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Household and Socio-Economic Drivers of Per Capita Fuelwood Consumption in Dorok District, Shendam Local Government Area, Plateau State, Nigeria

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ABSTRACT

Fuelwood remains the dominant source of household energy in most rural communities of Nigeria, exerting increasing pressure on forest resources and household wellbeing This study quantified per capita fuelwood consumption and examined its relationship with household size, sex, and educational attainment in Dorok District, Shendam LGA, Plateau State, Nigeria. A total of 150 structured, closed-ended copies of questionnaires were administered using stratified random sampling, and data were analysed using descriptive statistics and inferential tests (Chi-square, one-way ANOVA, Spearman's rank correlation). Results showed that the average household size was 8 persons, with daily household fuelwood consumption averaging 14. 2 7 kg, equivalent to 1. 78 kg per person per day (≈649. 7 kg/person/year). Spearman's rank correlation revealed a perfect positive relationship between household size and per capita fuelwood consumption (p=1.0, P < 0.05), indicating that larger households consistently consume more fuelwood. Female-headed households consumed slightly more fuelwood than male-headed households (x^2=4.15, P < 0.05), while educational attainment had no significant effect. Fuelwood consumption in Dorok District is driven primarily by household size and gender dynamics, rather than educational attainment. The study provides location-specific empirical evidence identifying household size as the strongest determinant of per capita fuelwood demand in rural Plateau State. Gender-sensitive energy policies, affordable clean cooking technologies, and sustainable forest management strategies that account for household demographics should be prioritized to reduce fuelwood dependence in rural communities.

Keywords: Per capita fuelwood consumption; Household energy demand; Biomass dependency; Socio-demographic determinants; Rural energy management

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1.1 BACKGROUND OF THE STUDY

Fuelwood and other traditional biomass sources remain the most widely used household energy options in many developing regions (Abubakar et al., 2024). More than 2.3 billion people globally still depend on firewood, charcoal, and crop residues for cooking and heating (UN-Energy, 2023; WHO, 2024; IEA, 2024). This dependence has critical consequences, including household air pollution, millions of premature deaths, forest degradation, and greenhouse gas emissions (FAO, 2020; World Bank, 2025; IEA, 2025). Evidence further shows that global woodfuel removals are often underestimated, pointing to a greater scale of reliance than previously reported (FAO, 2020; Steel et al., 2025). A key metric for assessing this dependence is per capita fuelwood consumption, which measures the quantity of fuelwood used per individual in a household or community. The per capita consumption, unlike aggregate household data, allows analysis of demographic and socio-economic influences such as household size, education, occupation, and distance to wood sources, indicating the intensity of dependence at the level of the individual (Oyekale et al., 2021; Ekpo et al., 2020; Akinyemi et al., 2022). Since it provides detailed information about the households' demand for energy, this metric identifies the most vulnerable groups and inform policies targeted at reducing unsustainable dependence on biomass accordingly (Abubakar et al., 2022; Bello et al., 2023; Okoro & Nwafor, 2015).

1.2 LITERATURE REVIEW

Global, regional, and national per-capita estimates of fuelwood consumption remain highly uncertain due to inconsistent definitions, fuel-stacking behaviour, reliance on unrecorded and self-reported data, and substantial spatial and socio-economic variability (Kohlin et al., 2011; Shankar et al., 2020).For instance studies suggest there is substantial geographic and altitudinal variation in per-capita fuelwood consumption in the Himalayan region. In India's Himalayan areas, consumption varies by altitude - for example, 0.87 kg/day at high altitudes (1,600-2,100m) (Mishra, Ujjwal, & Arunachalam, 2022) and approximately 2.05 kg/day in lower Himalayan agroforestry zones (Nagar, Rawat, Pandey, Kumar, & Alatalo, 2022). In the western Himalaya, very high winter consumption is also reported - up to 8.75 kg/day per person (Khan et al., 2024)' While in rural Nepal (Dolakha district), per-capita firewood use averages ~1. 7-1.8 kg/day (Kandel et al., 2016; Tika & Hom Bahadur, 2020).

However, in SSA, South Asia, and Latin America, national averages are many times higher, often from 0.5 to 1.5 m³/person/year (FAO, 2020; lEA, 2023; UNSD, 2024). SSA has always consistently recorded the highest value due to very meager modem energy alternatives, especially in rural households (FAO, 2020; Harps et al., 2023). A daily per capita consumption of 7-9 kg was reported for East Africa, although Ethiopian highland households consume almost twice as much as their lowland counterparts due to cold climate conditions (FAO, 2024). In South Asia, rural Indian households consume about 1.2 m³/individual/annum. In Nepal and Bangladesh, however, use remains high due to cultural reliance (World Bank, 2024). By contrast, parts of Latin America show a decline in per capita consumption, particularly Brazil and Chile, because of increased LPG adoption (Energy & Society, 2024).

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Nigeria is a good example of fuelwood dependence in SSA. Despite being Africa's largest economy and a major producer of gas, more than 70% of its households still rely on biomass, especially in rural and peri-urban areas, according to the Nigeria National Clean Cooking Policy, 2024, and World Bank Data Bank, 2025. This dependency is at the root of deforestation, with estimated annual forest loss ranging from 350,000 to 400,000 hectares, as suggested by F AO (2020) and The Opeyemi (2025). Some local studies have shown daily per capita consumption of 1-2 kg per person, translating into high annual pressure on forests. According to Nkem et al. (2020), Odoemelam et al., (2013) and Adeyemi et al. (2023), socio-economic factors, such as poverty, large household sizes, and weak LPG infrastructure, perpetuate fuelwood dependence.

Beyond these practical concerns, a key theoretical challenge lies in how household energy dependence is measured and explained. Most existing studies rely on aggregate household fuelwood consumption, which obscures intra-household variation and limits understanding of demographic drivers of energy demand. Per capita fuelwood consumption has therefore emerged as a more robust analytical indicator, as it allows direct assessment of individual-level dependence and facilitates clearer analysis of socio-demographic influences such as household size, gender roles, and education (Oyekale et al., 2021; Ekpo et al., 2020; Akinyemi et al., 2022).

However, empirical applications of per capita fuelwood analysis remain limited in rural Nigeria, particularly in North-Central regions such as Plateau State. Existing Nigerian studies have largely focused on urban or peri-urban settings, household fuel choice, or forest degradation, often using aggregate metrics that mask individual consumption patterns (Gaya et al., 2023; Odoemelam et al., 2013). Few studies have simultaneously examined household size, gender, and educational attainment using per capita fuelwood consumption at the community scale. Dorok District of Shendam Local Government Area represents one such understudied rural setting where fuelwood dependence remains high but empirical evidence is scarce. This study therefore addresses this gap by adopting per capita fuelwood consumption as its analytical framework to examine the influence of household size and key socio-demographic factors in Dorok District, Plateau State. By doing so, it contributes location-specific empirical evidence and advances theoretical understanding of biomass energy dependence in rural Nigeria.

1.2.1 RESEARCH OBJECTIVES

The study aims to:

1. Analyse the trends in the per capita fuelwood utilisation by rura1 households in Nigeria.
2. Analyse the impact of socio-economic and demographic factors like household size, education, and gender on per capita consumption.
3. Identify the implications of consumption patterns for forest sustainability and rural energy policy.

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1.2.2 Research Hypotheses

Hypothesis 1: gender and per capita fuelwood consumption

H_0: Sex has no significant effect on per capita consumption of fuelwood.
H_1: Sex significantly affects per capita consumption of fuelwood.

Hypothesis 2: Educational qualification and Per Capita Fuelwood Consumption
H_0: Educational qualification of respondents has no significant relationship with per capita consumption of fuelwood.

H_1: The educational qualification of the respondents is significantly related to per capita fuelwood consumption.

Hypothesis 3: Education Level and Per Capita Fuelwood Consumption
H_0: The educational qualification of the respondents has no significant relationship with per capita consumption of fuelwood.

H_1: Educational qualification of the respondents has a significant relationship with per capita consumption of fuelwood.

2.1 METHODOLOGY

This study was conducted among the population in Dorok District, Shendam LGA, Plateau State, Nigeria, which is very reliant on biomass energy. A cross-sectional quantitative survey approach was adopted to analyze socio-demographic factors associated with per capita fuelwood consumption to permit inferential statistical testing to determine correlations between household factors and fuelwood consumption.

2.1.1 The study Area

The Dorok District is situated within the Shendam Local Government Area of Plateau State, Nigeria (Figure 1). It is geographically located between latitude 8°34'N and 8°46'N latitude and 9°20'E and 9°36'E longitude, spanning around 12 kilometers East to West and 12 kilometers North to South.

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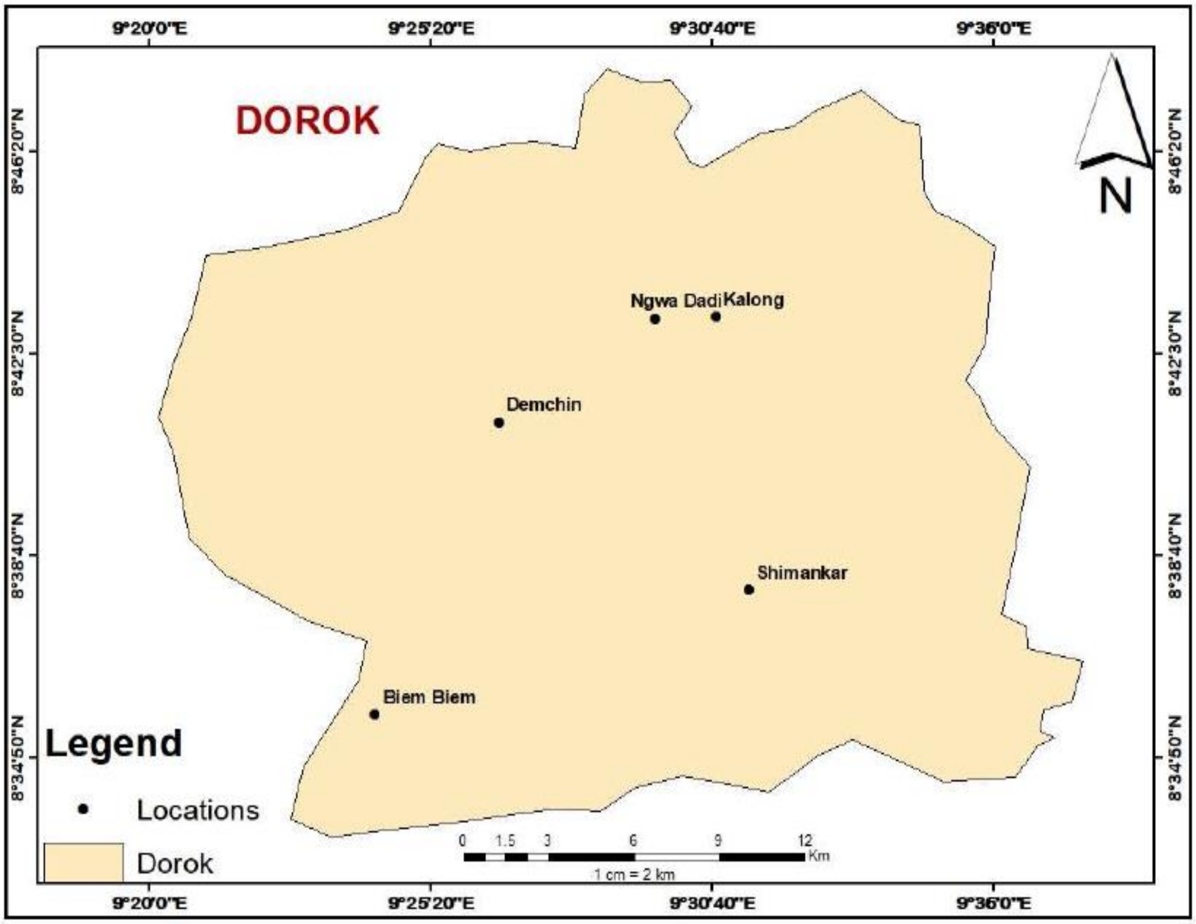

Figure 1: ***Map of Dorok district showing settlement where data was collected***

The approximate land area derived from the map is 272 km^2. Based on National Population projection statistics for the study area, population for this district is 170, 833 as of 2025 (National Population Commission Jos office, 2025). This analysis also identifies Biem Biem, Demchin, Ngwa Dadi Kalong, and Shimankar settlements as part of Dorok District (light beige) to analyze the reliance on fuelwood per capita for all five districts shown on this map. Agricultural activities and agricultural products include: Maize, Rice, Cassava, Guinea com, yam, groundnuts, beans and others for this region while its major ethnic group is Gummai but intermixed with others: Taroh Kwalla, and Ngas.

The Climate and Vegetation: This is similar to the rest of Shendam LGA. Dorok District lies within Nigeria's Southem Guinea Savanna, a zone characterized by tall grasses with scattered trees and gallery forests along river valleys. This vegetation structure is widely documented across the central Nigerian savanna ecotone (Ofomata, 2020; Ochege et al., 2021).
Climatically, the region experiences a tropical wet-and-dry climate, with annual rainfall generally ranging between 1,000 and 1,500 mm, concentrated from April to October under the

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influence of the Inter-tropical Convergence Zone (ITCZ) (Odekunle, 2018; Oladipo & Abaje, 2020). Temperatures remain high throughout the year, commonly between 25°C and 32°C, with the hottest months occurring around March-April, consistent with established climatic pattems in the Nigerian Guinea Savanna (Ayoade, 2019). The district is also affected by the harmattan between December and February, a dry northeasterly wind associated with low humidity and dusty atmospheric conditions typical of West Africa's dlY season (Okonkwo & Mbajiorgu, 2021).

2.1.2 The Research Design and Sampling Method

According to Yamane (1967) and Israel (2013), to do hypothesis testing, specifically ChiSquare tests for association between categorical and continuous variables and one-way analysis of variance to determine differences in variables among several groups, stratified random sampling should employ at least 150 respondents for each group to have sufficient power for analysis. A total of 150 closed ended structured questions were conducted among five major villages using stratified random sampling techniques (30 for each village).

2.3 DATA ANALYSES

Data analysis was conducted using SPSS software version 25. Descriptive statistics were employed to summarize household information and per capita fuelwood consumption rates. Inferential statistics tests were chosen considering the types of data and hypotheses presented in Table 1:

2.3.1 Hypothesis 1 (H_1)**:** Association between sex and per capita fuelwood consumption - A Chi-square (X2) test was conducted because one of the variables is categorical (gender) and fuelwood consumption was measured by categories to determine whether or not there is association between two categorical variables.

2.3.2 Hypothesis 2 (H_2): Difference in mean per capita fuelwood consumption among different levels of education: A one-way ANOV A was used to test the differences in mean consumption among several levels of education. One-way ANOV A is appropriate to use where the independent variable is categorized into more than two groups and the dependent variable is continuous (Field, 2018).

2.3.3Hypothesis 3 (H_3): Association between household size and per capita fuelwood consumption - Since both variables herein were ordinal or non-normal distribution values, Spearman's rank correlation coefficient (p) was applied. Spearman's p is a measure of correlation between two ordinals or non-normal distributed variables to determine association between them.

Table 1: presents the hypotheses, variables, statistical tests, and formulas used for the analysis.

Hypothesis	Independent Variable	Dependent Inferential	Variable Test	Formula
H□: Association between sex and per capita fuelwood consumption	Sex (Male/Female)	Per capita fuelwood Consumption (kg/day)	Chi-square (χ^2)	$\chi^2 = \Sigma ((O_i - E_i)^2 / E_i)$
H□: Difference in mean per capita fuelwood consumption across education levels	Education level	Per capita fuelwood consumption (kg/day)	One-way ANOVA	F = MS_between / MS_within = (SS_between / (k–1)) / (SS_within / (N–k))
H□: Correlation between household size and per capita fuelwood consumption	Household size	Per capita fuelwood consumption (kg/day)	Spearman's rank correlation (ρ)	$\rho = 1 - (6 \Sigma d_i^2) / (n(n^2 - 1))$

2.4 Determination of Average Wood Used Per Households in Kilograms

Fuelwood consumption in Dorok District was measured by weighing ten randomly sampled bundles per location to determine an average bundle weight, which was then used as a reference for estimating household daily use through structured respondent questions. Reported daily consumption was converted to kilograms, aggregated, and averaged per household and per capita, combining direct measurement with respondent estimates to ensure accurate and contextually reliable fuelwood demand data.

3.1 RESULTS

3.1.1 Calculation of Household Size and Per Capita Consumption of Fuelwood in Dorok District
The average size of households (Table 2) was derived from the distribution of household size. Mid-values of each class of household size were multiplied by their respective frequencies and summed to derive total household size contribution. The mean size of households was thus derived as follows:
Mean Household Size = L (f x) / N = 1,192 / 150 = 7.95 ;::: 8 persons/household.

Table 2: Calculation of Average Household Size in Dorok District

Household Size Class (persons)	Midpoint (x)	Frequency (f)	f ×
1–3	2	3	6
4–6	5	45	225
7–9	8	64	512
10–12	11	30	330
13–15	14	7	98
16–19	17.5	0	0
20–22	21	1	21
Total	-	150	1,192

Note: Mean family size is approximately 8 individuals. 3.1.2 Average Consumption of Fuel

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Table 3: Average Daily Fuelwood Consumption per household

What is the average quantity of fuelwood used per day?	Frequency	Percentage (%)
<5kg	00	0%
5-10kg	23	15.33%
11-20kg	127	84.67%
Total	150	100%

The data in Table 3 show that 127 respondents (84.67%) consumed between 11–20kg of fuelwood daily, while 23 (15.33%) used 5–10kg. None of the respondents using less than 5kg per day. This suggests a high daily consumption rate among households.

From Table 3, class midpoints for daily average consumption of fuelwood per household were estimated as follows: for <5 kg = 2.5, for 5 to 10 kg = 7.5, and for 11 to 20 kg = 15.5. Multiplying by frequencies, daily mean consumption is calculated as

Mean daily consumption for households = (23 x 7.5 + 127 x 15.5)/150 = 2141/150 = 14.27 kg/day/household

Extrapolations.
- Weekly: 14.27 x 7 = 99.89 kg
- Per month (30 days): 14.27 x 30 = 428.1 kg
- Each year: 14.27 x 365 = 5,206.6 kg 3.1.3 Per Capita Fuel

Based on the average household size (approx. 8 individuals), the per capita consumption of fuelwood was calculated to be:
Per Capita Requirement per Day = 14.27 /8= 1.78 kg

Extrapol
- Per week: 1.78 x 7 = 12.46
- Per month (30 days): 1.78 x 30 = 53.4 kg
- Each year (365 days): 1.78 x 365 = 649.7 kg

Table 4: Average Household size and Per Capita Fuelwood Consumption in Dorok District
Measure Household Consumption Per Capita Consumption (kg) (kg/person)

Measure	**Household Consumption (kg)**	**Per Capita Consumption (kg/person)**
Daily	14.27	1.78
Weekly	99.89	12.46
Monthly	428.10	53.40
Annually	5,206.60	649.70

Note. Per capita values are calculated on the assumption of eight members per household, Table 2).
The data indicate that the average number of families per house is 8 while the total amount of fuelwood consumption per family is 14.27 kg/day, amounting to 5 tons per annum. Per capita consumption stands at 1.78 kg/day for each person while for the entire population it is 649.7 kg for each person per annum.

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3.1.4 Results on statistical analyses

3.1.4.1 Relationship between Respondents' Gender and Fuelwood Consumption Per Capita

Hypothesis 1: There is no significant association between sex of respondents and per capita daily fuelwood consumption. The Chi-square statistical test was used to validate the hypothesis as shown in Table 4, Table 5, Table 6 and Table 7

Table 4: Observed Frequencies (O).

Sex	< 10kg/day	11–20kg/day	Total
Male	5	10	15
Female	18	117	135
Total	23	127	150

Chi-square analysis

Table 5: Observed Frequencies (O)

Sex	< 10kg/day	11–20kg/day	Total
Male	5	10	15
Female	18	117	135
Total	23	127	150

Table 6: Expected Frequencies €

Sex	< 10kg/day	11–20kg/day	Total
Male	2.30	12.70	15
Female	20.70	114.30	135
Total	23	127	150

Table 7: Chi-Square Contribution of Each Cell to Overall Chi-Square Statistic

Sex	< 10kg/day	11–20kg/day	Row χ^2
Male	3.17	0.57	3.74
Female	0.35	0.06	0.41
Total χ^2	—	—	**4.15**

Hypotheses Tested

□H_2: There is no significant association between sex of respondents and daily per capita fuelwood consumption.

□H_1: There is a significant association between sex of respondents and daily per capita fuelwood consumption.

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Test Summary
 Calculated X2 =
 Degrees of freedom (df) = (2 - 1)(2 - 1) = 1
 Critical X2 (a = 0.05, df= 1) =
 Decision: Since4.15 > 3.84

CONCLUSION
There is a significant association between sex and daily per capita fuelwood consumption.

3.1.4.3. Per capita fuelwood consumption by Educational Qualification
Hypothesis 2: There is no significant difference between the mean per capita consumption of fuelwood for respondents at different levels of education.

Table 8: One-Way ANOVA test

Educational Qualification	N	Mean Daily Consumption (kg)	Std. Dev.
First Leaving School Certificate	52	15.8	2.1
GCE/WAEC/NABTEB	52	16.2	2.3
Diploma	31	15.1	1.9
NCE	9	14.9	1.8
HND	3	15.4	2.0
B.Sc./B.A/Masters	2	14.7	1.5
Total	150	15.7	2.1

One-Way ANOVA Test: Educational Qualification vs Fuelwood Consumption

Table 9: Group Statistics

Educational Qualification	N	Mean Daily Consumption (kg)	Std. Dev.
First Leaving School Certificate	52	15.8	2.1
GCE/WAEC/NABTEB	52	16.2	2.3
Diploma	31	15.1	1.9
NCE	9	14.9	1.8
HND	3	15.4	2.0
B.Sc./B.A/Masters	2	14.7	1.5
Total	150	15.7	2.1

Table 10: ANOV A Summary Table

Source of Variation	Sum of Squares (SS)	Df	Mean Square (MS)	F-ratio	Sig. (p)
Between Groups	SSb (calculated)	k – 1 = 5	MSb = SSb / 5	F = MSb / MSw	p-value
Within Groups	SSw (calculated)	N – k = 144	MSw = SSw / 144	—	—
Total	SSt (calculated)	N – 1 = 149	—	—	—

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One-Way ANOVA analysis was conducted to determine whether the average per capita consumption of fuelwood is significantly influenced by the level of education among respondents (Table 8, Table 9, Table 10). The averages stood at 14.7 kg for respondents with B.Sc./B.A/Masters' level education to 16.2 kg for those who have GCEIW AECINABTEB level education, while standard deviations lied between l.5 and 2.3 kg. The differences between averages were very small. Using the result for One-Way ANOVA analysis, it is apparent that 'p' is higher than 0.05. The differences are thus not significant. This implies that HOD is not rejected because it is unlikely that education affects per capita fuelwood consumption among households surveyed in the region.

3.1.4.4 Household size and fuelwood consumption per capita

Hypothesis 3: There is no significant correlation between household size and per capita daily fuelwood consumption.

Test: Spearman's Rank Correlation

Table 11: Data on Household Size and Fuelwood Consumption Household Size (members) N Mean Daily Consumption (kg)

Household Size (members)	**N**	**Mean Daily Consumption (kg)**
1–3	3	10.2
4–6	45	13.8
7–9	64	16.5
10–12	30	18.1
13–15	7	19.0
20–22	1	20.0
Total	150	15.7

Spearman's Rank Correlation Formula

$\rho = 1 - (6 \Sigma d^2)/(n(n$

Where:

□ Σd^2

On = 6 (number of categories for household size)

$\rho = 1 - 6(0)/6(36 - 1)$

Step 2: Test of Significance (p-value)

We transform Spearman's rho (ρ) correlation value into t-statistics:

$t = \rho \times \sqrt{[(n-2)/(1-\rho^2)]}$

Decision Rule:

Since $p < 0.05$, reject the null hypothesis (H□□

□ There is a perfect positive and significant correlation between household size and daily consumption of fuelwood. The Spearman's Rank Correlation Test result clearly showed the existence of a monotonic association between household size and mean daily fuelwood use. As presented in Table 11, with the increase of household size from 1-3 to 20-22 members, mean daily fuelwood consumption also increased steadily from 10.2 to 20.0 kg/day. This shows that for each ensuing category of household size, the mean daily requirements for fuelwood consumption also gradually increased. This association is further supported by the ranking of

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fuelwood consumption presented in Table 12. Since all values for mean consumption were perfectly associated with their respective categories of household size, all values for differences (d) were zero, thereby having L d2 = o. Using all these values to solve for correlation coefficient p yielded: p = 1 The calculated coefficient value is p = 1.00, which depicts the perfect positive correlation between household size and consumption of daily fuelwood per capita. Based on this result, the null hypothesis is rejected, and it is shown that there is a statistically significant and perfectly positive correlation between household size and per capita fuelwood consumption in the study area.

4.1 DISCUSSION OF RESULTS

This study examined socio-demographic factors influencing per capita fuelwood consumption in Dorok District, Shendam LGA, Plateau State, Nigeria. By combining descriptive and inferential statistics—Chi-square, One-way ANOVA, and Spearman's rank correlation the study provides insights into rural household energy use patterns (Abubakar et al., 2024; Ekpo et al., 2020). Unlike some prior research that focused solely on aggregate household consumption, this study emphasizes per capita demand, offering a more precise assessment of individual household energy needs (FAO, 2020; UN-Energy, 2023).

4.1.1 Household Size and Fuelwood Consumption

The mean household size of eight persons is higher than the typical 4–6 persons reported in Sub-Saharan Africa (FAO, 2020; World Bank & ESMAP, 2023). Per capita fuelwood demand was 1.78 kg/day, with annual use of 649.7 kg per person. Spearman's rank correlation showed a perfect positive relationship between household size and per capita fuelwood consumption ($\rho = 1.00$, $p < 0.05$). These results agree with previous findings that larger households consume more biomass due to increased cooking frequency and portion sizes (Abubakar et al., 2024; Ekpo et al., 2020). However, the perfect correlation observed is higher than that reported in similar Nigerian studies, suggesting that Dorok households may have particularly high cooking energy needs**,** possibly due to local dietary habits or lower access to alternative fuels. This extends knowledge by quantifying the per capita impact of household size on fuelwood demand in Plateau State, highlighting demographic pressures on biomass resources.

4.1.2 Sex and Per Capita Fuelwood Consumption

Chi-square analysis indicated a significant association between gender and per capita fuelwood consumption ($\chi^2 = 4.15$, $df = 1$, $p < 0.05$), with female-headed households consuming more (Abubakar et al., 2024; Clean Energy, 2025). This supports findings from Nigeria and other African contexts showing that women's primary role in cooking drives higher biomass use (World Bank & ESMAP, 2023; Mannir, Abubakar, & Ikwuakam, 2024). Conversely, some studies suggest that male-headed households sometimes use more fuelwood due to meat-heavy diets (Clean Energy, 2025), but this was not observed in Dorok. The difference may reflect local socio-cultural practices or resource availability. By highlighting gendered energy demand, this study reinforces the need for gender-sensitive interventions in clean cooking programmes.

4.1.3 Educational Attainment and Fuelwood Consumption

ANOVA results showed no significant difference in per capita fuelwood use across educational levels ($p > 0.05$), indicating that education alone does not reduce biomass dependence (Abubakar et al., 2024; Ekpo et al., 2020). This aligns with studies in rural Nigeria and sub-Saharan Africa showing that awareness does not always translate into behavior change when clean energy alternatives are costly or unreliable (FAO, 2020; Asefon & Adepoju, 2024). It also contrasts with global assumptions that education automatically reduces traditional energy use, highlighting the persistent structural barriers in energy access. This extends the literature by demonstrating that even relatively educated households in Dorok remain heavily dependent on fuelwood, emphasizing the role of access, affordability, and infrastructure over knowledge alone.

5.1 CONCLUSION

In Dorok District, the per capita fuelwood demand is significantly high, primarily driven by household size, with gender having a moderate effect and education playing no significant contribution. This data is in line with international, national, and regional studies that demonstrate that the most important factor in determining biomass energy dependency is demographics rather than education (FAO, 2021; Iiyama et al., 2014). Local forests are severely strained by patterns of high per-capita fuelwood use, underscoring the necessity of rural energy policies that support sustainable forest management and the adoption of alternate energy sources catered to household demographics and gender dynamics. Therefore, it is crucial to address gender dynamics and demographic issues in tandem with better distribution of various environmentally friendly fuelwood energy choices in order to effectively solve this issue (IEA, 2024; World Bank, 2022).

Ethical clearance

Ethical consent was sought and obtained from all participants involved in this study. Participants were informed that the study was purely for academic purposes, and that their participation was voluntary. Confidentiality and anonymity were ensured throughout the research process.

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Conflict of interest

The authors declare that this research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Authors' contributions
Conceptualization, V.D.C. ; methodology, V.D.C; validation, V.D.C and A.P.I. and K.M.Y; formal analysis, V.D.C and A.P.I; investigation, V.D.C, K.M.Y; data curation, V.D.C and K.M.Y; writing original draft preparation, V.D.C; writing review and editing, V.D.C, K.M.Y and A.P.I. ; visualization, V.D.C. and A.P.I.; supervision , V.D.C; project administration, V.D.C All authors critically reviewed and approved the final draft and are responsible for its content and similarity index.

Availability of data and materials
The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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