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The Drivers of the Household Cooking Fuel Choices in Nigeria: Insights from Multinomial Logit Analysis

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Abstract

Overdependence on dirty cooking fuels in Nigeria threatens environmental sustainability, public health, and socioeconomic progress. This research investigates the factors influencing household cooking energy choice, emphasizing the impact of education, income sources, geographic location, and demographic variables. It also investigates whether the type of economic activity, not just the level of income, affects the choice of fuel. The study employs a nationally representative dataset of 12,499 households and utilizes a multinomial logit model to estimate the average marginal effects for firewood, charcoal, kerosene, liquefied petroleum gas (LPG), and electricity. The findings indicate that education is the most reliable driver for the adoption of clean energy. Households with primary education are 10.03% more likely to use LPG (AME = 0.1003, $p < 0.01$) and 10.36% more likely to use electricity (AME = 0.1036, $p < 0.01$). On the other hand, households with primary education are 16.79% less likely to use charcoal (AME = −0.1679, $p < 0.01$). These effects become more pronounced with higher education, as LPG adoption rises by 21.39% (AME = 0.2139, $p < 0.01$) and charcoal use decreases by approximately 24% (AME ≈ −0.24, $p < 0.01$). Income source shows a lot of variation: households that work in financial, insurance, and real estate services are 37.9% more likely to use LPG (AME = 0.379, $p < 0.05$), while households that work in agriculture are more likely to use charcoal (AME = 0.104, $p < 0.10$). Urban households are less likely to use firewood (AME = −0.1503, $p < 0.01$) but more likely to use electricity (AME = 0.1679, $p < 0.01$) and kerosene (AME = 0.1436, $p < 0.01$). The results corroborate energy transition dynamics influenced by structural and behavioral factors.

Keyword: cooking energy choice, multinomial logit, Marginal Effect, LPG, electricity, firewood.

Introduction

Just like many other nations, Nigeria is a signatory to the United Nations (UN) sustainable development goals (SDGs). As such, in addition the other goals (SDGs) Nigeria pledge to uphold SDG 7 which is to ensure access to affordable, reliable, sustainable and modern energy for all by 2030 and by extension, reduce its greenhouse gas (GHG) emissions which is SDG 13, climate action (*Goal 7 | Department of Economic and Social Affairs*, n.d.). Sadly, the levels of anthropogenic air emissions in Nigeria have been on increase. Studies indicate that domestic cooking is one of the drivers of the anthropogenic air emissions and it has been on increase across the country despite these goals and the government's expenditures on clean energy infrastructure (Okedere et al., 2021). The switch to cleaner cooking energy/fuel is a path to achieving sustainable economic development because of the positive environmental and health benefit (Waleed & Mirza, 2023). The transition process to clean fuel is slow, and due to economic hardship, some households are reverting to cooking with unclean energy (Waleed & Mirza, 2023). Moreso, energy stacking theory also has its course in Nigeria. As cited by some scholars (Waleed & Mirza, 2023), energy stacking theory argue that people don't completely stop using traditional fuels; instead, they use more than one type of fuel simultaneously based on their relative advantage.

Excessive use of unclean fuel type in Nigeria calls for a serious concern due to the negative impacts it has on the environment, health, and overall socio-economic wellbeing and development. A study in Nigeria has shown that there is a relationship between type of cooking fuel and under-five mortality in Nigeria (Samuel, 2016). It has been estimated that from 2010 to 2020 in Sub-Sahara Africa (SSA), two-thirds (65%) children under-five were exposed to household air pollution, while West Africa alone recorded 67% exposure (Joseph et al., 2026). Hence, unclean cooking fuel type is one of the major culprit (Joseph et al., 2026). It has been revealed that solid fuel cooking energy is a major source of one of the world's biggest killers – household air pollution (HAP) and fingered as one of the major environmental challenges (Olasehinde et al., 2025; Rosenthal et al., 2018). HAP from fuel combustion claims 3 to 4 million early deaths annually (Rosenthal et al., 2018). According to estimates from the World Health Organization (WHO), indoor air pollution from the burning of conventional fuels causes roughly 3.8 million deaths annually. More precisely, 28% of all adult pneumonia deaths and 45% of all pediatric pneumonia deaths worldwide are caused by particulates released from burning solid fuels, as reported by some scholars (Oyeniran & Isola, 2023). According to statistics, Nigeria ranks fourth in the world for air pollution and has the highest number of air pollution-related deaths in Africa. Over 600,000 people in the nation lost their lives to indoor air pollution in 2019 (Oyeniran & Isola, 2023). Indoor air pollution is a public health emergency due to the established risk it poses to human health and the environment.

Prior research has thoroughly examined the factors influencing household fuel choice in Nigeria (Ocen et al., 2024; Olasehinde et al., 2025; Oyeniran & Isola, 2023; Waleed & Mirza, 2023). These studies found that household cooking fuel choice in Nigeria was significantly influenced by sociodemographic factors, including the head of the household's age, education level, and gender, as well as factors pertaining to household income (Abdullahi, 2017). However, none of studies have paid closer attention to the impact of each level of education (primary, secondary, OND, higher education), the impact of different income sources and geographical locations and other variables. It is against this backdrop that this study examines the determinant factors that influence the choice of household cooking fuel in Nigeria. The study also seeks to discover whether different economic activity types other than income level itself influence the household cooking energy choice in Nigeria.

1.1 Objectives

The major objective of this paper is to determine the drivers of the household cooking fuel choices in Nigeria leveraging multinomial logit models.

The specific objectives of the paper are;

1. To determine the impact of geographic location of household on cooking fuel choice
2. To ascertain the influence of the age of the household head on cooking fuel choice
3. To examine the influence of the education level of the household head on cooking fuel choice
4. To assess the influence of different economic activity types of households on cooking fuel choice.

2.0 Theoretical Framework

This study is anchored in the integrated theoretical framework that combines Energy Ladder Theory, the Energy Stacking Model and consumer behaviour framework relative to the assumption of consumer utility function.

The energy ladder theory was designed as a hierarchical relationship between households' rise in purchasing power and the fuel type(s) they use for cooking and heating (Toole, 2015). The Energy Ladder Theory posits that households transition from traditional biomass/primitive fuels (e.g., firewood, agricultural waste and animal waste) to transitional fuels (kerosene, charcoal and coal) and eventually to modern fuels (LPG, electricity and biofuels) as income and socioeconomic status improve (van der Kroon et al., 2013; Waweru et al., 2022) thereby abandoning the previous fuel at each step. This is in contrast with energy transition theory (Singh et al., 2019). In this framework, rising education and income relax liquidity constraints and increase awareness of health and environmental consequences, thereby facilitating upward fuel switching.

In view of the established theory, households with higher education and more stable income sources are expected to exhibit a greater likelihood of adopting LPG and electricity relative to firewood (Adamu et al., 2020; van der Kroon et al., 2013).

The Energy Ladder Theory says that people move from one type of fuel to another in a straight line as their purchasing power and accessibility improves. While Energy Stacking Model, on the other hand, says that people don't completely stop using traditional fuels; instead, they use more than one type of fuel simultaneously based on their relative advantage, as cited by some scholars (Waleed & Mirza, 2023). This behaviour shows that people are managing risk, that fuel prices are unstable, and that infrastructure is limited. To a large extent, families who live in cities or have a

lot of education may still use charcoal or firewood along with modern fuels. As households cannot easily let go of their traditional cooking fuel type, contradicting energy transition theories thereby giving rise to energy stacking theory (Yadav et al., 2021).

In line with some scholars, (Axsen & Kurani, 2012; Frederiks et al., 2015; Szeląg-Sikora et al., 2024) this modelled the household cooking fuels under the consumer behaviour framework relative to the assumption of consumer utility function. The utility theory emphasizes the availability of alternative commodities with independent utility composition (Frederiks et al., 2015; Oyeniran & Isola, 2023). In this theory, it is assumed that the consumers are rational and choose the alternative with maximum utility. Hence, the household will choose her cooking energy from the different types of cooking energy available. The household drive utility indirectly through the attributes of the type of cooking energy used. The utility derived can be decomposed into two parts which include deterministic and random , as shown below:

$$U_i = v_i(S_j, S_i) + (Z_j S_i) \quad \text{..... (1)}$$

Where Z = set of attributes of the energy type

S = other factors such as socio-demographic, cultural and geographical features affecting household decisions.

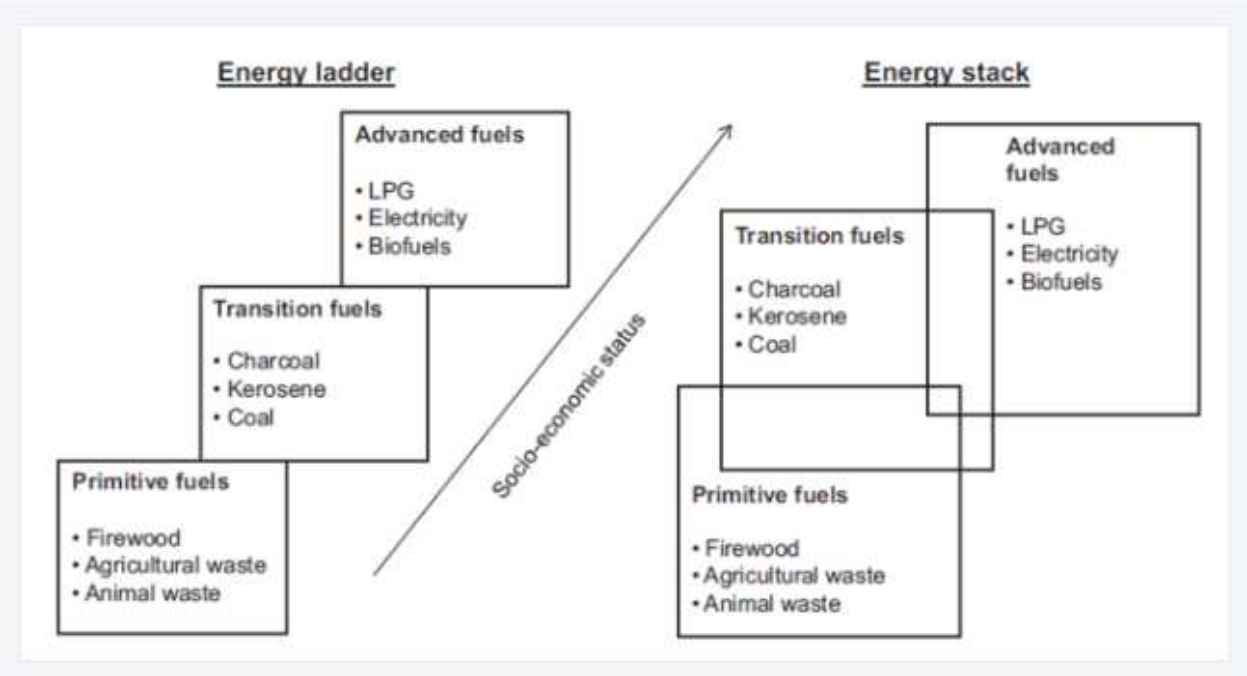


Figure 1: Energy ladder and Energy stack

(van der Kroon et al., 2013)

The choice of a particular energy type over different alternatives is driven by the probability that the utility from the chosen fuel type is higher than the utility associated with the alternate fuel types. The probability P_{ij} for the chosen fuel type over the alternative cooking energy type is as follows:

$P_{ij} = prob(U_{ij} > U_{ia})$; a= 1,2,3…….j;a ≠ j …… (2)

Where $U_{ij} > U_{ia}$, it means that when $i - th$ household chooses fuel type j, this implies that U_{ij} is the highest utility that can be obtained from the j possible choices. This aligns with the Aminu et al (2024) on the determinants of household cooking-fuel choice in sub-Saharan Africa.

3.0 Material and Method

3.1 Data

For this study, we used data from the Nigeria General Household Survey (GHS) panel's Wave 2 (2012-2013), wave 3 (2015-2016) and wave 4 (2018-2019). This is a nationally representative survey of agricultural households gathered from Nigeria's 36 states and six geopolitical zones (see Fig. 1). The survey covered a total of 450,397 households from

the six geopolitical zones. The GHS-Panel is a project carried out under the Integrated Surveys on Agriculture program in collaboration with the World Bank's Living Standards Measurement Study team (Ruggles et al., 2024). The information includes socioeconomic characteristics, education, credit, household assets, remittances, non-farm businesses, and income-generating activities, among other topics that are pertinent to households' well-being, primary cooking energy, agriculture, and community. For this study, we extracted data on the type of cooking fuel/energy used in Nigeria and other pertinent factors for our study. However, due to some missing variables and observations, we utilized only 12029 households for the study. 12,029 households serve as the sample size for this study.

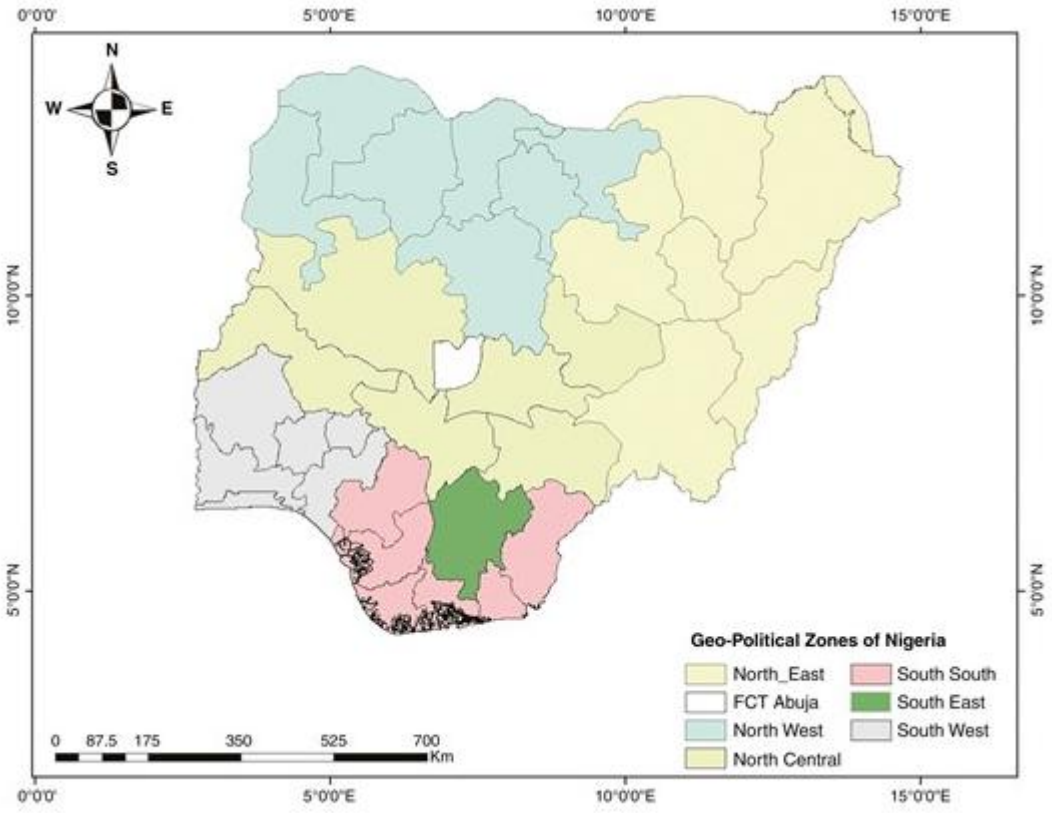


Figure 2: The map of Nigeria

3.1 Variables used in the study

This section contains the variables used in the study. The variables used for this study are categorized into dependent and independent variables. The dependent variables are the type of cooking fuel used which were captured across waves 2, 3 and 4 in the data repository. Hence, the dependent variables include firewood, charcoal, kerosene, liquified

petroleum gas (LPG) and electricity. While the independent variables which are consistent across waves 2 to 4 include age, geographic location (urban/rural), education and major source of income.

In this study, the different economic activity types recorded to have attracted income include agriculture (1), mining (2), manufacturing (3), professional/ scientific/technical activities (4), electricity/water/gas/waste (5), construction (6), transportation (7), buying and selling (8), financial/insurance/ real estate Services (9) and personal services (10). However, all the major sources of income were not used in the final analysis due to multicollinearity issues encountered. Note that each category of the income source is coded with numbers 1 to 10 to facilitate analysis.

3.2 **Econometric models**

In this study, a multinomial logistics (MNL) regression model was employed to analyse the determinants of households' cooking-energy choices in Nigeria. This is suitable for the study because the dependent variable has more than two outcomes which include firewood, charcoal, kerosene, Liquified petroleum gas (LPG) and electricity. The underline reason for a household to choose a certain cooking-energy fuel over the rest is to maximize utility. In line with Aminu et al (2024), the study hypothesizes that the utility a household derives from choosing an alternative cooking fuel j takes a linear form:

$U_{ij} = x_{ij}b_j + e_{ij}$ ……. (3)

Where U_{ij} = utility of cooking fuel preference $(j = 1 \dots, n)$ for each household $(i = 1 \dots, N)$.

$x_{ij=}$ the matrix of explanatory variables that remain constant across the cooking energy alternatives.

b_j = the coefficients of the independent variable of the regression.

$e_{ij=}$ the error term and unobserved attributes of cooking energy options.

In this study, the dependent variable has multiple outcomes j. Because of this, the $j-th$ cooking fuel choice that the $i-th$ (each) household chooses to maximise its utility $= 1$ if the household chooses the $j-th$ cooking fuel option and $= 0$ if otherwise.

The probability that a household chooses cooking fuel type over alternatives based on its socio-economic features (x_i) (such as geographic locations, age, education level and major income source) is modelled as:

$$P(y=j) = \frac{exp^{(b_j^i X_i)}}{1+\sum_j^{j=0} exp^{(b_j^i X_i)}} \ldots\ldots\ldots\

marginal effects (AMEs) to capture the impact of each determinant on the probability of choosing a particular fuel type. In this study the base outcome is firewood.

Table 1: Multinomial logit estimation result

Variable	Charcoal	Electricity	Kerosene	LPG
Urban (ref: Rural)	0.684***	7.307***	2.839**	27.269***
	(0.084)	(0.628)	(0.436)	(1.1)
	[0.580, 0.806]	[2.133, 25.034]	[1.207, 6.680]	[3.158, 235.505]
Age	0.998	0.995	1.001	0.992
	(0.003)	(0.004)	(0.003)	(0.004)
	[0.992, 1.004]	[0.987, 1.003]	[0.995, 1.007]	[0.984, 1.000]
Education: Primary	**0.603**	**3.631****	**1.742**	**9.869****
	(0.326)	(0.629)	(0.412)	(1.1)
	[0.319, 1.142]	[1.059, 12.450]	[0.776, 3.910]	[1.142, 85.316]
Education: Secondary	**0.736**	**7.307*****	**2.839****	**27.269*****
	(0.326)	(0.628)	(0.436)	(1.1)
	[0.388, 1.393]	[2.133, 25.034]	[1.207, 6.680]	[3.158, 235.505]
Education: OND	**0.674**	**6.489*****	**2.454***	**46.020*****
	(0.361)	(0.646)	(0.461)	(1.108)
	[0.332, 1.366]	[1.830, 23.010]	[0.993, 6.063]	[5.248, 403.581]
Education: Higher Degree	**0.656**	**8.212*****	**2.859****	**34.107*****
	(0.36)	(0.644)	(0.46)	(1.109)
	[0.323, 1.329]	[2.324, 29.021]	[1.161, 7.037]	[3.882, 299.631]
Income Source 1	**0.812**	**0.744**	**0.317***	**0.689**
	(0.512)	(0.496)	(0.586)	(0.502)
	[0.298, 2.215]	[0.272, 2.034]	[0.100, 1.000]	[0.252, 1.883]

Income Source 2	**0.018*** **	**0.016*** **	**0.764**	**0.822**
	(0.085)	(0.085)	(0.371)	(0.389)
	[0.015, 0.021]	[0.013, 0.020]	[0.349, 1.672]	[0.377, 1.792]
Income Source 3	**0.012**	**-0.005**	**0.034**	**0.450*** **
	(0.045) [-0.076, 0.100]	(0.018) [-0.040, 0.030]	(0.052) [-0.068, 0.136]	(0.082) [0.289, 0.611]
Income Source 4	**0.088**	**0.003**	**-0.045**	**0.027**
	(0.110) -0.128, 0.304	(0.009) -0.015, 0.021	(0.061) [-0.165, 0.075]	(0.040) [-0.051, 0.105]
Income Source 5	**-0.014**	**0.062**	**-0.009**	**0.105**
	(0.022) [-0.057, 0.029]	(0.095) [-0.124, 0.248]	(0.015) [-0.038, 0.020]	(0.150) [-0.189, 0.399]
Income Source 6	-0.033	0.019	-0.002	0.890***
	(0.048) [-0.127, 0.061]	(0.030) [-0.040, 0.078]	(0.005) [-0.012, 0.008]	(0.120) [0.655, 1.125]
Income Source 7	**0.077**	**-0.051**	**0.044**	**-0.011**
	(0.120) [-0.158, 0.312]	(0.082) [-0.212, 0.110]	(0.065) [-0.083, 0.171]	(0.019) [-0.048, 0.026]
Income Source 8	**0.029**	-0.082	**0.015**	**0.108** **
	(0.042) [-0.053, 0.111]	(0.135) [-0.347, 0.183]	(0.028) [-0.040, 0.070]	(0.042) [0.026, 0.190]
Income Source 9	**0.017*** **	**0.621**	**0.884**	**0.941**
	(0.089)	(0.402)	(0.39)	(0.401)
	[0.014, 0.020]	[0.282, 1.367]	[0.403, 1.939]	[0.429, 2.063]
Income Source 10	**0.901**	**1.104**	**-0.007**	**1.265**
	(0.41)	(0.418)	(0.012)	(0.421)
	[0.408, 1.990]	[0.499, 2.441]	[-0.031, 0.017]	[0.571, 2.803]

Standard error in round brackets.

95% confidence intervals in squared brackets.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 2: The result of the average marginal effect

Variable	Firewood	Charcoal	Electricity	Kerosene	LPG
Urban (ref: Rural)	**-0.150347*** **	**−0.020874**	**0.167967*** **	**0.143633*** **	**0.042003**
	(0.014359)	(0.050514)	(0.05901)	(0.026035)	(0.039918)
	[-0.072204, -0.128491]	[−0.119879, 0.078131]	[0.283624, 0.052309]	[0.052604, 0.154662]	[−0.036234, 0.120241]
Age	**−0.000224**	**−0.000610** **	**−0.000294**	**0.000156**	**0.0003**
	(0.000295)	(0.000309)	(0.00031)	(0.000315)	(0.000303)
	[−0.000802, 0.000354]	[−0.001216, −0.000004]	[−0.000902, 0.000313]	[−0.000461, 0.000773]	[−0.000293, 0.000894]
Education: Primary	**−0.020874**	**−0.167967*** **	**0.103633*** **	**0.042003**	**0.100347*** **
	(0.050514)	(0.05901)	(0.026035)	(0.039918)	(0.014359)
	[−0.119879, 0.078131]	[−0.283624, −0.052309]	[0.052604, 0.154662]	[−0.036234, 0.120241]	[0.072204, 0.128491]
Education: Secondary	**−0.103605** **	**−0.223273*** **	**0.133114*** **	**0.063061**	**0.172959*** **
	(0.050309)	(0.05886)	(0.0259)	(0.03981)	(0.01436)
	[−0.202209, −0.005001]	[−0.338636, −0.107911]	[0.082350, 0.183877]	[−0.014965, 0.141088]	[0.144813, 0.201104]
Education: OND	**−0.107275** **	**−0.239758*** **	**0.108277*** **	**0.033563**	**0.290443*** **
	(0.051826)	(0.060267)	(0.029379)	(0.042132)	(0.023197)
	[−0.208851, −0.005698]	[−0.357880, −0.121636]	[0.050696, 0.165859]	[−0.049015, 0.116140]	[0.244976, 0.335909]
Education: Higher Degree	**−0.106379** **	**−0.242360*** **	**0.150578*** **	**0.060096**	**0.213979*** **
	(0.051832)	(0.060203)	(0.030233)	(0.042487)	(0.022029)
	[−0.207969, −0.004790]	[−0.360355, −0.124366]	[0.091322, 0.209833]	[−0.023177, 0.143370]	[0.170804, 0.257155]
Income Source 1	**0.040054**	**0.104127***	**0.003976**	**−0.101966*** **	**0.001657**

	(0.052336)	(0.059177)	(0.049579)	(0.033648)	(0.048919)
	[−0.062522, 0.142630]	[−0.011858, 0.220112]	[−0.093198, 0.101199]	[−0.167915, −0.036017]	[−0.094222, 0.097536]
Income Source 2	**−0.051267**	**−0.164111*** **	**0.050298**	**0.053638**	**0.064196**
	(0.094983)	(0.004057)	(0.136594)	(0.13992)	(0.141894)
	[−0.237431, 0.134034]	[−0.172062, −0.156160]	[−0.217421, 0.318017]	[−0.220422, 0.327436]	[−0.213911, 0.342304]
Income Source 3	**−0.010415**	**0.008787**	**0.004898**	**0.055229**	**−0.068666*** **
	(0.032725)	(0.035393)	(0.033871)	(0.037937)	(0.025814)
	[−0.074556, 0.053725]	[−0.061584, 0.077153]	[−0.061487, 0.071283]	[−0.018874, 0.129181]	[−0.119261, −0.018070]
Income Source 4	**−0.039005**	**−0.016068**	**0.122016**	**0.021175**	**−0.072139**
	(0.053653)	(0.062183)	(0.08075)	(0.070513)	(0.052733)
	[−0.144163, 0.062154]	[−0.238976, 0.129508]	[−0.036252, 0.280284]	[−0.117462, 0.159384]	[−0.175493, 0.031215]
Income Source 5	**0.190054**	**−0.083130**	**−0.081581**	**−0.001268**	**0.069995**
	(0.137905)	(0.079515)	(0.081823)	(0.110971)	(0.120207)
	[−0.080234, 0.460343]	[−0.203918, 0.037271]	[−0.241503, 0.078341]	[−0.218767, 0.216230]	[−0.165606, 0.305587]
Income Source 6	**0.083024**	**−0.022402**	**0.03041**	**−0.008561**	**−0.115723*** **
	(0.05925)	(0.050213)	(0.055994)	(0.052605)	(0.030318)
	[−0.033103, 0.199152]	[−0.120818, 0.076015]	[−0.079337, 0.140157]	[−0.111664, 0.094543]	[−0.175145, −0.056300]
Income Source 8	**0.011247**	**0.007097**	**−0.011176**	**0.027259**	**−0.030231***
	(0.018865)	(0.019326)	(0.017998)	(0.019971)	(0.016673)
	[−0.025727, 0.048221]	[−0.030781, 0.044974]	[−0.046452, 0.024099]	[−0.046452, 0.024099]	[−0.062910, 0.002448]
Income Source 9	**−0.042672**	**−0.164142*** **	**−0.055661**	**−0.059058**	**0.378992** **
	(0.101993)	(0.004034)	(0.107704)	(0.108328)	(0.171098)
	[−0.242576, 0.157231]	[−0.172049, −0.156235]	[−0.266757, 0.155434]	[−0.271362, 0.151584]	[0.043646, 0.714338]
Income Source 10	-0.018	0.055	-0.038	0.120	-0.007
	(0.025) [-0.067, 0.031]	(0.088) [-0.117, 0.227]	(0.055) [-0.146, 0.070]	(0.210) [-0.292, 0.532]	(0.012) [-0.031, 0.017]

Geographic location: The result shows that geographic location has a significant effect on the probability of choosing one energy source against the other. As such, urban households in Nigeria are 15.03% (AME = -0.150347, $p < 0.01$) less likely to use firewood compared to rural households (see table 2). The energy ladder hypothesis, which holds that households switch from traditional biomass fuels to cleaner energy sources as access and socioeconomic conditions improve, is supported by this finding, which highlights the ongoing urban–rural disparity in access to modern energy sources. This aligns with the study in African continent (Amoah, 2025) which posits that more than 80% of rural populaces continue to rely on traditional biomass for cooking. In essence, rural Africans have limited access to clean energy relative to urban dwellers. In the same vein, a study in China (Gill-Wiehl et al., 2026; Zhou et al., 2025) reveals that the influence of infrastructure on sustainable cooking practices (clean energy) is more accessible in urban areas. Another study in China confirms that there is urban–rural disparity in household clean energy access (Wen et al., 2025). It was also established by a study across 40 developing countries from Sub-Saharan Africa, Latin America, and the Caribbean (Gill-Wiehl et al., 2026; Murshed, 2025) that income inequality widens the gap between urban and rural clean cooking fuel access rates while good institutional quality close the gap in urban–rural clean cooking fuel accessibility and use. The outcome emphasizes the necessity of focused policy changes and strong institutions to improve rural communities' access to clean energy.

In the same vein, the findings show significant variation in how urbanization affects Nigerian households' energy decisions. Living in an urban area greatly increases the likelihood of adopting electricity and kerosene, but there is no statistically significant difference in the use of charcoal between urban and rural households, indicating its role as a common transitional fuel across locations. In particular, urban households are 14.36 percentage points more likely to rely on kerosene (AME = 0.1436, $p < 0.01$) and 16.80 percentage points more likely to use electricity (AME = 0.1679, $p < 0.01$), which is indicative of better market availability and infrastructure access in urban areas. The result is supported my many other studies across the globe (Bassongui & Honlonkou, 2025; Oyeniran et al., 2025; Stoner et al., 2021). This aligns with some studies (Zhou et al., 2025) that reveals that infrastructure on sustainable cooking practices (clean energy) is more accessible in urban areas. In the same vein, energy transition plan of Nigeria fovours the implementation of LPG and electric cooking due to the likelihood of available infrastructure (Baba et al., 2025).

Age: The findings show that the likelihood of selecting charcoal as cooking fuel is slightly but statistically significantly impacted negatively by age (AME = −0.00061, $p < 0.05$). In particular, when all other variables are held constant, the likelihood of using charcoal decreases by roughly 0.061 percentage points for every year that the head of the household gets older. Despite this effect's small magnitude, it indicates that younger household heads are marginally more likely than their older counterparts to use charcoal. This also suggests that as household head age increases, the likelihood of switching from firewood to charcoal slightly decreases. This study however, contradict a systematic literature review in China (Shen et al., 2015) which reveal that age is one of the essential factors for the sustainable use of clean fuels.

Age, on the other hand, does not statistically significantly affect the use of electricity, kerosene, or LPG, suggesting that it is not a major factor in the shift to greener energy sources. This does not align with a study in Lagos State Nigeria (Ozoh et al., 2018) which reveal that younger household heads associate with LPG vs. kerosene use. Age does not significantly influence the adoption of cleaner fuels such as LPG and electricity. This suggests that household energy decisions are not strictly driven by a unidirectional transition along the energy ladder (Shen et al., 2015; van der Kroon et al., 2013), but rather by utility maximization under prevailing constraints.

On the other hands, however, the negligible effect of age on LPG and electricity may reflect structural barriers such as fuel availability and cost, which may outweigh demographic influences in Nigeria (Oyeniran et al., 2025; Oyeniran & Isola, 2023). Note that the ‘energy ladder’ is a concept used to describe the way in which households will transition to more clean energy sources as their economic status improves (Hosier & Dowd, 1987). Overall, the results indicate modest but significant generational variations in the uptake of transitional fuel to a large extent, showcases the changes in choices, adaptability, and exposure to alternative energy options.

Education: The findings show that household cooking fuel choice in Nigeria is strongly, consistently, and statistically significantly influenced by education. The marginal effects show a distinct gradient across educational levels when firewood is used as the reference category.

Households with primary education are 10.03 percentage points more likely to use LPG (AME = 0.1003, $p < 0.01$) and 10.36 percentage points more likely to use electricity (AME = 0.1036, $p < 0.01$), whereas the likelihood of using charcoal drops significantly by 16.79 percentage points (AME = −0.1679, $p < 0.01$). At the secondary education level, this pattern is more noticeable, with a greater decrease in charcoal use of 22.33 percentage points (AME = −0.2233, $p < 0.01$) and a further increase in the likelihood of selecting LPG to 17.29 percentage points (AME = 0.1729, $p < 0.01$).

The effects become more pronounced at higher educational levels, such as OND and advanced degrees. These households are roughly 24 percentage points less likely to use charcoal (AME ≈ −0.24, $p < 0.01$) and 21.39 percentage points more likely to use LPG (AME = 0.2139, $p < 0.01$). These findings show a monotonic relationship between rising levels of education and a noticeable decrease in the use of polluting substitutes and an increasing adoption of clean fuels. This is consistent with previous studies (Oyeniran et al., 2025; Oyeniran & Isola, 2023; Ozoh et al., 2018) which show that education is one of the significant determinants of household cooking fuel choice in Nigeria. The result is also supported by Aminu et al. (2025) who posits that the household head education level serves as a motivating factor for the adoption of LPG in Lagos State, Nigeria.

Interestingly, higher education reduces reliance on dirty fuel (charcoal use) substantially, suggesting educated households bypass intermediate fuels on the energy ladder. This is consistent with some scholars (Adamu et al., 2020; Wernecke et al., 2026), who noted that better-educated households often skip charcoal and directly adopt LPG or electricity. In this study, education is the strongest driver of fuel switching from traditional (firewood, charcoal) to modern fuels (electricity, LPG).

The energy ladder theory, which holds that households switch from conventional biomass fuels to cleaner energy sources as socioeconomic conditions improve, is strongly supported empirically by these findings. A clear indication of upward movement along the energy ladder is the steady rise in LPG adoption, which went from 10.03% at the primary level to 21.39% at higher education. Concurrently, a systematic move away from transitional fuels is reflected in the significant decrease in charcoal use, which went from −16.79% to roughly −24%

But the findings also point to a significant improvement over conventional theory. Educated households may completely avoid intermediate fuels, as evidenced by the substantial negative effects on charcoal across all educational levels and the notable increases in LPG and electricity use. This aligns with other studies (Adamu et al., 2020; Aminu et al., 2025; Wernecke et al., 2026). According to new evidence in the literature, this "fuel leapfrogging" behavior suggests that the transition is not strictly sequential but may involve direct movement from firewood to modern fuels.

The results do not necessarily imply total abandonment of other energy sources, even though the significant positive effects on LPG and electricity suggest a shift towards cleaner fuels. Rather, they align with the fuel stacking theory, which suggests that households keep a variety of fuels on hand to accommodate a range of cooking requirements.

However, the extent of the decrease in charcoal use, which ranges from −16.79% to roughly −24%, shows that education actively lessens reliance on polluting fuels in addition to encouraging diversification. This implies a type of "directed fuel stacking," in which households gradually phase out inferior fuels and prioritize cleaner fuels.

These patterns can be interpreted as the result of utility maximization under shifting constraints and preferences from the standpoint of consumer utility. This is in alignment with a study which opines that the choice of energy use is also determined by satisfaction, convenience, education and ownership of house (Manjula, 2024).

Household decision-making is improved by education in a number of ways:

• Knowledge and awareness: Households with higher levels of education are more likely to be aware of the negative health and environmental effects of firewood and charcoal, which increases the relative usefulness of cleaner fuels. This is supported by a study conducted in southwest Nigeria which posits that tertiary education was associated with higher willingness to adopt clean cooking (Adeloye et al., 2026; Manjula, 2024).

• Income effects: Higher education is linked to increased earning potential, which lowers the cost of LPG and electricity, whose use rises by up to 21.39 percentage points.
• Changes in preferences: Education affects lifestyle and time value, leading to a rise in the use of practical and effective fuels like LPG and electricity (+10.36% at primary level).

• Opportunity cost of time: Cleaner fuels save cooking time, which is more beneficial for households with higher levels of education.

Because modern fuels offer greater overall welfare package, the observed transition is not only structural but also represents a re-optimization of household utility functions.

Income Source: The findings show that household cooking fuel choices in Nigeria are significantly influenced by income source, which goes beyond income level itself. The analysis sheds more light on how income stability, liquidity, and structure affect energy transitions by differentiating between different economic activity types. The results show that household energy transitions in Nigeria are significantly influenced by the source of income, with significant variation across sectors. While households in high-skill, stable-income occupations are much more likely to use modern fuels like LPG (AME = 0.379, $p < 0.05$) and lessen their reliance on charcoal (AME = −0.164, $p < 0.01$), those in construction and agriculture show patterns that are consistent with their continued reliance on traditional fuels, such as increased use of charcoal (AME = 0.104, $p < 0.10$) and decreased adoption of LPG (AME = −0.115, $p < 0.01$). This is in alignment with other studies that supported energy ladder theory (Adamu et al., 2020; Amrullah et al., 2026; Oyeniran et al., 2025; Oyeniran & Isola, 2023; Shen et al., 2015; Tornel-Vázquez et al., 2024).

The energy ladder hypothesis is partially supported by these findings, but they more strongly highlight the applicability of a utility-based framework in which household fuel choices are influenced by income stability and liquidity constraints. The data also supports lower-income groups' fuel stacking practices, demonstrating the continued use of mixed fuels in the face of economic uncertainty.

5.0 Conclusion

With a focus on education, income sources, geography, and demographics, this study offers solid empirical evidence on the factors influencing household cooking fuel choice in Nigeria. The results show that rather than a straightforward linear transition across fuel types, household energy decisions are influenced by a complex interaction of socioeconomic factors.

This study's identification of education as the most reliable and potent motivator for the adoption of clean energy is a significant contribution. The findings demonstrate a distinct gradient effect: households with primary education reduce their use of charcoal by 16.79 percentage points (AME = −0.1679, $p < 0.01$), but are 10.03 percentage points more likely to use LPG (AME = 0.1003, $p < 0.01$) and 10.36 percentage points more likely to use electricity (AME = 0.1036, $p < 0.01$). Higher education levels increase clean energy use, with households with OND and higher degrees experiencing a 21.39 percentage point increase in LPG adoption (AME = 0.2139, $p < 0.01$) and a roughly 24 percentage point decrease in charcoal use (AME ≈ −0.24, $p < 0.01$). This shows that as education rises, there is a consistent and significant shift toward modern fuel.

Significant heterogeneity in fuel transitions is further revealed by the source of income. Households in high-skill industries like real estate and finance are 16.4 percentage points less likely to use charcoal (AME = −0.164, $p < 0.01$) and 37.9 percentage points more likely to adopt LPG (AME = 0.379, $p < 0.05$). In contrast, households in construction and agriculture show trends that are consistent with a continued reliance on traditional fuels, such as increased charcoal use (AME = 0.104, $p < 0.10$) and decreased LPG adoption (AME = −0.115, $p < 0.01$). These results demonstrate that energy choices are significantly influenced by income stability and structure rather than just income level.

Another important factor is geographic location. Urban households are much more likely to use electricity (AME = 0.1679, $p < 0.01$) and kerosene (AME = 0.1436, $p < 0.01$) and are 15.03 percentage points less likely to rely on firewood (AME = −0.1503, $p < 0.01$). The lack of a statistically significant impact on LPG, however, points to ongoing structural and financial obstacles, even in cities. Furthermore, the fact that there are no appreciable regional variations in the use of charcoal suggests that it is a common transitional fuel.

The results offer qualified theoretical support for the energy ladder theory, especially in light of the robust positive correlation between education and the use of clean fuels. Non-linear transitions, such as "fuel leapfrogging," in which households avoid intermediate fuels, and fuel stacking behavior, particularly among lower and unstable income groups, are also highlighted by the data. A consumer utility framework, in which households optimize fuel choices

based on cost, accessibility, reliability, and preferences under various constraints, ultimately provides the most consistent explanation for the results.

In all, this study shows that Nigerian households' energy transition is neither uniform nor automatic, but rather dependent on structural, economic, and behavioral factors that influence the availability and value of various energy sources.

6.0 Limitations of the study

This study has some limitations. First, this study is limited by the secondary data used, which only includes the information that is in the data set. We cannot include variables like the prices of cooking fuels and the amount of fuels used by households, and we cannot model how households switch between cooking fuels because we don't have enough information. Consequently, the study advocates for the incorporation of these variables in subsequent research. Despite these limitations, our study contributes to the existing literature by establishing major drivers of the household cooking fuel choices in Nigeria.

Conflict of interest statement

None declared

Data Availability

The data sets were derived from sources in the public domain: World Bank Microdata Library for General Household Survey - Panel 2010-2019, Uniform Panel Data; https://microdata.worldbank.org/catalog/5835

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