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SOCIOECONOMIC DETERMINANTS AND PATTERNS OF CHARCOAL UTILIZATION AMONG URBAN DWELLERS IN KADUNA METROPOLIS, NIGERIA

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ABSTRACT

Domestic energy poverty continues to be a problem for a lot of households in Kaduna Metropolis. However, with the rising use of charcoal by a lot of families, it is important to understand the drivers of energy use. This study assessed the socioeconomic factors influencing the utilization of charcoal as a domestic energy source among urban households in Kaduna Metropolis, Nigeria. Data were collected from 364 households using a structured questionnaire. Sociodemographic characteristics were analyzed using descriptive statistics, while binary and ordinal logistic regression models were used to examine the predictors of charcoal use and the factors influencing the frequency of charcoal use. The results revealed that 15.7% of the respondents use charcoal as their main cooking fuel. The result also revealed that 55.8% use charcoal more than once a week. Also, 67.3% of the respondents use charcoal, mainly due to affordability and availability, despite widespread awareness of cleaner alternatives such as gas. Educational attainment ($B = 0.370$, $p = 0.005$) and household size ($B = -1.149$, $p < 0.001$) significantly influenced charcoal use, while income and gender showed no significant effect ($p > 0.05$). The results revealed that an increase in household income significantly reduces the frequency of charcoal use ($B = -0.380$, $p = 0.004$). The study concludes that socioeconomic factors, not preference, are the predictors of household dependence on charcoal. The study recommends that stakeholders should enhance access to affordable clean energy, and energy education will be critical for achieving a sustainable urban energy transition in Nigeria.

Keywords: Kaduna Metropolis, Charcoal, Household Energy Sources

INTRODUCTION

Access to affordable, reliable, and sustainable energy continues to be one of Sub-Saharan Africa's most critical development concerns. Despite increased expenditures in electricity and liquefied petroleum gas (LPG) infrastructure, millions of families continue to utilize traditional biomass fuels, particularly charcoal, as their primary or secondary energy source (Ngowi, 2023; Oyeniran et al., 2025). Africa accounts for approximately two-thirds of global charcoal output, and consumption is expected to rise due to urbanization and ongoing energy poverty (Tazebew et al., 2023). Charcoal is vital for bridging the gap between traditional and modern energy systems, but its production and use create major environmental and health concerns, such as deforestation, indoor air pollution, and greenhouse gas emissions (Umar et al., 2025).

In Nigeria, charcoal remains an important energy commodity for millions of people, particularly in metropolitan areas where intermittent electricity supply and growing prices of cleaner fuels such as LPG and kerosene make charcoal an affordable option (Babalola & Opii, 2010; Sufiyan et al., 2020). Beyond residential use, it promotes informal economic activity such as food vending, blacksmithing, and cottage industries, generating income for thousands of traders and transporters. However, the use of charcoal promotes unsustainable forest exploitation and exposes consumers to health hazards from indoor air pollutants (Belay et al., 2024; Tazebew et al., 2023). These dual implications, economic necessity and environmental cost, emphasize the complexities of low- and middle-income households' energy decisions.

Energy consumption in Nigeria is heavily influenced by socioeconomic situations, cultural standards, and supply system reliability (Adewuyi, 2020). According to research, fuel preferences and consumption levels are influenced by income, education, household size, and access to energy infrastructure (Kimutai et al., 2022; Rahut et al., 2025). Many urban households employ "fuel stacking," a strategy of combining several fuels such as charcoal, gas, and firewood to deal with price volatility and supply uncertainty (Yunusa et al., 2024). This trend represents a partial energy transition, in which contemporary fuels live alongside traditional ones rather than completely replacing them. As a result, the persistence of charcoal use among urban people is determined by pricing, accessibility, and adaptive livelihood choices, rather than personal desire.

Kaduna Metropolis, one of northern Nigeria's fastest-growing cities, exemplifies these difficulties. With increasing population, urban expansion, and fluctuating fuel prices, demand for charcoal remains high, despite government initiatives advocating cleaner alternatives. Previous research in Nigeria has looked at charcoal production and its environmental impact (Mba, 2018; Muazu et al., 2022), as well as factors influencing rural fuel choices (Aduloju et al., 2020). However, specific, empirical research is scarce on how urban households in Kaduna choose and use charcoal, the socioeconomic motivations underlying these decisions, and the extent to which such factors influence energy transition dynamics in metropolitan environments.

Given the lack of empirical evidence on urban charcoal use in Kaduna Metropolis, this study aims to examine the socioeconomic factors that influence charcoal consumption in urban households in Kaduna Metropolis, Nigeria. Specifically, the objectives are to identify the factors driving household reliance on charcoal, examine usage frequency and intensity, and assess the consequences for sustainable urban energy planning. Understanding these processes will not only provide insights into energy behavior in developing cities but will also help to shape policies that promote cleaner, more sustainable household energy alternatives.

MATERIALS AND METHODS

Study Area

The study was carried out in Kaduna Metropolis, which includes Kaduna North, Kaduna South, and sections of the Chikun and Igabi Local Government Areas in Kaduna State, northwestern Nigeria (Figure 1). The metropolis is located between latitudes 10°23′00″ and 10°39′00″ N and longitudes 7°20′16″ and 7°35′00″ E, with an estimated area of 3,156 km² (Umar et al., 2025). It is strategically placed on major transportation lines that connect northern and southern Nigeria, making it an important political, administrative, industrial, and commercial hub (Bununu et al., 2015). Kaduna has a tropical continental climate with two distinct seasons: a wet season from April to October, with an average annual rainfall of roughly 1,400 mm, and a dry season from November to March, distinguished by harmattan winds and dust haze (Abubakar et al., 2024). The average annual temperature reaches 30 ºC, with March and May being the hottest months, and relative humidity ranges from 25% to 90% depending on the season (Muhammad & Abubakar, 2025).

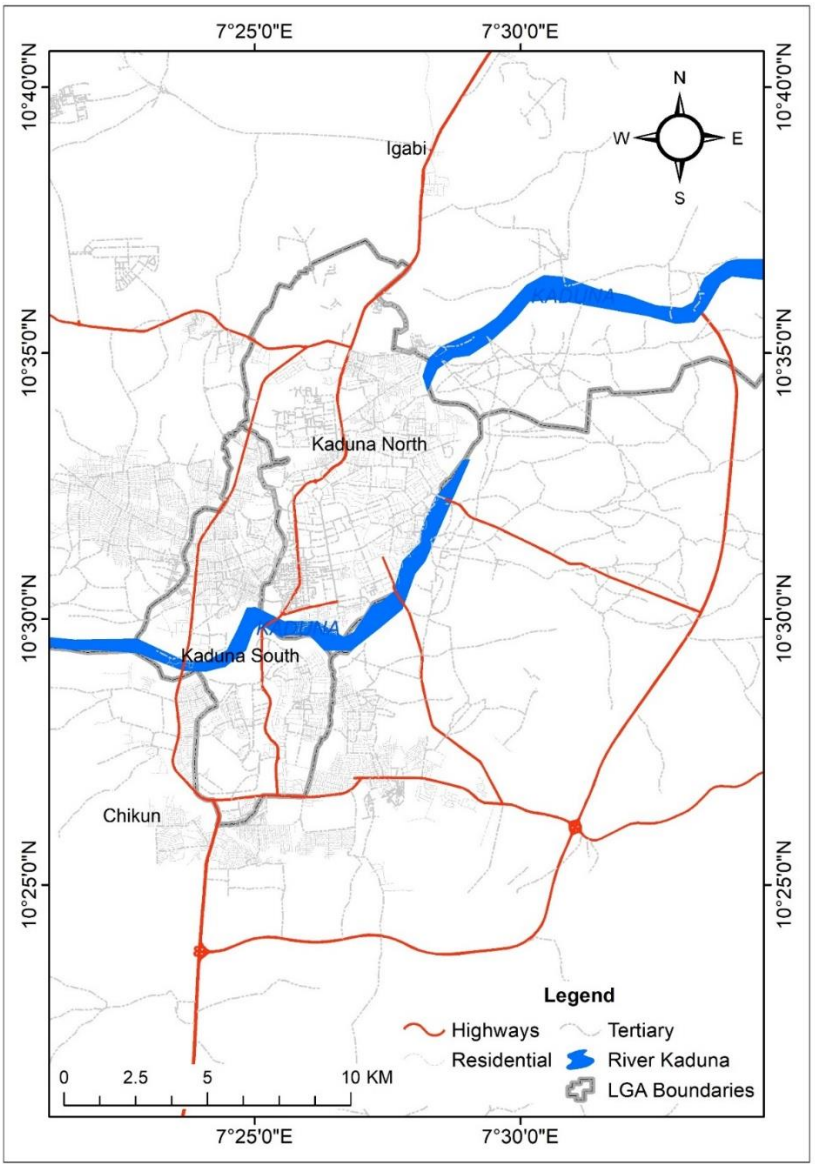

Figure 1: Map of Kaduna State showing the Kaduna metropolis
Source: Modified from GRID3 - Nigeria (2024)

The terrain is mainly undulating, with elevations ranging from 600 to 800 metres above sea level, with sporadic hills rising 50 to 200 metres. The Kaduna River, which runs through the city, is a key physical feature that separates the northern and southern areas of the metropolis. The underlying geology is primarily Precambrian Basement Complex rocks, with ferruginous tropical soils that are typically sandy, have moderate fertility, and are prone to erosion (Musa & Abubakar, 2024). The vegetation is classified as Guinea savanna, with tall grasses intermingled with deciduous trees like *Isoberlinia doka*, *Daniellia oliveri*, and *Vitellaria paradoxa*. This vegetation type promotes agriculture and offers wood resources, which indirectly benefit the region's charcoal supply chain (Ojonuba et al., 2025).

According to forecasts from the Kaduna Bureau of Statistics (2015), Kaduna Metropolis' population would top two million by 2017 and will continue to expand significantly due to urban migration and natural growth. The city's economy is broad, including commerce, manufacturing, public service, transportation, and small businesses. Kaduna has historically

been a textile production hub and continues to be a key center for education, trade, and informal economic activities such as street selling and energy-related industries, including charcoal sales (Saleh, 2015). Rapid urbanization, population development, and fluctuating energy prices all contribute to an increase in demand for low-cost domestic energy sources like charcoal, making the metropolis a perfect case study for studying Nigerian urban energy dynamics.

Data Sources

The types and sources of data needed for this study are shown in Table 1.

Table 1: Types, Sources, and Relevance of Data

S/N	Data Needed	Source of the Data	Relevance/Use of the Data
1	Sociodemographic characteristics (age, gender, income, education, household size)	Household survey (questionnaire)	To understand the profile of charcoal users and identify demographic patterns influencing charcoal use
2	Type of energy sources used for cooking (charcoal, firewood, gas, electricity, kerosene, etc.)	Household survey	To determine the level of dependence on charcoal relative to other energy sources
3	Frequency of charcoal usage	Household survey	To assess the intensity and patterns of charcoal utilization in households
4	Reasons for using charcoal (cost, availability, cultural preferences, etc.)	Household survey	To identify the motivating factors behind charcoal usage
5	Sources of charcoal (local markets, forests, vendors)	Survey of charcoal vendors	To trace the charcoal supply chain and origin
6	Awareness of the health/environmental effects of charcoal use	Household survey	To assess knowledge gaps and potential for behavior change
7	Population distribution and urban household density	NPC and Kaduna State Bureau of Statistics	To determine high-consumption zones and the sampling framework

Source: Author's compilation, 2025

Data Collection

Sampling Technique

Kaduna Metropolis is made up of four local government areas. The study needed good representation across the study area. Thus, a stratified multi-stage sampling method was used. The four LGAs served as the main strata. Then the study used purposive sampling to pick two wards in each LGA. These wards were chosen based on their populations, making a total of eight wards. Lastly, households in those wards were selected using systematic random sampling. Research assistants went along set streets or enumeration areas, approaching every kth housing unit, until the needed sample size was reached.

Sampling Size

Without figures from the National Census, this study uses Kaduna State's population projection between 2015 and 2030. According to the projections, Kaduna North LGA has a population of 620,742 people, Kaduna South has a population of 685,708 people, and Chikun and Igabi LGAs have populations of 633,847 and 733,419 persons, respectively (Kaduna Bureau of Statistics, 2015). Krejcie and Morgan's (1970) formula for sample size determination was used. Given that the population of the study area is 657,221, the sample size is calculated as follows:

$$n = \frac{x^2\, Np(1-p)}{e^2\,(N-1) + x^2\, p(1-p)}$$

Where:

n = the sample size.

N = population size

e = acceptable margin error

x^2 = chi-square of degree of freedom 1 and confidence 95% = 3.841

p = proportion of population (if unknown, 0.5)

Therefore, since N is greater than 75,000, e is 0.05, x^2 is 3.841 and p is 0.5, the formula is as follows:

$$n = \frac{3.841 * 657221 * 0.5 * 0.5}{\left((0.05)^{\,2} * (657221-1)\right) + (3.841 * 0.5 * 0.5)}$$

$$n = \frac{631096.5}{1643.5 + 0.96025}$$

$$n = 383.8762$$

Therefore, in this study, 384 questionnaires were administered.

Table 2: Proportion of Questionnaire Distributed to Selected Wards

S/N	Ward	LGA	Population	No of Questionnaire
1	Sabon Tasha	Chikun	99,579	58
2	Narayi	Chikun	51,102	30
3	Rigasa	Igabi	119,798	70
4	Rigachikun	Igabi	79,163	46
5	Kabala	Kaduna North	45,312	26
6	Kawo	Kaduna North	103,039	60
7	Makera	Kaduna South	92,513	54
8	Badiko	Kaduna South	66,715	39
	Total		657,221	384

Source: Author's compilation, 2025

Questionnaire Administration

Primary data collection was done through the use of a structured, pre-tested questionnaire given in an interviewer-administered mode to heads of households. The original instrument, developed in English, was verbally translated into Hausa by the trained enumerators when necessary to ensure

comprehension among respondents. It had three main sections with a total of 16 items:

i. *Section A*: The socio-demographic characteristics, which had 7 questions: age, gender, marital status, educational attainment, occupation, monthly household income, and household size. Most of the responses were categorical to facilitate subsequent regression analysis.
ii. *Section B*: Household energy use patterns (5 questions) assessed current use of charcoal (binary yes/no), identification of the primary cooking fuel, frequency of charcoal use (ordinal: daily, several times a week, weekly, occasionally), weekly expenditure on charcoal (categorical), and reasons for preferring charcoal (multiple-response tick-all-that-apply format with an open "others" option).
iii. *Section C*: Knowledge, attitude, and perceived impacts-4 questions-assessed the awareness of health risks from the use of charcoal, health symptoms experienced-disabling multiple responses, awareness of environmental impact, and willingness to switch to cleaner alternatives if affordably and reliably supplied.

All closed-ended questions used predefined response categories, whereas limited open-ended options were provided for "others/specify" to allow emergence of unanticipated responses. The questionnaire was pre-tested on 25 households in a non-sampled ward in Kaduna North LGA; minor adjustments were made to question wording and response categories for clarity and cultural appropriateness. The final instrument demonstrated high acceptability and took approximately 12–15 minutes to complete. Completed questionnaires were checked for completeness in the field by field supervisors to minimize missing data.

Ethical Procedure

This study included human subjects and was carried out only after receiving ethical authorization from Kaduna State University's Research Ethics Committee. All procedures were carried out in compliance with the authorized protocol and applicable institutional and national requirements. Participation was fully optional, and each responder had the right to refuse or withdraw from the study at any moment without penalty. All participants provided informed consent (written or oral, if necessary) after being fully told about the study's purpose, procedures, and voluntary nature. Strict confidentiality was maintained throughout: no personal identities were recorded, all data were anonymised using unique study IDs, and both paper and computer records were securely preserved with access limited to the research team.

Data Analysis

To identify the sociodemographic characteristics of charcoal users, the collected data were cleaned, edited, coded, and entered into SPSS version 28 for analysis. Descriptive statistics were employed via the Statistical Package for Social Sciences (SPSS v28). These included frequencies and percentages.

Secondly, to examine the reasons for choosing charcoal as a domestic energy source, binary logistic regression is employed. Binary logistic regression is used when the dependent variable is binary, meaning that it has two categories. It is commonly used when the outcome is coded as "1" or "0" and is not suitable for regular linear regression models (Harris, 2021). In this study, the use of charcoal as a domestic energy source is the dependent variable, whereas gender, income, household size, and education are predictors. The BLR is calculated via Equation (1):

$$p(y) = \frac{1}{1+e^{-(b_0+b_1x_1+b_2x_2)}} \quad (1)$$

$p(y)$ represents the probability of one category (yes or no) of the dependent variable y, b represents the coefficients of the independent variables or predictors, and x represents the independent variables.

Lastly, to determine the factors influencing the frequency and pattern of charcoal usage among households, ordinal logistic regression is applied. Ordinal logistic regression is a regression framework for ordinal dependent variables (McCullagh, 1980). Suppose that we have a dependent variable Y with p ordered categories $j = 1, \dots, p$ and predictor variables $\mathbf{Z} = (Z_1, \dots, Z_l)$. Y is a vector containing the responses of $i = 1, \dots, n$ observations, and $Z_1, \dots, Z_l$ are the vectors containing the explanatory variables. Then, we can specify the ordinal logistic regression model as Equation (2):

$$P(Y \leq j | Z_1, \dots, Z_l) = \frac{\exp(\theta_j - \beta_1 Z_1 - \cdots - \beta_l Z_l)}{1+\exp(\theta_j - \beta_1 Z_1 - \cdots - \beta_l Z_l)} \quad (2)$$

where θ_j is the vector of the intercept parameters for the different categories, which are ascending so that $\theta_j < \theta_{j+1}$ holds and where $\beta_1, \dots, \beta_l$ are the regression coefficients (Harrell, 2015). In this study, the frequency of charcoal use (daily, several times a week, weekly, or occasionally) was the dependent variable, whereas income, household size, education, and occupation were predictors.

RESULTS AND DISCUSSION

Sociodemographic Characteristics of the Respondents

This section shows the respondents' sociodemographic profile, which includes information such as their age, gender, education level, occupation, household size, and income level. Understanding these variables offers a framework for analysing the patterns of charcoal utilization and elucidates the disparities in energy selection and consumption behaviors among various demographic groups within the Kaduna Metropolis. The results are shown in Table 3.

Table 3: Sociodemographic Characteristics of the Respondents

Age	Frequency	Percent
<18	8	2.2
18-25	155	42.6
26-35	144	39.6
36-50	41	11.3
>50	16	4.4
Total	**364**	**100.0**
Gender		
Male	191	52.5
Female	173	47.5
Total	364	100.0

Marital Status	**Frequency**	**Percent**
Single	142	39.0
Married	216	59.3
Divorced	4	1.1
Widowed	2	0.5
Total	**364**	**100.0**
Educational Level		
No formal education	42	11.5
Primary	24	6.6
Secondary	117	32.1
Tertiary	181	49.7
Total	364	100.0
Occupation		
Student	112	30.8
Trader	143	39.3
Civil Servant	92	25.3
Unemployed	17	4.7
Total	**364**	**100.0**
Monthly Income		
Less than N20,000	16	4.4
20-000 - 50,000	121	33.2
50,001 - 100,000	121	33.2
More than 100,000	106	29.1
Total	**364**	**100.0**
Household Size		
<5	234	64.3
5-10	90	24.7
11-20	18	4.9
>20	22	6.0
Total	**364**	**100.0**

Source: Author's Analysis, 2025

Table 3 presents the sociodemographic characteristics of the 364 respondents in the study area. The results revealed that the majority of the respondents (42.6%) were between the ages of 18 and 25 years, followed by those aged 26–35 years (39.6%). A total of 11.3% of the respondents were aged 36–50 years, whereas only 4.4% were above 50 years, and 2.2% were under 18 years. This age distribution suggests that charcoal use in the Kaduna metropolis is most prevalent among young and economically active individuals. For the gender of the respondents, males constituted a slightly greater proportion (52.5%) than females (47.5%). This indicates a fairly balanced gender representation, implying that both men and women are actively involved in decisions or activities related to household energy use.

In terms of marital status, the majority of the respondents were married (59.3%), while 39.0% were single. Only a small proportion were divorced (1.1%) or widowed (0.5%). This suggests that most of the households surveyed are family-based, which could influence the volume and frequency of charcoal consumption (Derebe et al., 2025). Additionally, the distribution by educational level shows that nearly half of the respondents (49.7%) had a tertiary education, whereas 32.1% had a secondary education. A smaller percentage had primary education (6.6%), and 11.5% had no formal education. This indicates that a large proportion of the respondents are educated, similar to the findings of Ojonuba et al. (2025). This may influence their awareness of alternative energy sources and the environmental implications of charcoal use.

In terms of occupation, 39.3% of the respondents were traders, 30.8% were students, 25.3% were civil servants, and 4.7% were unemployed. This pattern reflects the predominance of informal economic activities in metropolises, which may be related to the affordability and accessibility of charcoal over other energy sources. In terms of monthly income, 33.2% of the respondents earned ₦20,000–₦50,000, another 33.2% earned ₦50,001–₦100,000, and 29.1% earned above ₦100,000. Only 4.4% earned less than ₦20,000. This distribution shows that most respondents belong to the low- and middle-income categories, which may influence their preference for charcoal as a relatively cheap energy source. Finally, the household size distribution indicates that 64.3% of the respondents had fewer than 5 members, 24.7% had 5–10 members, 4.9% had 11–20 members, and 6.0% had more than 20 members. The predominance of SMEs suggests that charcoal consumption patterns may be linked to family size and domestic energy needs.

Use of Charcoal as a Domestic Energy Source

This subsection examines the use of charcoal as a source of domestic energy. The study also examined respondents' choices of the main source of domestic energy in the Kaduna metropolis. The results are shown in Table 4.

Table 4: Usage of Charcoal as a Source of Domestic Energy

Use Charcoal	**Frequency**	**Percent**
Yes	245	67.3
No	119	32.7
Total	**364**	**100.0**

Main Cooling Fuel	Frequency	Percent
Charcoal	57	15.7
Firewood	72	19.8
Kerosene	25	6.9
Gas	190	52.2
Electricity	20	5.5
Total	**364**	**100.0**

Source: Author's Analysis, 2025

The results in Table 4 reveal that a considerable majority of the respondents (67.3%) reported using charcoal as a household energy source, whereas 32.7% answered that they do not use it. This study implies that charcoal remains a dominant source of home energy in the Kaduna metropolis, despite the availability of modern alternatives such as gas and electricity. According to Yunusa et al. (2024), the high level of charcoal usage in Kaduna may be due to its relative price, ease of access, and cultural familiarity, particularly among low- and middle-income households.

In terms of the major cooking fuel, more than half of the respondents (52.2%) chose gas as their primary source of cooking energy, followed by firewood (19.8%), charcoal (15.7%), kerosene (6.9%), and electricity (5.5%). This is similar to the findings of Mulima et al. (2025), which implies a steady transition toward cleaner energy sources such as gas among urban households, although traditional fuels such as firewood and charcoal still play a considerable role in meeting daily cooking demands. The continuous use of charcoal alongside gas implies that many homes embrace fuel stacking, a technique of combining several energy sources that is dependent on availability, cost, and purpose. These results agree with the findings of Adekoya et al. (2023) that although many households use charcoal, it is not their primary energy source because of the increasing adoption of alternatives such as liquefied petroleum gas (LPG) and electricity, driven by factors such as income growth, education, and convenience.

Factors Influencing the Choice of Charcoal as a Domestic Energy Source in the Kaduna Metropolis

This section examines the most important factors that make people choose charcoal as their main source of energy at home. It looks at things such as cost, ease of access, availability, convenience, and customary practices that affect people's lives in terms of their social and economic status, culture, and environment.

The data help determine what drives people to utilize charcoal even when other energy sources are available. The model summary for the binary logistic regression is shown in Table 5.

Table 5: Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	411.189[a]	.126	.175

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

Source: Author's Analysis, 2025

The model summary shown in Table 5 provides key indications of the overall performance and explanatory power of the binary logistic regression model used to analyse the factors influencing the use of charcoal as a residential energy source in the Kaduna metropolis. The −2 log likelihood score of 411.189 shows the measure of unexplained variation in the model. A lower value of the −2 log likelihood suggests a better match; hence, the model indicates a reasonably good fit to the data.

The Cox and Snell R^2 and Nagelkerke R^2 are pseudo R^2 statistics that provide an indicator of how much variation in the dependent variable is explained by the model. The Cox and Snell R^2 value of 0.126 and the Nagelkerke R^2 value of 0.175 show that approximately 12.6% to 17.5% of the variation in the likelihood of utilizing charcoal as a domestic energy source can be explained by the predictor factors (gender, income, household size, and education).

Although these values are very low, they are appropriate in social and behavioral studies where several external influences may impact family energy decisions. The results show that while the predictors included in the model significantly contribute to explaining charcoal use, other environmental and socioeconomic factors not included in the model may also play a role (Chukwuemeka & Osuji, 2020).

Furthermore, binary logistic regression provides the influence of each variable on the use of charcoal by various households in the Kaduna metropolis. The results are shown in Table 6.

Table 6: Influence of Socioeconomic Variables on the Use of Charcoal

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Gender	-0.047	0.240	0.039	1	0.844	0.954
	Educational Level	0.370	0.130	8.039	1	0.005	1.447
	Monthly Income	0.077	0.136	0.315	1	0.575	1.080
	Household Size	-1.149	0.231	24.821	1	0.000	0.317
	Constant	-0.500	0.735	0.461	1	0.497	0.607

a. Variable(s) entered on step 1: Gender, Educational Level, Monthly Income, Household Size.

Source: Author's Analysis, 2025

Table 6 reveals the results of the binary logistic regression analysis, indicating the influence of gender, educational level, monthly income, and household size on the likelihood of choosing charcoal as a home energy source in the Kaduna metropolis. The results suggest that educational level and family size were statistically significant predictors of charcoal usage, whereas gender and monthly income were not significant predictors.

Gender (B = -0.047, p = 0.844) has a negative coefficient, but it is not statistically significant ($p > 0.05$), indicating that gender has no causal effect on the likelihood of using charcoal as a household energy source. Both male- and female-headed households are equally likely to utilize charcoal. In contrast, the level of education (B = 0.370, p = 0.005) has a positive and significant connection with charcoal usage at the 1% level. The odds ratio (Exp(B) = 1.447) implies that with each

rise in educational level, the likelihood of using charcoal increases by approximately 44.7%. This indicates that even educated persons continue to rely on charcoal because of convenience, cultural preferences, or a lack of modern economic energy options.

Monthly income (B = 0.077, p = 0.575) has a positive but statistically negligible effect (p > 0.05), implying that differences in household income do not significantly influence the choice of charcoal as a domestic energy source. This implies that charcoal use cuts across income ranges, probably because it remains relatively economical and widely available compared with alternatives such as gas or electricity.

Household size (B = -1.149, p = 0.000) is very significant (p < 0.001), with a substantial negative coefficient. The odds ratio (Exp(B) = 0.317) implies that as the household size increases, the likelihood of utilizing charcoal decreases by approximately 68.3%. This may be because larger homes tend to employ bulk or alternative energy sources (e.g., firewood) that are more cost-effective for cooking in large numbers. The constant (B = -0.500, p = 0.497) is not significant, indicating that without the influence of the independent variables, the model does not significantly predict charcoal consumption. Overall, the regression results reveal that educational level and family size are the most important drivers of charcoal use in the Kaduna Metropolis, whereas gender and wealth play relatively small roles.

Frequency and Pattern of Charcoal Usage among Households in the Kaduna Metropolis

This section analyses how frequently and in what manner households utilize charcoal for domestic purposes. It assesses the intensity of use across various income groups and residential areas, as well as the types of cooking or heating activities for which charcoal is most commonly employed. The analysis provides insight into the extent of the dependence on charcoal within the study area. This is shown in Table 7.

Table 7: Frequency of Charcoal use in the Kaduna Metropolis

Frequency of Charcoal Use	Frequency	Percent
Daily	103	28.3
Several times a week	100	27.5
Weekly	11	3.0
Occasionally	31	8.5
Never	119	32.7
Total	**364**	**100.0**
Spending on Charcoal		
Less than N1,000	117	32.1
N1,000 - N2,000	74	20.3
N2,001 - N3,000	77	21.2
More than N3,000	96	26.4
Total	**364**	**100.0**
Why you prefer charcoal		
It is cheap	136	37.4
Readily available	65	17.9
Cooks better/faster	32	8.8
Cultural reasons	12	3.3
Others	119	32.7
Total	**364**	**100.0**

Source: Author's Analysis, 2025

The results presented in Table 7 describe the frequency, expenditures, and reasons for using charcoal among households in the Kaduna metropolis. The findings reveal that a substantial proportion of respondents use charcoal frequently. Specifically, 28.3% of the respondents reported using charcoal daily, whereas 27.5% reported using it several times a week. Only 3.0% use it weekly, and 8.5% use it occasionally. Approximately 32.7% reported that they never used charcoal. This pattern indicates that charcoal remains an important and regularly used domestic energy source for many households in the study area, likely because of its accessibility and adaptability to various cooking needs.

In terms of households' monthly spending on charcoal, 32.1% of respondents spend less than ₦1,000 monthly, whereas 20.3% spend between ₦1,000 and ₦2,000. Another 21.2% spend between ₦2,001 and ₦3,000, and 26.4% spend more than ₦3,000 monthly. This distribution suggests that a notable share of households incur moderate to high monthly expenditures on charcoal, reflecting its consistent demand and potential economic impact on household budgets. With respect to the reasons for preferring charcoal, 37.4% cited its cheap cost, 17.9% indicated ready availability, 8.8% mentioned that it cooks better or faster, and 3.3% attributed their choice to cultural reasons. The remaining 32.7% fell under "others," which likely includes respondents who use alternative fuels. Overall, affordability and availability stand out as the major drivers of charcoal use among households in the Kaduna metropolis.

Influence of Socioeconomic Variables on the Frequency of Charcoal Usage

Following the application of the ordinal logistic regression model to analyse the predictors of the frequency of charcoal use, this section presents the empirical findings. The model assessed the influence of key socioeconomic variables on the frequency of charcoal use. The parameter estimates, detailed in Table 8, reveal the direction, magnitude, and statistical significance of these relationships. The results reveal several compelling and, in some cases, counterintuitive patterns that challenge conventional assumptions about household energy choices, highlighting the complex interplay between socioeconomic status and charcoal consumption in the study area.

Table 8: Influence of Socioeconomic Variables on the Frequency of Charcoal Usage

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Q10 = 1.00]	-1.411	.595	5.620	1	.018	-2.577	-.244
	[Q10 = 2.00]	-.142	.590	.058	1	.809	-1.299	1.014
	[Q10 = 3.00]	-.004	.590	.000	1	.995	-1.160	1.152
	[Q10 = 4.00]	.401	.591	.461	1	.497	-.756	1.559
Location	Q6	-.380	.130	8.517	1	.004	.125	.635
	Q7	-.487	.119	16.592	1	.000	-.721	-.252
	[Q4=1.00]	-.462	.317	2.125	1	.145	-1.083	.159
	[Q4=2.00]	-.814	.408	3.974	1	.046	-1.614	-.014
	[Q4=3.00]	-.462	.219	4.435	1	.035	-.891	-.032
	[Q4=4.00]	0[a]	.	.	0	.	.	.
	[Q5=1.00]	-.452	.482	.879	1	.348	-1.398	.493
	[Q5=2.00]	-.498	.483	1.059	1	.303	-1.445	.450
	[Q5=3.00]	-.526	.493	1.139	1	.286	-1.492	.440
	[Q5=4.00]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

Source: Author's Analysis, 2025

Table 8 presents the results of the ordinal logistic regression for the factors influencing the frequency of charcoal use (Q10) among households in the Kaduna metropolis. The dependent variable, frequency of charcoal use, was modelled against predictors such as monthly income (Q6), household size (Q7), educational level (Q4), and occupation (Q5). The model identifies how these socioeconomic factors affect the likelihood of using charcoal more or less frequently.

The results show that monthly household income (Q6) has a negative and statistically significant effect on charcoal use frequency (B = -0.380, p = 0.004). This implies that as household income increases, the probability of using charcoal more frequently decreases. This suggests that low-income households continue to use charcoal either as the main energy source or because of its affordability, perceived convenience, and taste in cooking. This result contradicts the findings of Brobbey et al. (2019) in Ghana, which showed that reliance on charcoal increases with increasing income. In contrast, household size (Q7) has a negative and highly significant relationship (B = -0.487, p = 0.000), indicating that as household size increases, the likelihood of frequent charcoal use decreases, possibly because larger families prefer more cost-effective energy options such as firewood or bulk fuels (Adekoya et al., 2023).

With respect to educational level (Q4), respondents with tertiary (B = -0.814, p = 0.046) and secondary education (B = -0.462, p = 0.035) are significantly less likely to use charcoal frequently than those with primary education. This finding agrees with the findings of Vihi et al. (2023), who suggested that higher educational attainment discourages charcoal use, potentially because of lifestyle or preference factors among educated urban households. (Sapnken et al., 2025) reported that households are less likely to use charcoal as a cooking fuel when they have a higher level of education. Occupation (Q5) was not statistically significant (p > 0.05), suggesting that employment type has little effect on the frequency of charcoal use. The model thresholds indicate well-defined category separations for frequency levels, confirming that the ordinal logistic regression appropriately fits the ordered response data. Overall, the findings highlight that income, household size, and education are the major socioeconomic determinants influencing how often households use charcoal as a domestic energy source in the Kaduna Metropolis.

CONCLUSION

This study has presented empirical evidence that a significant number of households in Kaduna Metropolis still use charcoal, as 68% of the respondents reported its use despite access to electricity and LPG infrastructure. Unlike previous studies that suggested persistent biomass use is driven by poverty and low education, the findings revealed charcoal to be widely adopted across young, tertiary-educated, and economically active respondents engaged in informal trading. This likelihood provides the basis for the phenomenon of fuel stacking rather than a complete energy transition, even within socio-economic groups who, ideally, would be presumed to have climbed the modern-energy ladder. To buttress this, the results from logistic regression reinforce such ramification: while higher income and education reduce the odds and frequency of charcoal use, culturally embedded uses, reliability of charcoal during power outages, and relative affordability remain strong drivers across the income strata.

These findings have implications for wider debates on the nature of urban energy transitions in sub-Saharan Africa. They contest linear "energy ladder" approaches and underscore how "fuel stacking" can be a rational risk-mitigation strategy in contexts of unreliable electricity and volatile LPG prices. In northern Nigeria, where seasonal harmattan dust and religious/cultural cooking practices further favour charcoal, a complete shift to modern fuels is unlikely without addressing both supply-side constraints and deeply embedded socio-cultural preferences.

However, there are some limitations: the cross-sectional design captures a single point in time and cannot assess seasonal variations in fuel choice. Self-reported expenditure and health symptoms are also subject to potential recall bias, while the purposive selection of high-population wards, though intentional, might underrepresent newer, peri-urban settlements that have different energy access profiles.

These findings point to four actionable policy directions: i) the scaling up of LPG starter-kit subsidy programmes targeting middle- and low-income traders, ii) the incorporation of charcoal-efficiency messaging into health and environmental campaigns already in existence, iii) the investment in mini-grid and improved cookstove pilots that cater to the needs of informal commercial users, and iv) the enforcement of sustainable charcoal production standards to reduce environmental externalities without criminalising livelihoods.

Future longitudinal or comparative research-analyses of fuel-switching patterns at a seasonal scale, or comparisons of Kaduna with cities of higher or lower LPG penetration, for instance, Kano versus Abuja-would provide further detail on the pathways to cleaner urban energy systems. This study illustrates that the pursuit of Nigeria's sustainable energy objectives in rapidly growing secondary cities will involve context-specific, multi-fuel approaches that look beyond income-based supposition and appreciate the persistence of charcoal in contemporary urban livelihoods.

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