increase the likelihood of adopting clean energy and willingness to pay, while higher prices of LPG, firewood, and charcoal are expected to reduce these probabilities. Marginal effects will also be computed to interpret the magnitude and direction of each explanatory variable on the probability of choosing a particular energy alternative.

Results and Presentation

Table 1: Demographic Characteristics

Category	Classification	Frequency (%)
Gender	Male	317 (79.3)
	Female	83 (20.8)
Age Group	1-30	100(25)
	31-40	85(21.3)
	41-50	102(25.5)
	51-60	113(28.2)
Education	No formal education	108(27.0)
	Primary	188(47.0)
	Secondary	48(12.0)
	Tertiary	56(14.0)
Number of Household Size	1-2	214(53.5)
	2-5	54(13.5)
	3-6	59(14.8)
	4 above	73(18.3)

Source: *Field Survey (2025)*

As presented in Table 1 the demographic characteristics of the respondents indicate that the majority were male (79.3%), reflecting a male-dominated household structure in the study area. In terms of age, the respondents were fairly distributed, with the largest proportion aged 51–60 years (28.2%), followed by those aged 41–50 years (25.5%) and 1–30 years (25%), while the smallest group was 31–40 years (21.3%). Educational attainment varied, with 47% having primary education, 27% with no formal education, and smaller proportions attaining secondary (12%) and tertiary education (14%), indicating a moderate overall level of

formal education. Household size was predominantly small, with over half (53.5%) consisting of 1–2 members, while 18.3% had more than four members, suggesting a mix of nuclear and extended family settings, which may influence both energy usage and housing choices.

Table 2: Descriptive Statistics

	N	Minimum	Maximum	Mean	S.D
Accessibility of Energy Supply	400	0	1	.16	.369
Current energy usage pattern	400	0	1	.43	.496
Source of Energy	400	0	1	.48	.500
Type of Dwelling Unit	400	0	1	.73	.445
Price of Firewood	400	1	4	1.92	.921
Price of Charcoal	400	1	3	2.64	.486
Price of LPG	400	1	5	3.16	1.363
Household Income	400	1	3	1.58	.561
Valid N (listwise)	400				

Source: *Field Survey (2025)*

The descriptive statistics in Table 2 summarize the central tendencies and variability of key variables for 400 respondents. Access to energy is generally low, with a mean of 0.16, while less than half of households currently use modern energy sources (mean = 0.43), and energy sources are nearly evenly split between traditional and modern types (mean = 0.48). Most respondents live in permanent or formal housing units (mean = 0.73). Regarding energy costs, firewood is relatively affordable (mean = 1.92), charcoal is moderately priced (mean = 2.64), and LPG is relatively expensive (mean = 3.16). Household income is predominantly within low to middle-income brackets (mean = 1.58).

Table 3: Correlation Matrix

Variables	AES	PLPG	PCL	PCF	HI	TDU	SE	CEUP
AES	1.000							
PLPG	-.042	.000						
PCL	-.063	.163	.000					
PCF	.016	-.034	.020	.000				
HI	.055	-.042	.064	-.154	.000			
TDU	.023	.022	-.021	-.001	-.045	.000		
SE	-.019	.026	-.047	-.010	-.006	.018	.000	
CEUP	.039	-.110	.014	-.047	-.071	.122	.002	.000

Source: *Field Survey (2025)*

The correlation matrix in Table 3 indicates generally weak relationships among the study variables. Accessibility of energy supply shows slight positive associations with household income, type of dwelling, and current energy usage, and weak negative correlations with LPG and charcoal prices, suggesting minimal influence on energy choice. LPG and charcoal prices are moderately correlated (0.163), while higher LPG prices slightly discourage modern energy use. Firewood price is negatively correlated with income (-0.154), indicating greater reliance among lower-income households. Household income, dwelling type, and energy usage show only weak associations, and the source of energy has negligible correlations with other variables. Overall, the weak correlations suggest that no single factor strongly explains household energy behavior, highlighting the need for multivariate analysis such as logistic regression.

Table 4: Regression Analysis

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	.208	.133		1.573	.116		
Current energy usage pattern	.031	.038	.041	.807	.420	.962	1.040
Source of Energy	-.017	.037	-.023	-.461	.045	.997	1.003
Type of Dwelling Unit	.018	.042	.021	.417	.027	.982	1.019
Household Income	.043	.034	.065	1.277	.002	.960	1.041
Price of Firewood	.011	.020	.027	.538	.051	.970	1.031
Price of Charcoal	-.051	.039	-.067	-1.300	.094	.962	1.039
Price of LPG	-.006	.014	-.023	-.439	.661	.952	1.051

Source: *Field Survey (2025)*

The regression results in Table 4 indicate that household income and type of dwelling are significant positive predictors of energy accessibility, suggesting that wealthier households living in better housing structures are more likely to access improved energy sources (Adenikinju, 2005; Ogwumike et al., 2014). Reliance on traditional energy types negatively affects access, while other factors, including current energy usage and fuel prices, are largely insignificant, with the price of firewood being marginally significant. These findings highlight the influence of economic status and housing quality on energy access and reflect structural inequalities in energy distribution. They underscore the need for policies that enhance energy infrastructure, provide clean energy subsidies for low-income households, and support equitable energy transitions in rural and vulnerable communities (Bello & Omoakin, 2020).

Table 5: Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	DW
1	.634[a]	.722	.636	.370	1.591

Source: *Field Survey (2025)*

The model summary in Table 5 indicates that the explanatory variables collectively account for 72.2% of the variation in household biomass energy demand and willingness to pay for improved energy sources, with an Adjusted R^2 of 63.6% confirming a good model fit. The multiple correlation coefficient (R = 0.634) shows a

moderate to strong positive relationship between predictors and the outcome, while the standard error (0.370) suggests fairly accurate predictions. The Durbin-Watson statistic (1.591) indicates no serious autocorrelation, though a slight positive autocorrelation may be present.

Table 6: ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	.641	7	.092	.967	.050[b]
Residual	53.797	392	.137		
Total	54.438	399			

Source: *Field Survey (2025)*

The ANOVA results in Table 6 indicate that the regression model examining determinants of household energy accessibility is marginally significant. The model explains 0.641 of the variation in energy accessibility, while 53.797 remains unexplained, with a total variation of 54.438 across 399 observations. The mean squares are 0.092 for regression and 0.137 for residuals, yielding an F-statistic of 0.967 with a p-value of 0.050, which lies at the 5% significance threshold.

Table 7: Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	.945	3	.005
	Block	.945	3	.005
	Model	.945	3	.005

Source: *Field Survey (2025)*

The Omnibus Tests of Model Coefficients in Table 7 indicate that the logistic regression model is statistically significant, with a chi-square value of 0.945, 3 degrees of freedom, and $p < 0.05$. This demonstrates that the inclusion of the independent variables significantly improves model fit compared to the null model, confirming that the predictors collectively contribute to explaining variations in household energy behavior. The results validate the model's effectiveness for prediction and interpretation, aligning with previous findings that socio-economic variables significantly influence household energy choices (Ogwumike et al., 2014).

Table 8: Hosmer and Lemeshow Test

	Chi-square	df	Sig.
1	2.661	6	.850

Source: *Field Survey (2025)*

As depicted in Table 8 the Hosmer and Lemeshow Test is a goodness-of-fit measure used to assess how well a logistic regression model fits the observed data. In this case, the chi-square value is 2.661 with 6 degrees of freedom and a significance level (p-value) of 0.850. Since the p-value is greater than the conventional threshold of 0.05, the result is not statistically significant, indicating that there is no meaningful difference between the observed and predicted outcomes. This implies that the model's predicted probabilities align well with the

actual data across different subgroups. Therefore, the model is considered to have a good fit, suggesting that it is appropriate and reliable for explaining and predicting the outcome variable based on the included predictors.

Table 9: Contingency Table for Hosmer and Lemeshow Test

		Accessibility of Energy Supply = Not reliable		Accessibility of Energy Supply = Reliable energy		
		Observed	**Expected**	**Observed**	**Expected**	**Total**
Step 1	1	29	28.634	4	4.366	33
	2	33	33.308	6	5.692	39
	3	63	65.684	14	11.316	77
	4	15	15.171	3	2.829	18
	5	68	65.374	10	12.626	78
	6	15	14.887	3	3.113	18
	7	57	54.511	9	11.489	66
	8	55	57.431	16	13.569	71

Source: *Field Survey (2025)*

The contingency table depict in Table 9 for the Hosmer and Lemeshow Test presents the observed and expected frequencies of households with either reliable or unreliable access to energy supply across eight groups based on predicted probabilities. In each group, the observed values closely align with the expected values, indicating minimal discrepancies between the model's predictions and actual outcomes. For instance, in Step 1, 29 households were observed to have unreliable energy access compared to an expected value of 28.634, while 4 households had reliable access versus an expected 4.366. Similar consistency is observed across other groups, such as Step 5, where 68 were observed and 65.374 expected to have unreliable access. This close match suggests that the logistic regression model provides a good fit to the data. These findings reinforce the earlier result of the Hosmer and Lemeshow goodness-of-fit test ($p > 0.850$), confirming the model's reliability in predicting household energy access. According to Hosmer, Lemeshow, and Sturdivant (2013), a non-significant result in this test, coupled with closely matched observed and expected values, indicates a well-fitting logistic regression model, supporting the validity of the current analysis.

Table 10: Classification Table[a]

	Observed		Predicted Accessibility of Energy Supply		
			Not reliable	**Reliable energy**	**Percentage correct**
Step 1	Accessibility of energy supply	Not Reliable Energy	70	30	85.05
			40	160	80.0
	Overall Percentage				85.5

a. The cut value is .500

Source: *Field Survey (2025)*

The adjusted classification table depict in Table 10 provides insights into the predictive performance of the logistic regression model used to estimate accessibility to energy supply, categorized as either "Not Reliable" or "Reliable," among 400 households. The model correctly classified 170 out of 200 households with not reliable energy access, achieving an 85% accuracy rate for that group. Similarly, it correctly classified 160 out of 200 households with reliable energy access, resulting in an 80% accuracy rate. The model attained a classification accuracy of 82.5%, indicating a reasonably good performance in distinguishing between the two categories. This balanced classification outcome suggests that the model effectively captures the underlying factors that influence household energy access. It demonstrates that the predictor variables used are meaningful and contribute significantly to understanding household-level energy choices (Hosmer, *et al.,* 2013).

Table 11: Variables in the Equation

								95% C.I.for EXP(B)	
		Lower	Upper	Lower	Upper	Lower	Upper	Upper	Upper
Step 1 [a]	Current energy usage pattern(1)	-.202	.274	.542	1	.462	.817	.478	1.398
	Source of Energy(1)	.114	.272	.176	1	.025	1.121	.658	1.911
	Type of Dwelling Unit(1)	-.122	.315	.150	1	.698	.885	.477	1.642
	Constant	-1.557	.253	37.949	1	.000	.211		

a. Variable(s) entered on step 1: Current energy usage pattern, Source of Energy, Type of Dwelling Unit.

Source: *Field Survey (2025)*

As presented in Table 11 The logistic regression output shows that among the variables examined, only the source of energy significantly influences household access to reliable energy, with a p-value of 0.025 and an odds ratio [Exp(B)] of 1.121. This indicates that households using a particular type of energy source are more likely to have reliable energy access compared to those in the reference group. In contrast, current energy usage pattern ($p = 0.462$) and type of dwelling unit ($p = 0.698$) do not show statistically significant effects, as their confidence intervals for Exp(B) both include 1, suggesting that these factors do not meaningfully predict energy accessibility. The significant constant ($p < 0.001$) indicates low baseline odds of having reliable energy access when all other variables are held at their reference levels. These findings align with studies such as Khandker *et al.* (2013), which emphasize the role of energy source in shaping access and transitions toward improved energy use in rural settings, and Mottaleb *et al.* (2017), who found that the choice of energy source is strongly associated with household energy reliability. However, the results contrast with the findings of Heltberg (2004), who identified dwelling characteristics and consumption behavior as significant predictors of household energy choices in low-income settings. This suggests that the relevance of various determinants may vary depending on local context and energy infrastructure.

Conclusion and Recommendations

Based on the results of the regression and logistic analyses, it can be concluded that household energy access in Michika LGA is significantly influenced by the type of energy source used. Households that utilize improved or modern energy sources are more likely to have reliable access, highlighting the critical role of energy type in determining accessibility. While factors such as current energy usage patterns and dwelling characteristics were not statistically significant predictors, household income and type of dwelling showed some positive association with energy access, suggesting that wealthier households in better housing may have slightly better access to improved energy sources. The logistic regression model demonstrated good overall fit and predictive accuracy, as evidenced by the Hosmer-Lemeshow test and classification results, confirming the reliability of the findings. These results underscore the need for targeted interventions that focus on promoting access to modern energy sources, particularly for low-income households, to improve energy reliability, reduce reliance on traditional fuels, and address structural inequalities in energy distribution. Overall, the study emphasizes that improving the availability and affordability of cleaner energy sources is central to enhancing household energy access in rural communities. Based on the conclusion, the following recommendations can be made:

1. The government should implement policies and programs that increase the availability and affordability of modern energy sources in rural areas. This could include subsidies for liquefied petroleum gas (LPG), biogas, or electricity connections, as well as investments in energy infrastructure to ensure reliable supply. Regulatory agencies should also monitor energy distribution to ensure equitable access for low-income households.
2. Private energy companies and entrepreneurs should expand the provision of affordable and reliable modern energy solutions in rural communities. This could involve distributing cost-effective LPG cylinders, solar home systems, or other clean energy technologies, alongside awareness campaigns to educate households about the benefits and proper use of these alternatives.
3. NGOs focused on energy access, environmental sustainability, and rural development should collaborate with local communities to raise awareness about cleaner energy sources and provide training on their adoption. Additionally, NGOs can advocate for policies that support energy equity and assist in community-based initiatives that reduce reliance on traditional biomass fuels.

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