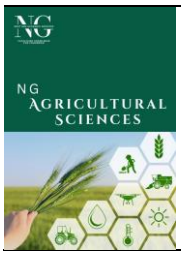

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Household Energy Transition and Forest Dependence after Fuel Subsidy Reform in Ijebu-Ode, Nigeria

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ABSTRACT

This study assessed the effects of removing the fuel subsidy on household energy preferences and forest resource utilisation in Ijebu-Ode Metropolis, Ogun State, Nigeria. A cross-sectional quantitative survey was conducted among 300 households selected through stratified random sampling across six communities. Data were collected using structured questionnaires covering household characteristics, energy sources before and after subsidy removal, forest-product use, and perceptions of environmental impact. Forest-product use was measured using a Likert-scale index. The findings showed a marked shift in household energy choices after subsidy removal, with reduced use of LPG and kerosene and increased dependence on firewood and charcoal. Mean household forest-product use increased from 1.92 before subsidy removal to 5.55 after subsidy removal. Regression analysis identified household size and previous forest-product use as important predictors of post-subsidy forest dependence, with the model explaining 63.5% of the variation. Although many respondents were aware of the environmental implications of forest-resource extraction, affordability constraints strongly shaped household energy decisions. The study concludes that removing fuel subsidies, unless accompanied by affordable clean-energy alternatives such as subsidised LPG, improved cookstoves, and solar-based solutions, may intensify energy poverty and increase pressure on local forest resources. Targeted support for LPG access, improved cookstoves, and community-level biomass governance is needed to reduce both energy poverty and forest degradation.

1. INTRODUCTION

Fuel subsidy programmes in Nigeria have historically been used to reduce the burden of petroleum-price volatility on consumers. However, they have also generated fiscal pressure, market inefficiencies, and governance concerns, including leakages and overstatement of import-related claims (PWC, 2022; Agu et al., 2018). However, successive administrations have increasingly viewed these subsidies as fiscally unsustainable and prone to corruption, such as over-reporting imported figures for petrol imported for local consumption (Sambo & Sule, 2024). In Nigeria, fuel subsidies have remained a politically sensitive and economically significant issue, consuming a large portion of government expenditure, accounting for 24% of the total 2022 national budget of ₦17.126 trillion and 30% of the 2023 budget (Zukbee & Anayamobi, 2024; Evans et al., 2023). While the economic justification for subsidy removal centres on reducing fiscal deficits and promoting market efficiency, the social and

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environmental consequences of such reforms are often underexplored. Following the 2023 subsidy removal, petrol prices increased sharply, rising from about ₦165–₦197 per litre to approximately ₦600–₦900 per litre in many locations. This sudden increase affected transport costs, household expenditure, and the affordability of modern cooking fuels (Akintayo, 2023). It can shift household energy consumption from modern fuels (such as kerosene and LPG) to traditional biomass (such as firewood and charcoal) (Liu & Xu, 2022). In household energy studies, such a shift may be interpreted as energy-ladder regression or fuel-stacking intensification, in which households reduce reliance on cleaner fuels and increase use of traditional biomass under economic stress (Garcia-Lopez et al., 2024).

Ijebu-Ode Metropolis provides a relevant setting for examining the household-level environmental consequences of energy-price shocks because it combines urban and peri-urban settlements with nearby forested areas that supply fuelwood and other biomass resources. Rising costs of kerosene, LPG, and transport after subsidy removal may therefore influence household energy choices and increase pressure on local forest resources (Derebe & Alemu, 2023). With kerosene and gas prices now beyond the reach of many, following the change in petrol prices from N167 per litre to over N600-N900 per litre, anecdotal and empirical reports indicate a reversion to forest-based biomass sources, particularly fuelwood. This shift not only has implications for household health and time burden, especially on women, but also poses a serious threat to local forest resources.

Despite global emphasis on cleaner fuels, many households in sub-Saharan Africa remain reliant on traditional biomass such as firewood and charcoal (Derebe et al., 2025; Aminu et al., 2024), with Nigeria's household use of biomass (woodfuel and charcoal) at 95% (Africa Energy Commission [AFREC], 2022). Also, it has been reported that between 80% to 83% of Nigerian households rely on biomass, specifically firewood, charcoal, and agricultural residues, as their primary source of cooking energy, which is slightly above the average for Sub-Saharan Africa, which stands at 81.5% (World Health Organisation [WHO], 2024; International Energy Agency [IEA], 2023). Energy poverty remains a critical issue in sub-Saharan Africa, where over 600 million people lack access to electricity or clean cooking technologies (Byaro et al., 2024; Mukhtar et al., 2023). Energy transition in rural Africa is often shaped by affordability, accessibility, and cultural practices (Nalule et al., 2024; Peters et al., 2024). In Nigeria, rural energy poverty is linked to weak infrastructure, low incomes, and a high reliance on traditional biomass (Amadi et al., 2025; Ebisi, 2024; Somoye, 2023). The "energy ladder" hypothesis suggests that as income rises, households shift from traditional to modern energy sources (Kumar, 2024; Waleed & Mirza, 2023). However, this transition is often disrupted by economic shocks and policy changes, such as the removal of fuel subsidies.

The recent removal was lauded by economic reform advocates but criticised for lacking accompanying social protection measures (Percy & Gloria, 2024). However, these subsidies became fiscally unsustainable, accounting for billions in government expenditure annually. In 2023, the Nigerian government intensified efforts to remove subsidies, leading to a significant rise in fuel prices (Yunusa et al., 2023). While intended to stabilise the economy, this policy has disproportionately affected low-income households, increasing energy poverty and altering consumption behaviours (Ali et al., 2024).

Forests play a vital role in rural livelihoods, providing food, medicine, income, and fuelwood, with 80% to 83% of Nigerian households reported to rely on them (Chama et al., 2023; WHO, 2023). However, unsustainable harvesting driven by energy insecurity can lead to deforestation, biodiversity loss, and ecosystem degradation (John et al., 2024). Forests in Nigeria are under pressure from agricultural expansion, logging, and biomass extraction. In rural areas, forests serve as critical energy sources. Increasing fuelwood collection correlates with forest degradation and biodiversity loss (Khan et al., 2024). In regions with weak regulatory enforcement, increased reliance on forest biomass due to rising energy costs threatens both conservation goals and local climate resilience.

Forest dependency is influenced by household size, income level, education, and proximity to forest resources (Bisui et al., 2023). Poor households often lack access to modern energy alternatives, making forest biomass a critical resource. Household income, education, gender roles and cultural factors shape energy preferences in Nigeria (Abubakar et al., 2024; Boluwaduro & Boluwaduro, 2023). Policy shocks such as subsidy removal can exacerbate this dependency, particularly in rural areas where economic options are limited (Kayode & Idera, 2025). Understanding these drivers is key to designing policies that balance energy needs with forest sustainability.

Although several studies have examined the economic consequences of fuel subsidy removal in Nigeria, limited empirical attention has been given to its localised environmental consequences, particularly how rising fuel prices affect household dependence on firewood, charcoal, and nearby forest resources. This study addresses this gap using household-level evidence from Ijebu-Ode Metropolis. The specific objectives are to:

1. Examine changes in household energy-consumption patterns following fuel subsidy removal.
2. Assess household dependence on forest products in response to changes in fuel affordability.
3. Identify socio-economic factors associated with post-subsidy forest-resource utilisation.

2. MATERIALS AND METHODS

2.1 Study area

The study was conducted in Ijebu Ode Metropolis, located in Ogun State, Southwestern Nigeria. Geographically situated between latitude 6°49′N and longitude 3°56′E, Ijebu Ode is the administrative and commercial centre of the Ijebu Division. The metropolis lies approximately 110 km northeast of Lagos and is bounded by Omo forest reserves and agricultural lands that support both ecological services and rural livelihoods (Abiodun et al., 2025; Oke & Choji, 2016). Ijebu Ode has a humid tropical climate with two distinct seasons: the rainy season (April–October) and the dry season (November–March). It has an average annual rainfall of 1,200-2,000 mm and average temperatures of 26-32°C (Ganiyu et al., 2025). The vegetation comprises a mix of secondary forests, fallow lands, and derived savanna, with forest enclaves such as the Ijebu Ode Community Forest, OkeAje Woodland Belt, and surrounding bush lands, which are increasingly under threat from human activities, such as wildlife poaching and illegal timber felling. The local economy includes informal trade, agriculture, public-sector employment, and small-scale services. The combination of urban expansion, peri-urban forest patches, and households' reliance on biomass fuels makes Ijebu-Ode a relevant setting for assessing the household-level environmental consequences of energy price shocks. Following the removal of the national fuel subsidy, the community experienced increased energy costs (petrol prices rose from N165 to N800), prompting a shift in household fuel-sourcing behaviour. The area also experiences a growing population with an estimated population of 200,000 (Mabogunje & Kates, 2020), with a strong informal sector, high dependency on biomass fuels (firewood, charcoal), and increasing urban expansion, factors that make it a significant case study for assessing the impact of subsidy removal on households and alternative energy preferences.

2.2 Research design

This study adopted a cross-sectional quantitative survey design to assess household energy-use patterns and forest-product utilisation after the 2023 fuel subsidy removal. Data were collected between July and September 2023 and analysed using descriptive statistics, chi-square tests, and multiple regression.

2.3 Data Sources and Collection Methods

Stratified random sampling was used to select 300 households, with 50 households drawn from each of the six communities: Oke-Aje, Ijasi, Itoro, Molipa, Sabo, and Imowo. Strata were based on income groups ranging from low to high (N70, 000 – N100, 000) and on location relative to forest proximity, determined by self-assessment. The sample size enabled both descriptive and inferential analysis. Quantitative data were collected through structured questionnaires that captured household demographics, income, energy sources before and after subsidy removal, forest product use, and perceptions of environmental impact. Forest-product use was measured using a Likert-type index, with higher scores indicating greater dependence on forest-derived energy sources and related products. Reliability analysis yielded a negative Cronbach's alpha value (-0.748), indicating that these variables represent conceptually distinct constructs; they were treated as independent variables in subsequent analyses using descriptive and inferential statistical techniques.

2.4 Data Analysis Techniques

Descriptive statistics summarised energy source usage. Inferential analysis, assuming normality in the data distribution, was conducted, including chi-square tests, descriptive statistics, and multiple regressions. Chi-square tests assessed associations between categorical variables, while multiple regression analysis identified predictors of forest product use post-subsidy, with an R^2 of 0.635 and an adjusted R^2 of 0.538, indicating a strong model fit. All statistical tests used a 95% confidence level using the JASP statistical software package version 0.9.2.

3. RESULTS

Table 1 shows that forest product use increased among both male and female respondents after the subsidy was removed. Female respondents recorded slightly higher post-subsidy forest-product use than male respondents, although the gender difference was not statistically significant.

Table 1. Gender-wise forest-product use before and after fuel subsidy removal

Gender	FPUBS	FPUAS	AHS	AA
Female	1.87	5.58	5.56	41.92
Male	1.99	5.52	4.99	39.49
($p < 0.05$)	ns	ns	ns	ns

Note: FPUBS: Forest product use before subsidy removal. FPUAS: Forest product use after subsidy removal. AA: Average age. AHS: Average household size. ns = no significant level at $p > 0.05$

Figure 1 indicates that forest-product use after subsidy removal was higher than before, across perceived environmental impact categories, suggesting a general rise in forest-resource dependence regardless of perception level. Means separated by error bars are significantly different from each other at a probability level of 0.05. Mean forest-product dependence increased from 1.92 before subsidy removal to 5.55 after subsidy removal, indicating a substantial rise in household reliance on forest-derived resources.

Table 2 shows that households using firewood and charcoal recorded the highest post-subsidy forest-product use score, followed by those using LPG, kerosene, and electricity. This indicates that biomass-based energy users had the strongest association with increased forest-product dependence after subsidy removal. LPG use declined from 43% to 21% and kerosene from 36% to 19%, while firewood use rose from 41% to 69% in this study.

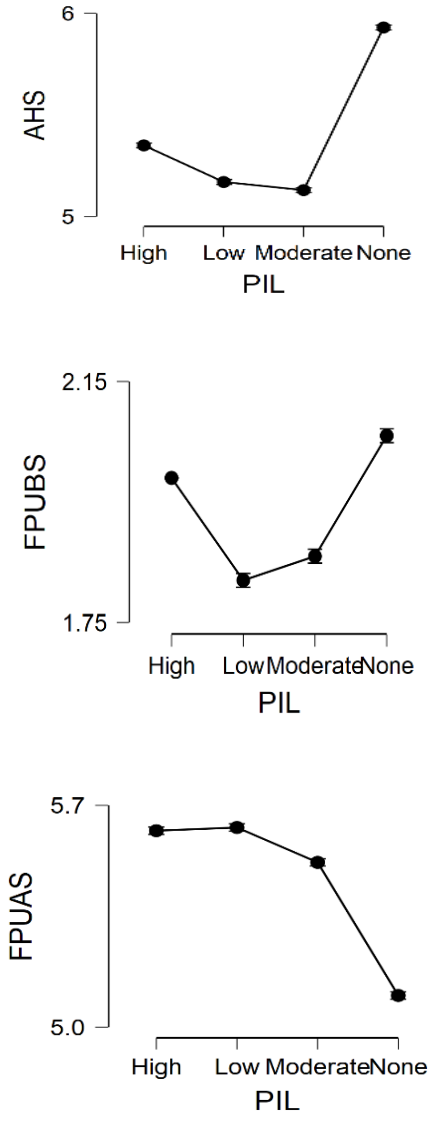

Figure 1 Forest-product dependence by perceived environmental impact level (PIL: Perceived impact level. FPUBS: Forest product use before subsidy removal. FPUAS: Forest product use after subsidy removal. AHS: Average household size)

Table 2. Household energy preference and forest-product use after subsidy removal

ET	FPUBS	FPUAS	AHS	AMI(NGN)
Electricity	1.8**(0.46)	5.36**(0.47)	5.12**(0.36)	84340.66**(5132)
Firewood & Charcoal	1.81**(1.00)	6.29**(2.65)	5.22**(1.18)	89794.44**(20870)
Kerosene	1.80**(0.22)	5.51**(0.38)	5.05**(0.91)	80421.23**(13230)
LPG	2.17**(0.20)	5.52**(0.65)	5.72**(0.76)	80207.15**(7392)

Note: ** indicates $p < 0.01$. LPG: Liquefied petroleum gas. The figure in brackets represents the standard deviation of the mean. NGN: Naira

Table 3 shows variations in average household size and monthly income across energy-preference categories. LPG users had the highest average household size, while firewood and charcoal users recorded the highest average monthly income among the listed energy groups. That households with larger sizes and higher incomes were still not immune to post-subsidy-removal shocks and had to diversify their energy use to increase forest product use due to limited access to affordable energy

alternatives. This is explained by different energy use types such as Electricity users with an average household and income size of 5.12 and N84340.67, kerosene users of average household and income size of 5.05 and N80421.24, Firewood/Charcoal of average household and income size of 5.22 and N89794.44 and LPG users of average household and income size of 5.72 and 80207.16 all showed the trend that they all adjusted their consumption behavior in response to economic constraints diversifying into adapting forest product use (Jåstad et al., 2021).

Table 3. Household size and monthly income by energy preference

Energy type	AHS	AMI(NGN)
Electricity	5.12*(0.36)	84340.67**(5132)
Firewood & Charcoal	5.22**(1.18)	89794.44**(20870)
Kerosene	5.05**(0.91)	80421.23**(13230)
LPG	5.72**(0.76)	80207.15**(7392)

Note: ** represents p < 0.01 AHS: Average household size. AMI: Average monthly income in Naira. The figure in brackets represents the standard deviation of the mean.

The level of significance is determined by the placement of error bars. When there is no intersection, the two variables differ significantly. Table 4 shows that perceived impact level and gender were significantly associated with average monthly income, while awareness level was not significantly associated with household size, income, forest-product use, or age. Forest-product use before and after subsidy removal did not differ significantly across awareness, perceived impact, or gender categories. Awareness level was not significantly associated with post-subsidy forest-product use, suggesting that awareness alone did not correspond with reduced forest-resource dependence

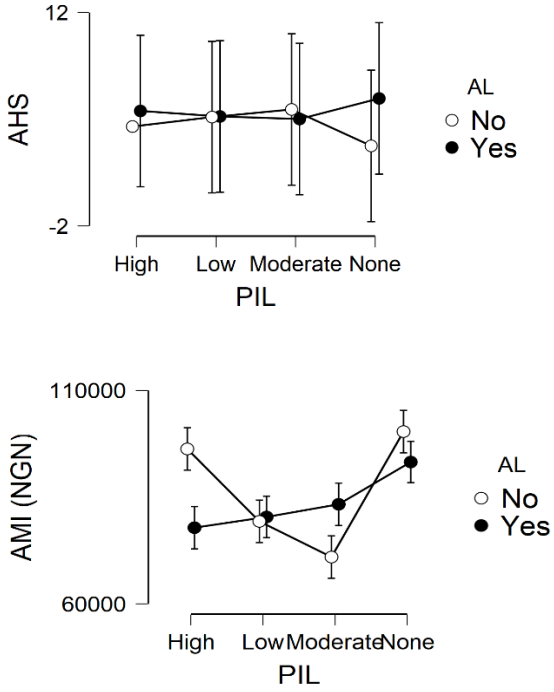

Figure 2. Non-overlapping error bars indicate statistically meaningful differences among groups at the stated probability level (AL: Awareness level, PIL: Perception Impact level, AHS: Average Household size, AMI: Average Monthly Income in Naira. P>0.05)

Table 4. Association of awareness, perceived impact, and gender with household characteristics and forest-product use

Variables	AHS	AMI (NGN)	FPUBS	FPUAS	AA
	P value	P value	P value	P value	P value
AL	0.326	0.303	0.366	0.577	0.813
PIL	0.093	**0.001***	0.194	0.569	0.370
GND	0.369	**0.0011***	0.429	0.879	0.684

Note: AL: Awareness level. PIL: Perception impact level. AHS: Average Household size. AMI: Average Monthly Income in Naira. FPUBS: Forest product use before subsidy removal. FPUAS: Forest product use after subsidy removal. GND: Gender. P< 0.05.

Table 5. Regression estimates for predictors of post-subsidy forest-product use

	Coefficients	Standard Error	t Stat	P-value
Intercept	7.184589	2.557032	2.809738	0.013198
Average of Age	0.048325	0.036473	1.324944	0.20502
Average of Household Size	-0.488	0.204464	-2.38672	0.030609
Average of Monthly Income NGN	-2.5E-05	1.52E-05	-1.66607	0.11644
Average of Forest Product Use Before	0.674651	0.330102	2.043764	0.05895
Multiple R: 0.797131	P < 0.05: 0.002981			
R Square: 0.635418	F value: 6.535758			
Adjusted R Square: 0.538196				

Table 5 shows that the regression model explained 63.5% of the variation in post-subsidy forest-product use. Household size was a significant predictor, while previous forest-product use was marginally significant. Age and monthly income were not statistically significant predictors. Multiple regression identified the strongest predictors of post-subsidy product use as previous forest use ($p < 0.001$), household size ($p < 0.01$) and income ($p < 0.05$). Previous use of forest products has strong predictive power for post-subsidy behaviour due to habit formation and energy-use path dependence, limited access to affordable energy alternatives, assets, coping strategies under economic stress, and socio-cultural dependency over the years. Education level and age were not significant predictors, as economic capacity often determined energy choices.

Summary model: $FPUAS = 7.18 + 0.048(Age) - 0.488(AHS) - 0.000025(AMI) + 0.675(FPUBS)$

4. DISCUSSION

There was a clear shift from modern to traditional energy sources after subsidies ended. This indicates energy ladder regression, especially among low-income and female-headed households, due to affordability constraints. The gender-wise results indicate that both male and female respondents increased their use of forest products after the subsidy was removed. This shows that households adjusted to cheaper, natural alternative energy sources but not to cleaner ones, due to increased energy costs after the subsidy ended (Qudrat-Ullah, 2024).

Forest product use significantly increased among both genders, with females reporting higher post-subsidy use, likely due to their home-making and management duties, as is common in many Nigerian households. Respondents had mean ages of approximately 39–42 years, suggesting that the observed shifts in energy use occurred mainly among economically active adult households. Age was not a significant predictor of post-subsidy forest-product use, suggesting that the shift toward biomass was not confined to a particular age category (Stout et al., 2020; Osburg et al., 2016).

Figure 1 shows that the population sampled's perception of the increased use of forest products post-subsidy shifted gradually from average household size to high utility. Therefore, this suggests that economic survival took the forefront in decision-making about energy use, with environmental concerns given lower priority. This has also been posited by Raimi et al. (2024), citing energy supply cost, geopolitics as important indices that need to be balanced to achieve the desired goal of the international climate target and on this, government policies towards introducing cleaner energy is required to ensure sustainability of the forest and sustainable use of forest products to achieve the country's climate goals and international commitment towards the same.

Energy type, forest product use, income and household size, and the patterns observed in this table show that, on average, firewood and charcoal users had the highest use of forest product use post-subsidy (up to 6.0+) with higher income per household on average, which indicates that the energy source became expensive even for households with higher income. LPG users, the cleanest source of energy, showed either a drop or a moderate rise in forest product use, depending on income and household size. Kerosene users showed an increase in forest product use among households with low- to mid-income levels. Electricity users showed inconsistent patterns. However, households with lower incomes relied more on forest products.

There is no significant difference in the average household size awareness level, but there is a significant difference in the perception impact level of forest product use before and after subsidy removal, leading households to adjust to prevailing economic realities, given their income levels. Awareness levels do not influence household and energy choices because household sizes are shaped by long-term demographic and socio-cultural factors. Also, it does not remove economic constraints on energy choices, which are more reflective of necessity than of preference, pointing to economic capacity and structural constraints and reinforcing the need for complementary interventions beyond awareness. Households with high energy literacy were lower-income, indicating inequality in energy literacy and economic power. These findings suggest that awareness alone may not be sufficient to change household energy choices when cleaner fuels remain unaffordable (Ajide & Dada, 2024).

Perception impact level and gender significantly affected the monthly income related to forest product utilisation. This is a trend that is predicted to increase as there is an increasing demand for alternative energy sources on one hand (Jåstad et al., 2021), but also suggests that many households are grappling with strained economic capacity as their incomes can only accommodate the use of forest products for alternative energy, leading to energy poverty (Ajide & Dada, 2024). This shows that the

increase in forest product utilisation was widespread across all variables considered in this study, indicating a population-wide response to an energy crisis. It also showed that households across all awareness levels, perception impact levels, and genders adapted to using forest products to cope with the new economic shocks following the subsidy withdrawal.

The data show that 63.5% of the variation in post-subsidy forest use is explained by factors such as age, household size, monthly income, and pre-subsidy forest product use. The model was theory-driven and restricted to a limited number of predictors to reduce the risk of overfitting, and interpretation focused on effect sizes rather than on sole reliance on p-values, with results being more indicative than conclusive. However, household size and prior forest use are significant predictors of post-subsidy forest product use, whereas age and income are less influential. This shows that larger household sizes use more forest products, with the strongest post-subsidy behaviour influenced by pre-subsidy patterns of use. This correlates with a higher quality of life, as can be influenced by energy usage (Ajide & Dada, 2024) and the energy challenges amongst households, which cuts across age, gender and income (consumption power) has increased demand for energy from forest products as clean energy cost is out of reach for most households (Kishida, 2025).

The observed increase in firewood and charcoal use suggests a possible energy-ladder regression, in which households move away from cleaner fuels and intensify their reliance on traditional biomass under economic pressure. This indicates that energy transition is not always linear; policy shocks can reverse household progress toward cleaner energy when affordability is not protected. This study is limited by its cross-sectional design, which captures household responses within a specific post-subsidy period but cannot establish long-term behavioural trends. The reliance on self-reported household data may also introduce recall or response bias. Future studies should combine household surveys with longitudinal tracking of energy use and direct assessment of forest-resource extraction.

5. CONCLUSIONS

The study shows that fuel subsidy removal was associated with a clear shift in household energy use from cleaner fuels such as LPG and kerosene toward biomass-based sources, especially firewood and charcoal. This shift increased household dependence on forest products and may intensify pressure on peri-urban forest resources in Ijebu-Ode. Although many households were aware of the environmental consequences of forest-resource extraction, affordability constraints strongly influenced their energy choices. The findings suggest that energy-price reforms, when introduced without adequate social protection and clean-cooking alternatives, can deepen energy poverty and create unintended environmental risks. Therefore, policy measures should prioritise affordable access to clean-cooking options, including LPG support, improved cookstoves, clean-energy microfinance, and community-level distribution systems. Forest governance should also be strengthened through regulated biomass harvesting, community forest monitoring, and replanting programmes. In addition, energy-literacy campaigns should be linked with practical support for women, youth, and low-income households to encourage sustainable energy use and reduce pressure on local forests.

Author contributions: A.A.O. conceptualised the study. O.A.A. developed and implemented the methodology, conducted the investigation, provided the resources, curated the data with E.G.O., and supervised the research work. O.A.A. and E.G.O. handled the software component, while E.G.O. carried out the validation, formal analysis, visualisation, and contributed to data curation. L.L.M. prepared the original draft of the manuscript. O.A.A., E.G.O., A.M.O. and A.O.O. reviewed and edited the manuscript. All authors read and approved the final version of the manuscript.

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