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DETERMINANTS OF HOUSEHOLD DEMAND FOR CHARCOAL IN IBARAPA LOCAL GOVERNMENT, OYO STATE

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ABSTRACT
Charcoal remains a dominant household cooking fuel in many Nigerian communities, despite the growing availability of modern alternatives such as Liquefied Petroleum Gas (LPG) and electricity. Persistent reliance on charcoal raises concerns about health outcomes, deforestation, and energy poverty. However, the socioeconomic and behavioral drivers behind its continued use remain poorly understood. This study, therefore, examined the determinants of household demand for charcoal in Ibarapa Local Government, Oyo State. The study concluded that charcoal exhibited strong expenditure responsiveness and significant nonlinear income effects, indicating that while charcoal behaves as a necessity among low- income households, its budget share declines as income increases; likewise, substitution between charcoal and other fuels was weak, with only moderate cross-price effects such as the significant interaction with LPG and recommends that expanding LPG distribution infrastructure as the most effective strategy for reducing charcoal dependence, as access to LPG showed the strongest negative effect on charcoal use.

Keywords: Determinants, Household, charcoal demand

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INTRODUCTION

Energy plays a crucial role in global economic development and improving living standards. Access to affordable, reliable, and sustainable energy is vital for achieving the United Nations Sustainable Development Goal (Affordable and clean energy: SDG) 7, which seeks to ensure universal access to modern energy services by 2030. While developed countries have made substantial progress in energy access, billions of people in developing regions, especially in sub-Saharan Africa, still depend heavily on traditional biomass fuels such as firewood, charcoal, and animal dung for cooking and heating (IEA, 2021). This dependence creates significant economic, environmental, and health challenges, including deforestation, greenhouse gas emissions, and indoor air pollution.

Globally, about 2.4 billion people rely on traditional biomass for their daily energy needs, with the majority residing in developing countries (World Bank, 2020). Charcoal, in particular, is a dominant energy source due to its low cost, ease of transportation, and compatibility with local cooking habits. Despite its importance to low- and middle-income households, charcoal production and use contribute to deforestation and environmental degradation. The World Health Organisation (WHO, 2022) reports that approximately 4 million premature deaths occur annually from indoor air pollution, primarily among households that use solid fuels such as charcoal.

In sub-Saharan Africa, over 80% of the population depends on biomass for cooking and heating (IEA, 2021). Charcoal remains especially prevalent in urban areas, where it is preferred for its convenience and higher energy density compared to firewood. Rapid urbanisation, population growth, and limited access to modern energy infrastructure have led to increasing demand for charcoal across cities in the region (Zulu and Richardson, 2013). However, the methods used for charcoal production, which are typically inefficient and unsustainable, accelerate deforestation and land degradation. In countries such as Kenya, Tanzania, and Ghana, charcoal production has been identified as a key driver of forest loss (Chidumayo and Gumbo, 2013). Furthermore, the charcoal sector is often informal, poorly regulated, and associated with precarious working conditions, which worsen both environmental and social inequalities.

Despite these drawbacks, charcoal remains a crucial energy source for many African households. Transitioning to cleaner alternatives such as liquefied petroleum gas (LPG), electricity, or renewable energy has been hindered by barriers including high costs, limited availability, and cultural preferences. For millions of households in rural and peri-urban areas, charcoal remains the most accessible and affordable fuel option. Therefore, understanding the factors influencing charcoal demand is essential for developing policies that promote sustainable energy transitions.

Nigeria, Africa's most populous nation, reflects these challenges acutely. Despite its rich energy resources, oil, gas, and renewable potentials, energy poverty remains pervasive. About 70% of Nigerian households depend on biomass fuels, including charcoal and firewood, for cooking and heating (NBS, 2021). The widespread use of biomass is driven by limited access to modern energy infrastructure, unreliable electricity supply, and the high cost of alternatives such as LPG. Rapid urbanisation has further increased charcoal demand as low- and middle-income households in expanding cities continue to rely on it for daily cooking (Ajayi *et al.*, 2016). In rural areas, inadequate energy infrastructure sustains dependence on firewood and charcoal.

The environmental consequences of this reliance are severe. Charcoal production contributes significantly to deforestation, land degradation, and greenhouse gas emissions in Nigeria. Weak regulatory frameworks and poor enforcement exacerbate these environmental issues (Ogundele *et al.*, 2022). Additionally, indoor air pollution from charcoal use poses significant health risks, especially for women and children exposed to smoke during cooking.

METHODOLOGY

The study was carried out in Ibarapa Central, located in Oyo State, Nigeria, is part of the larger Ibarapa region, which comprises the towns of Igbo-Ora and Idere, with its administrative headquarters in Igbo-Ora. The total area of Ibarapa Central is 440 km², and according to the 2006 census, the population was 102,979, increasing to an estimated 322,189 by 2018. The Ibarapa people predominantly inhabit the region, a sub-group of the Yoruba ethnic group, known for their deep cultural heritage (Wikipedia Contributors, 2024).

The latitudes of 7°15′ N and 7°55′ N, and the longitudes of 3° E and 3°30′ E, correspond to the Ibarapa region. The capital of Oyo State, Ibadan, lies 95 miles southwest of Lagos and about 120 km north of it. Yewas and Egbas share their borders to the south and west, Ibadan to the east, and Kajola and Iseyin to the north. The area is well known for its savannah woodlands, which are found along river courses such as the Oyan and Ofiki rivers, where vegetation is concentrated. Though rocky inselbergs and outcrops reach up to 340 meters above sea level, the majority of the landscape lies between 120 and 200 meters above sea level.

RESULTS AND DISCUSSION

Socioeconomic characteristics of the Respondents

The age distribution of respondents reveals that charcoal use cuts across all age groups, although usage is more concentrated among economically active adults. Among charcoal users, the largest proportion falls within the 41–50 age group (27.9%), followed closely by the 21–30 (25.2%) and 31–40 (23.4%) age categories. This indicates that individuals in their productive and middle-aged years rely more heavily on charcoal as a primary cooking fuel. A similar pattern is observed among non-users, with the 41–50 age group also accounting for the highest proportion (27.0%), followed by the 21–30 (24.3%) and 31–40 (21.6%) groups.The older age categories (51–60 and 60+) constitute smaller proportions of both users and non-users, although their representation remains notable. Among users, each of these groups accounts for 11.7% of the sample, while among non-users, they represent 12.1% and 14.9% respectively. This suggests that older adults continue to depend on household energy sources such as charcoal, though at slightly lower rates than younger adults. The calculated mean age was 2.65, suggesting that the overall sample was middle-aged. This group often plays a critical role in household decision-making and economic activities.

Table 1: Age Distribution by User Status

Age Group	Users (n=111)	%	Non-users (n=74)	%
21–30	28	25.2	18	24.3
31–40	26	23.4	16	21.6
41–50	31	27.9	20	27.0
51–60	13	11.7	9	12.1
60 and above	13	11.7	11	14.9
Total	**111**	**100**	**74**	**100**

Source: Field Survey, 2025

The gender distribution shows that both men and women participate significantly in household energy decisions, although with slight variations between charcoal users and non-users. Among charcoal users, males constitute a marginal majority at 55.9% (62 out of 111), while females account for 44.1% (49 respondents). This suggests that male-headed households may be slightly more likely to use charcoal as a primary cooking fuel. This finding aligns with studies indicating that male-headed households often have greater involvement in the acquisition of fuel resources (Anyanwu & Eyisi, 2021).Among non-users, the gender distribution is more balanced, with males representing 51.4% and females 48.6%. The relatively small difference between the two groups suggests that gender alone may not be a strong determinant of whether households rely on charcoal or alternative energy sources. Instead, gender differences may interact with other socioeconomic factorssuch as income, household composition, or cultural normsto shape energy preferences, as noted in previous research.

Table 2: Gender Distribution by User Status

Gender	Users (n=111)	%	Non-users (n=74)	%
Male	62	55.9	38	51.4
Female	49	44.1	36	48.6
Total	**111**	**100**	**74**	**100**

Source: Field Survey, 2025

The marital status distribution shows that charcoal use is most common among married respondents, who make up 55.0% of users and 45.9% of non-users. Single respondents represent 19.8% of users and 23.0% of non-users, indicating a slightly higher proportion of non-users in this category. Divorced or separated individuals account for a small share in both groups—8.1% of users and 9.5% of non-users. Widowed respondents constitute 17.1% of users and 21.6% of non-users, showing a modestly higher presence among non-users. Overall, the findings suggest that marital status does not create large differences between users and non-users, although married households appear somewhat more likely to use charcoal, likely due to larger household sizes and higher cooking demands.

Table 3: Marital Status by User Status

Marital Status	Users (n=111)	%	Non-users (n=74)	%
Single	22	19.8	17	23.0
Married	61	55.0	34	45.9
Divorced/Separated	9	8.1	7	9.5
Widowed	19	17.1	16	21.6
Total	**111**	**100**	**74**	**100**

Source: Field Survey, 2025

The household size distribution shows that both users and non-users are concentrated in medium-sized households. Among users, 51.4% fall within the 4–6 member category, similar to non-users at 50.0%. Small households (1–3 members) account for 23.4% of users and 23.0% of non-users, while larger households (7–9 members) make up 20.7% and 21.6% respectively. Very large households (10 or more members) represent a small share in both groups. Overall, household size patterns are similar across users and non-users, but the higher proportion in the 4–6 category suggests that medium-sized families are the primary consumers of household cooking fuels, including charcoal.

Table 4: Household Size by User Status

Household Size	Users (n=111)	%	Non-users (n=74)	%
1–3	26	23.4	17	23.0
4–6	57	51.4	37	50.0
7–9	23	20.7	16	21.6
10 and above	5	4.5	4	5.4
Total	**111**	**100**	**74**	**100**

Source: Field Survey, 2025

The education distribution shows that charcoal use spans all levels of educational attainment. Among users, secondary education is the most common at 38.7%, followed by tertiary education at 26.1% and no formal education at 19.8%. Non-users also show a strong presence in secondary (32.4%) and tertiary education (32.4%). Primary education represents the smallest share for both groups. Overall, both users and non-users are concentrated in the secondary and tertiary categories, indicating that education level does not create a major distinction in household charcoal.

Table 5: Education Level by User Status

Education Level	Users (n=111)	%	Non-users (n=74)	%
No formal education	22	19.8	15	20.3
Primary	17	15.3	11	14.9
Secondary	43	38.7	24	32.4
Tertiary	29	26.1	24	32.4
Total	**111**	**100**	**74**	**100**

Source: Field Survey, 2025

The primary occupation profile shows that charcoal use is most common among traders and farmers. Among users, traders represent the largest share at 36.9%, followed by farmers at 32.4%. Civil servants account for 19.8% and artisans 10.8%. For non-users, trading also dominates at 43.2%, with civil servants (24.3%) and farmers (23.0%) following. Overall, both groups are concentrated in trading and farming, indicating that livelihood type—especially informal and agrarian occupations play a notable role in shaping household energy choices.

Table 6: Primary Occupation by User Status

Occupation	Users (n=111)	%	Non-users (n=74)	%
Farming	36	32.4	17	23.0
Trading	41	36.9	32	43.2
Civil service	22	19.8	18	24.3
Artisan	12	10.8	7	9.5
Total	**111**	**100**	**74**	**100**

Source: Field Survey, 2025

The income distribution shows that both users and non-users are concentrated in the lower- to middle-income ranges. The largest proportions in both groups fall within ₦50,001–90,000 (35.1%) and ₦90,001–130,000 (27.0%). The lowest income group (₦10,000–50,000) accounts for 24.3% of both users and non-users. Higher-income categories (₦130,001 and above) represent the smallest shares, with fewer than 10% in each group. The mean income was 2.34 (SD = 1.066), suggesting that most respondents were concentrated in the lower to middle-income group, reflecting modest earnings consistent with rural and semi-urban economies.Overall, users and non-users exhibit nearly identical income patterns, indicating that monthly income does not create strong differences in charcoal reliance, although most charcoal use occurs among low- and middle-income households.

Table 7: Monthly Income by User Status

Monthly Income (₦)	Users (n=111)	%	Non-users (n=74)	%
10,000–50,000	27	24.3	18	24.3
50,001–90,000	39	35.1	26	35.1
90,001–130,000	30	27.0	20	27.0
130,001–170,000	11	9.9	7	9.5
Above 170,000	4	3.6	3	4.1
Total	**111**	**100**	**74**	**100**

Source: Field Survey, 2025

2.0 Socioeconomic Characteristics of Households Influencing Charcoal Demand

The logistic regression model was employed to examine the influence of socioeconomic characteristics on household charcoal use, as seen in Table 4.10. The overall model was statistically significant, with an R^2 of 0.210, indicating that the included variables explained approximately 21% of the variance in household charcoal use.Among the predictors, the highest level of education and village of residence emerged as statistically significant determinants. Households with higher levels of education were significantly more likely to use charcoal (B = 0.612, Wald = 6.029, p = .014). The odds ratio (Exp(B) = 1.843) suggests that for each unit increase in education level, the likelihood of using charcoal increased by approximately 84%. This finding is notable as it challenges conventional expectations under the "energy ladder" model, which posits that more educated households should transition to modern fuels such as LPG or electricity. Instead, the result suggests that charcoal retains cultural and practical appeal even among educated households.Other socioeconomic variables, including household income, occupation, household size, and gender, did not show significant effects on charcoal use in this model (p > .005). This suggests that charcoal demand in Ibarapa Local Government is not primarily driven by income or demographic composition but rather by education and local context.This aligns with the findings of Brouwer and Falcão (2004), who noted that educated urban households in Mozambique continued to rely on charcoal. Additionally, Eze *et al.* (2021) found that although education increases knowledge of clean fuels, if structural barriers (such as high costs or inadequate supply) persist, it may not lead to behavioural change. Therefore, rather than completely replacing charcoal, education in Ibarapa Local Government may increase family energy portfolios.Another critical factor was household income: households with higher incomes tended to consume more charcoal than those with lower incomes. The energy ladder hypothesis, which maintains that households are inherently drawn to contemporary fuels as wages rise, is clearly contradicted by this result. Instead, the outcome supports the fuel stacking hypothesis (Akinbami, 2022), which maintains that as household earnings increase, they diversify their energy consumption. In actuality, this means that while wealthy homes may utilise LPG for light or short cooking, they may continue to use, or even increase, charcoal for bulk cooking, certain meals, or entertaining visitors. Reports of comparable outcomes have been published in sub-Saharan Africa. According to Antwi-Agyei *et al.* (2018), for example, middle- and upper-class households in metropolitan Africa frequently used charcoal alongside LPG and electricity.

This conclusion can also be viewed through the perspective of demand theory, specifically the QUAIDS model (Deaton and Muellbauer, 1980), which indicates that as incomes rise, demand for both necessary and superior products can increase. Charcoal, in this example, is

viewed not only as a necessity but also as a culturally valued fuel that continues to command demand even among higher-income homes.

Households in villages with robust charcoal markets or inadequate LPG infrastructure, for example, might use charcoal more frequently than those in places with easier access to contemporary fuels. This finding is consistent with Nkansah (2020) contention that market and geographic factors frequently predict energy choices more so than household characteristics. The importance of geography, income, and education underscores the need for strategies that move beyond crude energy-ladder assumptions.

Table 8: Results of Logit Regression Analysis

Predictor Variables	Unstandardized Coefficients (B)	Std Error	B	Wald	df	P. value
Total monthly household income	0.865	0.215	-0.145	0.455	1	0.500
Highest Level of Education	1.843	0.249	0.612	6.029	1	0.014**
Primary Occupation	1.592	0.262	0.465	3.139	1	0.076
Household Size	0.994	0.046	-0.006	0.015	1	0.903
Gender	0.741	0.448	-0.300	0.448	1	0.503
Constant	0.382	1.365	-0.962	0.497	1	0.481

Source: Field Survey, 2025
Variables Significant at ***1% and **5%

3.0 Impact of Household Income on Charcoal Demand

The QUAIDS results provide strong empirical evidence on how prices, income, and household demographics shape charcoal demand in Ibarapa Local Government, Oyo State. The significant expenditure coefficients ($\beta_1 = 0.444$, p =0.000 $\beta_2 = -0.381$, p = 0.002) show that income changes meaningfully influence household fuel allocation. Specifically, the positive β_1 indicates that as household income rises, the budget share allocated to charcoal increases, suggesting that charcoal behaves as a normal good among low-income households. This aligns with findings by Akinbami (2022) and Olotu *et al*. (2020), who argue that charcoal consumption persists even with rising income due to its cultural suitability and affordability. Conversely, the negative β_2 coefficient reflects a shift away from alternative fuels (likely firewood) as income increases, consistent with the view that income growth gradually diversifies household fuel portfolios, a key feature of the fuel stacking model (Heltberg, 2004). This supports the argument that income-induced transitions do not lead to complete abandonment of traditional fuels but rather their strategic combination with modern alternatives.Price and substitution effects, captured through the gamma coefficients, provide further insight into household behaviour. The significant own-price effects $\gamma_{11} = 0.865$ (p = 0.021) and $\gamma_{33} = 0.146$ (p =0.000) indicate that charcoal and the third fuel category are highly price-responsive. This supports earlier studies by Miller and Nyaga (2019), who found strong price responsiveness in charcoal markets, especially where substitutes exist. Significant cross-price effects, such as $\gamma_{21} = -0.734$ and $\gamma_{22} = 0.749$, highlight the substitution and complimentary between fuels. Positive coefficients suggest that households substitute towards certain fuels when relative prices increase, while negative coefficients point to complementary consumption. These findings mirror the observations of Zulu and Richardson (2013), who noted that urban households dynamically switch between charcoal, LPG, and

kerosene depending on market conditions, reinforcing the multi-user nature of energy consumption.The quadratic term (λ_1 = 0.041, p = 0.000; λ_2 = –0.038, p =0.000 confirms the presence of non-linear Engel curves, validating the use of QUAIDS rather than the simpler AIDS model. This implies that charcoal demand does not change proportionally with income; instead, the relationship bends as income rises reflecting the complex nature of fuel decisions among evolving households. Banks *et al*. (1997) similarly observed that non-linear income effects more accurately represent household behaviour in developing economies where multiple fuels coexist.

Demographic influences also emerged as significant predictors of charcoal demand. Gender plays a notable role, with eta_gender$_2$ (–0.011, p = 0.017) showing that female-headed households devote a lower share of their energy budget to charcoal. This supports the argument of Anyanwu and Eyisi (2021) that women often prioritise cleaner fuels for health and safety reasons when resources permit. Household size, reflected in the rho_householdsize coefficient (0.035, p = 0.008), also significantly increases fuel budget shares, aligning with Antwi-Agyei *et al*. (2018), who noted that larger households gravitate towards cost-effective fuels due to scale economies. Age reduces overall fuel budg*et al*locations (rho_age = –0.015, p =0.000), suggesting that older household heads may adopt more stable or familiar energy routines, corroborating findings by Nkansah (2020).

Collectively, the results reaffirm the fuel stacking theory, demonstrating that households do not follow a linear progression towards cleaner fuels but rather combine charcoal with alternatives based on affordability, cultural preferences, and price dynamics. The interaction of income, price, and demographic factors underscores the complexity of energy decisions and highlights the need for nuanced, multidimensional policy interventions that account for household behavioural realities.

Table 9: QUAIDS Expenditure (Income) Effects

Parameter	Coefficient	Std. Error	z-value	p-value
β_1	0.4443	0.1168	3.80	0.000
β_2	–0.3815	0.1210	–3.15	0.002
β_3	–0.0628	0.0705	–0.89	0.373

Table 10: QUAIDS Price and Substitution Effects (Gamma Coefficients)

Parameter	Coefficient	Std. Error	z-value	p-value
γ_{11}	0.8650	0.3759	2.30	0.021
γ_{21}	–0.7339	0.3383	–2.17	0.030
γ_{31}	–0.1310	0.1168	–1.12	0.262
γ_{22}	0.7487	0.3298	2.27	0.023
γ_{32}	–0.0147	0.0930	–0.16	0.874
γ_{33}	0.1458	0.0338	4.32	0.000

Table 11: Quadratic Engel Effects (Lambda Coefficients)

Parameter	Coefficient	Std. Error	p-value
λ_1	0.0409	0.0101	0.000
λ_2	–0.0382	0.0109	0.000
λ_3	–0.0028	0.0066	0.674

Table 12: Demographic Effects (Eta Coefficients)

Demographic Variable	Coefficient	Std. Error	p-value
Gender (eta_gender$_2$)	–0.0111	0.0046	0.017
Gender (eta_gender$_1$, eta_gender$_3$)	0.0083; 0.0027	—	>0.05
Household size (eta_hh$_2$)	–0.0006	0.0003	0.087
Household size (eta_hh$_3$)	0.0005	0.0003	0.056

Table 13: System-wide Demographic Scaling Effects (Rho Coefficients)

Parameter	Coefficient	Std. Error	p-value
ρ_gender	0.1485	0.0576	0.010
ρ_householdsize	0.0353	0.0134	0.008
ρ_age	–0.0154	0.0017	0.000
ρ_marital status	0.0792	0.0709	0.264
ρ_education	–0.0085	0.0053	0.109

Source: Field Survey, 2025

Variables Significant at ***1% and *5%

CONCLUSION AND RECOMMENDATIONS

The study demonstrates that the determinants of charcoal demand in Ibarapa Local Government are multidimensional, involving economic, cultural, environmental, and infrastructural factors. Energy transitions are best understood not as a simple substitution process, but as a complex interplay of access, affordability, and cultural adaptation and the following recommendations were made:

- Government and private sector actors should invest in expanding the distribution infrastructure for LPG and electricity, particularly in peri-urban and rural areas. Improved access will reduce reliance on charcoal and promote fuel substitution.
- Subsidy programs for LPG cylinders, cookstoves, and electricity tariffs should be designed to make clean fuels affordable for low- and middle-income households. These should be complemented with micro-financing options for poor households.
- Environmental conservation initiatives such as reforestation and sustainable wood harvesting should be encouraged, coupled with stronger enforcement of forestry regulations to curb unsustainable charcoal production.

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