Original Research Article

DETERMINANTS OF HOUSEHOLD FUELWOOD CONSUMPTION IN PUBLIC RESIDENTIAL ESTATES IN MAIDUGURI, BORNO STATE, NIGERIA

ABSTRACT

The type of energy utilized by households is a good reflection of the quality of life and socio-economic development in any given country. Unfortunately, the continued dependence on traditional fuels such as fuelwood as a major source of energy for domestic purposes particularly in Nigeria is generating concerns due to its negative environmental, socio-economic and health effects. This study was therefore undertaken to examine the factors that drive household fuelwood consumption in public residential estates in Maiduguri, Borno State, Nigeria. A survey questionnaire was used to elicit data from a sample of 355 household-heads that were selected using systematic random sampling technique from a population of 3,192 households. The data were analyzed using Ordinary Least Square regression analysis. The results revealed that gender, marital status, larger household size and prices of alternative fuels had positive and significant correlation with the quantity of fuelwood consumed in households while higher level of education, higher income; location of residence, share of dwelling and prices of fuelwood were significant and negatively related to fuelwood consumption. It is recommended that stakeholders and policy makers in the energy sector should vigorously promote access to affordable and modern energy sources for household cooking activities by subsidizing the prices of modern fuels and increasing the availability of electricity supply to households. This will go a long way to reducing the rate of indoor air pollution and other environmental consequences associated with the use of fuelwood in the study area. Finally, there is the need for proactive enlightenment campaigns with a view to strengthening public awareness on the deleterious effects of the consumption of solid fuels such as fuelwood in Maiduguri, Borno State, Nigeria.

Keywords: Household, fuelwood, consumption, traditional fuels, modern fuels.

1.0 INTRODUCTION

Globally, about 2.5 billion people rely on traditional energy sources in the form of fuelwood, charcoal, agricultural waste and cow dung for their daily household energy requirements. Without strong policy action, this figure is projected to increase to 2.7 billion by 2030 (IEA, 2018). Given that the household sector accounts for about 80% of total energy consumption with cooking having the largest share of about 95% of such energy (Olugbire, Aremu, Opute, Ojedokun, Olawale & Adisa, 2016), there is a growing concern on households' over-dependence on traditional energy sources such as fuelwood and charcoal and the need to embrace modern fuels for domestic purposes particularly in developing countries such as Nigeria.

In Nigeria, fuelwood remains one of the primary sources of energy used in most parts of the country especially in rural areas where the supply of modern energy sources such as electricity and liquefied

petroleum gas (LPG) are limited. It is estimated that over 70% of households in Nigeria depend on fuelwood for their cooking energy needs making the country to have the third highest deforestation rate globally with 410,000 hectares of forests cut down per year (UNDP, 2015). Reasons for the overdependence on fuelwood and biomass has been attributed to its availability and affordability relative to other sources of energy (Maconachie, Tanko & Zakariya, 2009).

Statistics indicate that Nigeria consumes about 50 million metric tons of fuelwood annually, a rate considered unsustainable in meeting with future needs raising concerns that the country's 15 million hectares of forest and woodland resources could be depleted by the next fifty years (Akeh, Adamu, Adamu & Ade, 2023a; ECN, 2003). The widespread use of traditional energy sources such as fuelwood have been associated with negative environmental externalities. Deforestation, loss of biodiversity, soil erosion, flooding, Greenhouse Gas emissions and climate change problems are some of the common examples (Toole, 2015). Massive deforestation arising from increasing fuelwood demand accentuated by rising population growth have been attributed to the loss of CO_2 sink resulting in increased atmospheric greenhouse gas concentrations (GHG) and global climate change. According to the 2014 World Climate Change Vulnerability Index, Nigeria is one of the 10 most vulnerable countries to climate change in the world (UNFCCC, 2015).

Indoor Air Pollution (IAP) arising from incomplete combustion of traditional energy sources is reckoned as the world's single largest environmental health risk by the World Health Organization accounting for about 3.2 million premature deaths annually (WHO, 2018). In Nigeria, it is estimated that over 90,000 people, mostly women and children, die every year from smoke and other complications arising from the use of traditional fuels (Nnodim, 2022). The adverse effects associated with traditional fuels therefore require urgent policy intervention that will make households accessible to modern and efficient sources of energy. There is the need to encourage households to shift from the use of less efficient energy sources such as fuelwood to the adoption of more efficient ones (Akeh *et al*., 2023a).

Understanding the determinants that drive fuelwood consumption in households is of fundamental importance in the search for policies to support a transition to clean and modern cooking energy sources and technologies. Access to clean energy sources is therefore a necessary prerequisite for sustainable economic development and an important step in achieving the Sustainable Development Goals, which seeks for the attainment of universal access to clean and modern energy services for all by 2030.

Most existing studies in relation to fuelwood consumption in Nigeria tend to focus on rural populations (Arowolo, Ibrahim, Sanusi, Ayinde & Sheleru, 2020; Chidiebere-Mark, Agunanne & Anyanwu, 2018; Maurice, Umar and Zubairu, 2015; Ojo, Bawa and Chuffor, 2013). Only a few similar studies such as Ebe (2014), Abdulhamid, Abdullahi, Safiyanu, Suleiman, Shu'aib and Dambatta. (2019) specifically covered

urban areas in the south-eastern and North-central parts of the country respectively. Interestingly, these studies have produced conflicting results in relation to the impacts of those factors that influence households' consumption of fuelwood due to differences in the choice of variables used as well as differences in economic, cultural and socio-demographic factors.

Consequently, the determinants that drive household fuelwood consumption remain largely unclear in the study area due to paucity of empirical data underscoring the need for further empirical investigation in public residential estates in Maiduguri, Borno State, Nigeria. The outcome of the study is expected to guide policy action as well as strategies based on households' economic and socio-demographic characteristics for sustainable energy use and environmental sustainability.

2.0 LITERATURE REVIEW

In a study of fuelwood consumption in France, Couture, Garcia and Reynaud (2012) found that the existence of a fire place was positively related with fuelwood consumption while fuelwood price had negative correlation with fuelwood consumption. While in urban Ethiopia, household size and level of education of the household head were found to have significant negative effects on fuelwood consumption per capita (Abebaw, 2007).

In a study of the determinants of fuelwood expenditure in Kenya, Osiolo (2010) found that only age and level of education of the household head were found to have positive significant relationship with household fuelwood expenditure. Meanwhile, Demurger and Fournier (2011) used descriptive statistics from the household survey carried out in ten villages in Labagoumen Township in northern China to analyze the general dependence of households upon forest resources as well as energy consumption patterns in the studied villages. It reported that income was a key factor in explaining energy use and fuel substitution and that wealth was a significant but negative determinant of household firewood consumption in northern China.

Meanwhile, Sharma (2018) examined household fuel transition and determinants of fuelwood demand in three different ecological zones of Nepal using data from the 2013 household survey and found that various socio-economic and access factors such as presence of large ruminants, land holding size, household size, location of household by ecological belts had positive effects on fuelwood consumption. However, literacy status, presence of alternative fuels and price of fuelwood were found to have negative effects on the consumption of fuelwood.

On the other hand, Ojo *et al*. (2013) examined the effects of women's socio-economic characteristics on household fuel consumption in Damboa local government area of Borno State, North-east Nigeria using

multiple regression analysis on a sample of 40 households. The results showed that the quantity of fuelwood consumed by households was determined by income, age, family size and marital status.

Maurice *et al.* (2015) analyzed the factors that influence fuelwood energy consumption in some selected local government areas of Taraba State, Nigeria using a multi-stage random sampling technique. The results of the study revealed that marital status and cost of alternative fuel such as kerosene positively influenced fuelwood energy consumption by households. They pointed out that the utilization of fuelwood in Nigeria contributes greatly to desert encroachment with implications on climate change.

Danlami (2019) analyzed the socio-economic factors influencing the quantity of firewood use in Bauchi State, Nigeria using OLS on a sample of 750 households. The study found that gender of the household head and number of rooms in a home had positive impact on the quantity of firewood consumption while marital status, prices of firewood and kerosene as well as the level of education of the household head had negative impacts on the quantity of firewood consumption.

Onoja and Idoko (2012) adopted econometric techniques in analyzing some factors influencing fuelwood demand in rural and peri-urban farm households of Kogi State and found that variables such as distance from fuelwood source and household income had negative impacts on fuelwood consumption while price of kerosene and household size had positive relationship with the consumption of fuelwood.

Abduhamid *et al.* (2019) analyzed energy utilization pattern in Kano metropolis, Nigeria and evaluated households' fuelwood consumption using multiple regression analysis on a sample of 200 respondents. The result of the study found that age, household size and price of alternative energy sources had positive coefficients and were statistically significant with the quantity of fuelwood consumed by households while monthly income, education and price of fuelwood had negative signs and were found to be statistically significant.

Ebe (2014) examined the socio-economic factors influencing the use of fuel wood in urban areas of Enugu State, South-east Nigeria using both descriptive and regression analysis on a sample of 120 respondents. The results found that household size and prices of fuelwood substitutes were positively related to fuelwood consumption while income and prices of fuelwood were found to be negatively correlated with the consumption of fuelwood. The study also found that education was negative but was not statistically significant.

The review of empirical literature on fuelwood consumption have revealed different outcomes and conclusions among scholars due to differences in geographical study locations, the type of data, the variables utilized as well as the magnitude/impact of the variables on household fuelwood consumption. For instance, while Danlami (2019) did not find any significant relationship between income and

fuelwood consumption among households in Bauchi, Abdulhamid *et al*. (2019) found a negative statistical significant coefficient among fuelwood consumers in Kano metropolis indicating that with every unit increase in monthly income of households, the consumption of fuelwood decreased by 15.1%. Hence the conclusions of such studies cannot be generalized to the study area. There is therefore the need to empirically investigate the determinants of household fuelwood consumption in public residential estates in Maiduguri, Borno State, Nigeria in order to formulate policies and strategies that will facilitate households' transition to modern, efficient and affordable energy sources with a view to achieving the targets of Agenda 2030 as well as fostering environmental sustainability.

3.0 STUDY AREA AND METHODOLOGY

3.1 Study Area

Maiduguri, the capital of Borno state is one of the cosmopolitan cities in Nigeria with an estimated population of 845,000 (PopulationStat, 2023). It lies between latitude $11^0$48'N and $11^0$55' North and longitude $13^0$04'E and $13^0$14'E (Figure 1). It is situated at an elevation of 325 metres above sea level and covers a total land area of 543 Square kilometres (Daura, 2001). Maiduguri, also called Yerwa by its locals, is the capital and the largest city of Borno State in north-eastern Nigeria. The city sits along the seasonal River Ngadda and it is bounded by Konduga and Mafa local government areas to the south, west, east and north respectively (Waziri, 2009). There are several housing estates in Maiduguri directly under the control and management of Borno State Housing Agency. The housing units are distributed across different housing estates in the area. They include the 202 Housing Estate and the 303 Housing Estate located along Bama Road respectively. The 505 housing estate located in Gamboru Ngala, the 777 Housing Estate, 1000 Housing Estate and the Legacy Housing Estate located along Kano/Jos Road respectively. There is also the CBN Quarters located along Damboa Road and many others within the city.

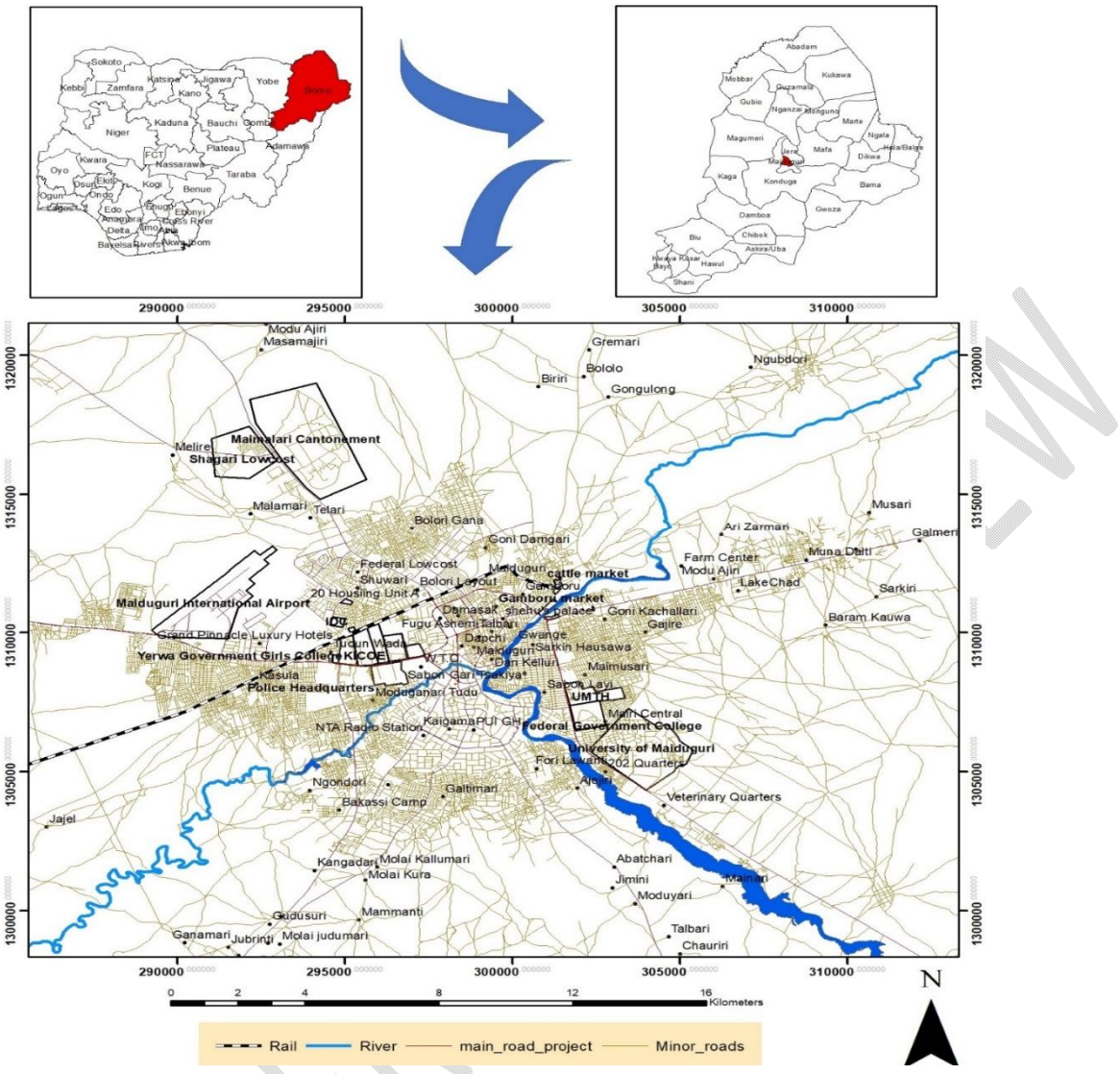

Figure 1: The study area
Source: Department of Geography, University of Maiduguri, 2019.

3.2 Methodology

3.2.1 Population and sample

The target population of the study consisted of all household heads in the 3,192 public housing estates directly under the control and management of the Borno State Housing Corporation (BSHC). Households' heads were chosen since they were essentially the ones responsible for making decisions on energy use in their respective households. The sample size was determined using Yamane's (1967) formula for sample size determination as follows:

$$n = {}^{N}/_{1 + N(e)^2}$$

Where: n = sample size, N= population size, e= level of precision.

At 95% level of significance

$n= 3192/\{1+3192(0.05)^2\}$ Therefore, n = 355 Households

Having calculated the sample size of 355 households, the figure was then divided proportionately among the seven public housing estates currently under the management and control of Borno State Housing Corporation so as to determine the actual copies of questionnaire to be distributed in each estate (Table 1). This was achieved by multiplying the total housing units in each housing estate by the sample size of 355 and dividing the product with the total number of housing units (3,192) in the entire estates. Altogether, 285 questionnaires were retrieved from respondents representing 80% of the total distributed and were therefore analyzed for the study.

Table 1: Distribution of questionnaire across public housing estates in Maiduguri

S/No	Name of Housing Estate	Location	Number of Housing Units	Sample Size	Percentage (%)
1	202 Housing Estate	Bama Road	202	22	6.2
2	303 Housing Estate	Bama Road	316	35	9.9
3	505 Housing Estate (Abbagana Terab Estate)	Gamboru-Ngala Road	500	56	15.8
4	777 Housing Estate	Kano Road	756	84	23.7
5	1000 Housing Estate	Kano Road	1004	112	31.5
6	Legacy Estate (Zannah Umar Mustapha Housing Estate)	Kano Road	288	32	9.0
7	CBN Quarters	Damboa Road	126	14	3.9
TOTAL			**3,192**	**355**	**100**

Source: Authors' compilation (2022)

3.2.2 Sampling techniques

Systematic random sampling technique was adopted in selecting the actual respondents for the study. The width interval for each estate was first determined by dividing the total population of housing units in a given estate by the sample frame as stated by Kumar (2011). According to Kothari (2004), an element of randomness is introduced when using systematic sampling technique. Thus, the first house was randomly selected and subsequently, every ninth house was chosen as the width interval/sampling digit for all the housing units with the exception of CBN Quarters where every tenth housing unit was chosen as the width interval/sampling digit.

3.2.3 Data analysis

Multiple linear regression based on Ordinary Least Squares (OLS) in IBM's Statistical Package for Social Sciences (SPSS) was used to analyze the influence of economic and socio-demographic variables of households on fuelwood consumption. OLS has widely been used in household energy studies by Louw, Conradie, Howells and Dekenah (2008), Osiolo (2010) and John (2022). The independent variables consisted of households' economic and socio-demographic characteristics consisting of gender, marital status, education, household size, household income, location of residence, ownership of dwelling, price of liquefied petroleum gas (LPG), share of dwelling and price of fuelwood while quantity of fuelwood consumed in kilograms constituted the dependent variable.

4.0 RESULTS

Table 2 shows the results of the estimated coefficients of the variables. The estimated results show that overall, the model is statistically significant at 1% level with an estimated F-value = 6.21 and the corresponding probability value Prob(F) = 0.0000.The coefficient of determination (R^2 = 0.62) showed that 62% of the variation in the fuelwood model is explained by the independent variables.

Table 2: Estimated coefficients of OLS model for households' fuelwood consumption

Variables	Coefficients	Standard errors
Gender	0.228*	(0.121)
Marital status	0.195*	(0.052)
Education	-0.170*	(0.045)
Household size	0.286**	(0.132)
Household income	-0.135***	(0.026)
Location	-0.143*	(0.028)
Ownership of Dwelling	0.006	(0.036)
Price of LPG (substitutes)	0.291**	(0.047)
Share of dwelling	-0.190*	(0.006)
Price of fuelwood	-0.121*	(0.001)
Constant	3268***	(0.225)
Observations	285	
R^2	0.62	

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: Field survey, 2022

The results of the estimated OLS regression (Table 2) indicates that the coefficient for gender is positively and statistically significant for fuelwood consumption at 10% level of probability. It shows that male-headed households consume more fuelwood by 23% higher compared to female-headed households. Similarly, the estimated coefficient for marital status was found to be positively and statistically significant for fuelwood consumption at 10% level of probability. The results showed that married household heads consume more of fuelwood by about 20% compared to unmarried households.

The result of the OLS regression also revealed a negative and statistically significant coefficient for education at 10% level of probability. It shows that an increase in the educational level of the household head reduces fuelwood consumption by 17%, when all other variables are held constant. This finding suggests that higher educational level of household heads results in lower fuelwood consumption. This could have implication on the rate of deforestation due to fuelwood exploitation as well as the health effects of indoor air pollution associated with incomplete combustion of fuelwood.

On the other hand, the coefficient for household size was positive and statistically related to fuelwood consumption at 5% level of probability. The results revealed that an increase by one additional person in the household increases the household's consumption of fuelwood by 29%, when all other variables are held constant. This implies that larger household size increases the quantity of fuelwood consumption in the study area. Meanwhile, the estimated coefficient of income of household head was negative and statistically significant for fuelwood consumption at 5% level of probability indicating that an increase by 1% in the monthly income of the household head decreases the consumption of fuelwood by 14%. The implication of this finding is that higher income of household heads translates to the adoption of clean energy sources.

Similarly, the estimated coefficient for location was negative and statistically significant for fuelwood consumption at 10% level of probability indicating that households living in public housing estates within the urban core of Maiduguri consume lower amount of fuelwood by 14.3% compared to households living outside the city centre, which seems to suggest that there are spatial differences in fuelwood consumption within the study area. In addition, the price of LPG (substitutes) was also positive and statistically significant at 5% level of probability indicating that for every unit increase in the price of LPG, there is a corresponding increase of 29.1% in the quantity of fuelwood consumption.

Furthermore, share of dwelling had a positive coefficient and was statistically significant for fuelwood consumption at 10% level of probability. The results revealed that households that share dwelling with other households consume lower amount of fuelwood by 19% compared to households that do not share same building. Finally, the estimated coefficient for price of fuelwood was negative and statistically significant for fuelwood consumption at 10% level of probability indicating that for every 10% increase in the price of fuelwood per kilogramme in a month, its consumption decreases by 12%.

5.0 DISCUSSION

The findings on the determinants of households fuelwood consumption in public residential estates in Maiduguri shows that out of the ten (10) explanatory variables that were used in the OLS regression model, nine (9) were found to have statistically significant effects on the quantity of fuelwood

consumption in households (Table 2). While gender of the household head, marital status, household size and price of LPG (substitutes) had positive influence on the consumption of fuelwood, variables such as education, monthly income, location of residence, share of dwelling and price of fuelwood had negative impact on fuelwood consumption.

The findings indicated that male-headed households consume higher amount of fuelwood compared to female-headed households. The reason for this outcome may be that males have more financial responsibilities in the home and may therefore be reluctant to change to clean energy sources because of the additional cost burden that may be associated with such a decision given that fuelwood is still relatively cheaper than other fuels. This finding confirms the results of Farsi, Filippini and Pachauri (2007), Rao and Reddy (2007), which found that female-headed households consumed a higher proportion of clean fuels than their male counter-parts. Similarly, marital status had a positive and statistically significant relationship with fuelwood consumption indicating that households headed by married people consumed more of fuelwood compared to households that are headed by unmarried households. This is not surprising given that married people tend to have larger families and therefore may want to decrease the consumption rate of alternative energy sources since fuelwood is comparatively cheaper for large families. However, this finding is contrary to earlier results by Danlami (2019), who found that marital status had a negative relationship with the amount of fuelwood consumption in Bauchi.

The study found a negative association between education of the household head and fuelwood consumption indicating that an increase in the educational level of the household head leads to lower fuelwood consumption by households. This finding suggests that the more the household head is educated, the higher will be the income and the probability of adopting cleaner energy sources rather than fuelwood. Secondly, education brings about more awareness of the harmful effects associated with fuelwood use. The results are consistent with the findings of Gebreegziabher, Mekonnen, Kassie and Köhlin (2012) which found a statistically negative relationship between the level of education and wood consumption in Ethiopia. Similarly, Sharma (2018) also found that literacy status of household heads reduced household fuelwood consumption by about 8% compared to non-literate households in Nepal, which further corroborates the results of this study.

Household size was found to be positive and statistically related to fuelwood consumption indicating that larger households consumed higher amount of fuelwood compared to households with smaller household size in the study area. This finding is in line with the results of Barnes, Khandker and Samad (2011), Mensah and Adu (2013), Bamiro and Egunjobi (2015) which showed positive correlation between fuelwood use and household size. However, this result contrasts with Joshi and Bohara (2017) which found a significant positive relationship between use of modern fuels and household size in Nepal.

The findings further revealed that household income was negative and statistically significant for fuelwood consumption, which suggests that higher income households were less likely to use fuelwood. In other words, as household income increases, households will prefer cleaner alternative energy sources such as LPG. This finding is in line with the Energy ladder hypothesis which indicates that as the socio-economic status of households improves, households were more likely to move away from low and polluting energy sources to modern and efficient energy sources. A recent detailed empirical review by Adamu, Adamu, Ade and Akeh (2020), which indicated that rising poverty levels in Nigeria was a major factor for households' dependence on traditional energy sources such as fuelwood confirms the results of this study. However, Danlami (2019) reported that income was insignificant in determining household fuelwood consumption in Bauchi, which is contrary to this result.

Location of household had a negative relationship with for fuelwood consumption. It shows that households living in public housing estates within the urban core of Maiduguri consume lower amount of fuelwood compared to households living outside the city centre. This is expected given that most of the housing estates within the city centre are relatively new and their occupants may be under obligation to maintain the aesthetics of the buildings consistent with the terms of their occupancy as stipulated by the Borno State Housing Corporation. In addition, some of the buildings are in storey form with in-built internal kitchens that might not be suitable for fuelwood use due to limited space constraints. This result is consistent with the findings of Akeh, Adamu, Adamu and Ade (2023b), which found that the likelihood of choosing fuelwood as the main cooking energy source by households living in public housing estates within the city centre of Maiduguri decreased by about 12.5% compared to households living outside the city centre.

The findings revealed that the price of LPG (substitutes) had a positive correlation with the quantity of fuelwood consumption in households, which seem to suggest that an increase in the price of alternative energy sources such as LPG may result to more consumption of fuelwood with its adverse consequences on the environment and human health. This finding is in conformity with the results of Ebe (2014), which found that the price of fuelwood substitutes had positive and significant correlation with fuelwood consumption in urban areas of Enugu state.

The study also revealed that households that share dwelling with other households consume lower amount of fuelwood compared to households that do not share same building (Table 1). This finding contradicts earlier results by Danlami (2019), which found that share of dwelling was insignificant in determining fuelwood consumption in Bauchi State. A simple explanation for this difference may be due to reasons that most of the houses in this study were either semi-detached or block of storey buildings with

households having exclusive possession to separate units within the same building, which may have limited space and convenience for fuelwood use.

Furthermore, the findings indicated that price of fuelwood was negatively related to fuelwood consumption in public residential estates in Maiduguri (Table 1). This finding is consistent with the results of an earlier study by Abdulhamid *et al*. (2019) in Kano metropolis, which found that price of fuelwood was negative and significantly related to fuelwood consumption. The finding is also in line with the economic theory that price is inversely related to quantity demanded of a commodity. In other words, the higher price of a commodity, the lower would be the quantity demanded, all things being equal. This finding suggests that higher prices of fuelwood may substantially reduce households' consumption of fuelwood, which could have positive implication for deforestation and other associated problems relating to unsustainable fuelwood exploitation.

CONCLUSION AND RECOMMENDATIONS

The study examined the determinants of fuelwood consumption among households of public residential estates in Maiduguri, Borno State, Nigeria. The findings indicated that a number of economic and socio-demographic characteristics of households influence the consumption of fuelwood in public residential estates in the study area. It revealed that gender, marital status, household size and prices of alternative fuels had positive and significant correlation with the quantity of fuelwood consumed in households. On the other hand, education, income, location of residence, share of dwelling and prices of fuelwood were negative and significantly related with fuelwood consumption. Given the tendency of deforestation and other environmental problems associated with fuelwood exploitation, stakeholders and policy makers in the energy sector should take adequate and proactive steps that will promote access to cleaner, efficient, affordable and modern sources of energy for household cooking activities by subsidizing the prices of modern fuels and increasing electricity availability to households. This will go a long way to reducing the rate of indoor air pollution and other environmental consequences associated with the use of fuelwood in the study area. Finally, there is the need for proactive enlightenment campaigns with a view to strengthening public awareness on the deleterious effects of the consumption of solid fuels such as fuelwood in the study area.

CONSENT

Informed consent was sought and obtained by the researchers before administering copies of the questionnaire on each of the household head selected for the study.

REFERENCES

Abdulhamid, U.M., Abdullahi, Z.Y., Safiyanu, S.A., Suleiman, I., Shu'aib, A.U., & Dambatta, M.A. (2019). Energy utilization pattern and socio-economic evaluation of household fuelwood consumption: A case study of Kano State, Nigeria. *International Journal of Strategic Research in Education, Technology and Humanities.* 6(1): 145-155.

Abebaw, D. (2007). Household determinants of fuelwood choice in urban Ethiopia: A case study of Jimma Town. *The Journal of Developing Areas,* 41 (1): 117-126.

Adamu, M.B., Adamu, H., Ade, S.M., & Akeh, G.I (2020). Household energy consumption in Nigeria: A review of the applicability of the Energy ladder model. *Journal of Applied Science and Management,* 24(2): 237-244.

Akeh, G.I., Adamu, M.B., Adamu, H., & Ade, S.M. (2023a). Household energy consumption pattern in public housing estates in Maiduguri, North-east Nigeria: An economic and socio-demographic analysis. *International Journal of Research in Environmental Science and Technology,* 9(1): 18-29.

Akeh, G.I., Adamu, M.B., Adamu, H., & Ade, S.M. (2023b). Determinants of household cooking energy choice in public housing estates in Maiduguri, Borno State, North-east Nigeria. *Journal of Energy Research and Reviews.* In press.

Arowolo, A.O., Ibrahim, S.B., Sanusi, M.M., Ayinde, A.F.O., & Sheleru, K.M. (2018). Households' cooking energy preferences and determinants of transition to non-biomass fuels in rural Nigeria. *Journal of sustainable Development in Africa* 20(1): 127-145.

Bamiro, O.M., & Ogunjobi, J.O. (2015). Determinants of household energy consumption in Nigeria: Evidence from Ogun State. *Research Journal of Social Science & Management*, 4(12): 35-41.

Barnes, D. F., Khandker, S. R. & Samad, H. A. (2011). Energy poverty in rural Bangladesh. *Energy Policy*, *39*, 894-904.

Chidiebere-Mark, N.M., Agunanne, U.T., & Anyanwu, U.G. (2018). Determinants of cooking energy consumption among farming households in Owerri agricultural zone, Imo State. *International Journal of Energy and Environmental Research*, 6(2): 55-62

Couture, S., Garcia, S., & Reynaud, A. (2012). Household energy choices and firewood consumption: An econometric approach using French data. *Energy Economics,* 34:1972-1951.

Danlami, A. (2019). Assessment of factors influencing firewood consumption in Bauchi state, Nigeria. *Journal of Sustainability Science and Management*. 14(1):99-109.

Daura, M.M. (2001). The physical environment and development: A study of Borno region in Ogunika, O., Irefin, J., Daura, M.M., and Balami, D. (eds) *Environment and Development issues in Sub Saharan Africa*. Seminar series 1:35-47. Faculty of social and management sciences, University of Maiduguri.

Démurger, S., & Fournier, M. (2011). Poverty and firewood consumption: A case study of rural households in Northern China. *China Economic Review,* 22 (4): 512–523.

Ebe, F.E. (2014). Socio-economic factors influencing the use of fuelwood in urban areas of Enugu State, Nigeria. *IOSR Journal of Business and Management.* 16(11): 147-151.

Energy Commission of Nigeria (2003). National Energy Policy. Federal Republic of Nigeria.

Farsi, M., Filippini, M., & Pachauri, S. (2007). Fuel choices in urban Indian households. Environment and Development Economics, 12, 757-774.

Gebreegziabher, Z., Mekonnen, A., Kassie, M., & Köhlin, G. (2012). Urban energy transition and technology adoption: The case of Tigrai, northern Ethiopia. *Energy Economics,* 34 (2): 410–418

International Energy Agency (2018). World Energy Outlook 2018: Paris, France. IEA publications.

John, M.A. (2022). The effect of household income on cooking fuel demand in Ibadan. *Journal of Applied Economics and Business.* 10(3): 46-67.

Joshi, J., & Bohara, A. K. (2017). Household preferences for cooking fuels and inter-fuel substitutions: Unlocking the modern fuels in the Nepalese household. *Energy Policy, 107*, 507-523.

Kothari, G.R. (2004). *Research methodology: Methods and Techniques*. New Delhi: New Age International Ltd

Kumar, R. (2011). *Research methodology: A step-by-step guide for beginners.* 3rd edition. London: Sage publication Ltd.

Louw, K., Conradie, B., Howells, M., & Dekenah, M. (2008). Determinants of electricity demand for newly electrified low-income African households. *Energy Policy* 36 (8), 2812-2816.

Maconachie, R., Tanko, A., & Zakariya, M. (2009). Descending the energy ladder? Oil price shocks and domestic fuel choices in Kano, Nigeria. *Land Use Policy* 26 (4): 1090-1099.

Maurice, D.C., Umar, Y., & Zubairu, E. (2015). Analysis of factors influencing fuelwood consumption in some selected local government Areas of Taraba State, Nigeria. *Journal of Agricultural Economics, Environment and Social Sciences,* 1(1): 163-168.

Mensah, T., & Adu, G. (2013). An empirical analysis of household energy choice in Ghana. Uppsala Working Paper Series No. 6.

Nnodim, O. (2020, July 6). 62% Nigerians without electricity, 90% lack cooking fuels-FG. The Punch newspaper. Retrieved October 15, 2022 from http://www.punchng.com

Ojo, C.O., Bawa, D.B., & Chuffor, L. (2013). Effect of women's socio-economic characteristics on household fuel consumption in Damboa local government area of Borno State. *Research on Humanities and Social Sciences*. 3(1): 73-78.

Olugbire, O.O., Aremu, F.J., Opute, O.H., Ojedokun, C.A., Olawale, O.O., & Adisa, A. (2016). *RJOAS* 4(52): 28-36.

Onoja, A. O., & Idoko, O. (2012). Econometric Analysis of Factors Influencing Fuelwood Demand in Rural and Peri-Urban Farm Households in Kogi State, Nigeria. *The Journal of Sustainable Development,* 8(1):115 – 127.

Osiolo, H. H. (2009). Enhancing household fuel choice and substitution in Kenya, Kippra discussion paper no. 102. http://searchworks.stanford.edu/ view/9608349. Accessed 7 Sept 2017.

PopulationStat, 2023 retrieved March 24, 2023 from http://www.populationstat.com/nieria/maiduguri

Rao, M. N., & Reddy, B. S. (2007). Variations in energy use by Indian households: An analysis of micro level data. *Energy*, 32 (2): 143-153.

Sharma, B.P. (2018). Household fuel transition and determinants of fuelwood demand in Nepal. *Economic Journal of Development Issues.* 25 & 26 (1-2): 83-95.

UNFCCC (2015). Nigeria's Intended Nationally Determined Contribution, Retrieved July 28, 2019 from http://www4.unfccc.int/submissions/INDC/Published%20Documents/Nigeria/1/Approved%20Nigeria's%20INDC_271115.pdf.

United Nations Development Programme (2015). Sustainable Fuelwood Management in Nigeria. Retrieved July 28, 2019 from http://www.undp.org

United Nations Development Programme. Sustainable Development Goals. Goal: Affordable and clean energy. Retrieved July 28, 2019 from http;//www.undp.org

Waziri, M. (2009). The geography of Borno: An overview in Waziri, M., Kagu, A., & Monguno, A. K. (2009) *Issues in the geography of Borno State.* Kano, Adamu Joji publishers

WHO (2018). Frequently asked questions-Ambient and household air pollution and health. USA: Fact Sheet No 292.Geneva.

Yamane, T. (1967). *Statistics: An introductory analysis,* 2nd Edition, New York: Harper and Row.