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Assessment of factors influencing fuelwood utilization in Makurdi metropolis, Benue state, Nigeria

Paul Utser Ancha[1]
Leoskali Nguuma Sambe[2+]
Lilian Chinenye Peter[3]

[1,2,3]*Department of Social and Environmental Forestry, Federal University of Agriculture, Makurdi, Nigeria.*
[1]*Email: ancha-paul@gmail.com*
[2]*Email: leoskalisambe@yahoo.com*
[3]*Email: jollyjoytor2020@gmail.com*


(+ Corresponding author)

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ABSTRACT

The study was conducted to assess the factors influencing the utilization of fuelwood in Makurdi metropolis due to the paucity of information on the factors in the area. Simple random sampling technique was used to select 125 people in 25 houses from five locations in the study area. Data for the study was obtained through a semi-structured questionnaire, interview, and personal observation. Field data was analyzed using descriptive, Likert scale rating and regression models. Results of analysis of field data show that seven tree species were utilized for fuelwood in the study area with *Prosopis africana* (34%) being the most preferred fuelwood spp utilized while *Burkia africana* (2.1%) was the least utilized fuelwood spp. The Multilinear regression model was selected as the best-fit model in explaining the factors influencing fuelwood utilization in the study area based on its high r2 value and low standard error estimated compared to the other three regression models. None of the socioeconomic variables investigated had a significant influence on fuelwood utilization ($P > 0.05$). However, age, income, family size, unit price, and availability of the commodity positively influence fuelwood utilization in the study area. The socioeconomic factors were able to explain 67% of the variation in fuelwood utilization in Makurdi Metropolis. Fuelwood is highly utilized in the area. Therefore, the conservation of the preferred fuelwood tree species in community forests and agroforestry practices should be encouraged by the Government, Non-governmental organizations (NGOs), and private individuals to enhance the sustainability of the resource.

Contribution/Originality: Application of Multilinear regression best-fit model in explaining factors influencing fuelwood utilization. Quantification of the variation in fuelwood utilization explained by socioeconomic factors. Contribution to the understanding of energy resource utilization and management in urban areas and recommendations for conservation efforts to sustain fuelwood resources, particularly the preferred tree species.

1. INTRODUCTION

Fuelwood serves as an important energy source for people living in both rural and urban areas in developing nations, constituting the majority of domestic energy usage [1, 2].

The International Energy Agency (IEA) [3] indicated that more than three billion people worldwide have limited energy access and predominantly utilize biomass fuel in rural areas. The Food and Agriculture Organization of the United Nations (FAO) [4] reported that approximately 2 billion people rely on forest resources, including fruits, game meat, fibers, and charcoal, to meet their basic requirements. In developing countries, charcoal harvesting is a significant energy source, with 70 percent of the population relying on wood and its by-products for cooking [5].

Biomass fuel particularly wood in most African nations, is the primary source of charcoal production. As a result, there is a notable increase in urban charcoal consumption in Africa [6] and both urban and rural populations depend on it for cooking [7]. Fuelwood is crucial for meeting the basic energy needs of people involved in primary activities like farming, hunting, and fishing. This is due to the ease of gathering and cost-effectiveness of using fuelwood in rural areas [8]. The usage of fuelwood is widespread in Nigeria, as over 80% of households rely on it for cooking, making it the most commonly utilized cooking energy source [9]. The high demand for fuelwood in the country is due to its availability and affordability relative to other energy sources [10]. The need for fuelwood usage has risen due to poverty, population growth, poor agricultural productivity, inefficient traditional cooking methods, lack of adoption of sustainable cooking techniques, disparities in land ownership, fast urbanization, increasing fossil fuel, kerosene, gas, and electric cooker costs, as well as low electricity generation and high expenses Sambo [9] and Nash and Cecilia [11]. Olise and Nria-Dappa [12] assert that Nigeria's energy crisis is more severe than publicly acknowledged. Their arguments were presented based on the household income ratio and its correlation to energy expenditure. They revealed that the poorest households earn approximately 1-2 US dollars daily and allocate about 0.4 dollars per day to energy expenses. This signifies that 20-40 percent of the households' income is allocated solely to energy costs. In their study, Tee, et al. [13] found that in the Makurdi metropolis of Nigeria, fuelwood serves as the primary energy source for both domestic and industrial purposes. Their findings also indicated that the growing demand for fuelwood coupled with limited supply has led to heightened pressure on the tree species used for fuelwood, ultimately causing them to become extinct in the region.

Fuelwood accounts for two-thirds (2/3) of all energy, excluding human and animal energy, that is utilized in Africa. [14] most rural and urban people still rely on trees and woody vegetation to meet their basic energy needs [15] this has contributed to enormous deforestation. According to Bailis, et al. [16] global estimates indicate that about 30% of fuelwood harvesting is unsustainable and this contributes to forest degradation when wood is harvested more rapidly than the landscape can recover. The afforestation rates are either stable or increasing, not only in temperate regions where planted forests have been essential parts of the forest land for a long time but also in tropical areas where the size of planted forests has almost doubled since 1990 [17]. The survival of rural dwellers and urban residents depends on accessing enough wood to prepare their meals which currently constitutes the major source of cooking fuel for over 76% of the Nigerian population Bearer [18]. The forests of the country may soon be transformed into savannas and grasslands due to the current rate of charcoal consumption and cutting [19]. In numerous tropical biodiversity hotspots, people depend on endangered, diminished, and isolated forests to satisfy their need for charcoal, land for farming, and the supply of animal protein [20, 21]. The demand for Fuelwood varies daily, weekly, within and between seasons. The wood used each day is influenced by many factors such as low-income nations depending heavily on wood for fuel. According to Babanyara and Saleh [22] there is a direct relationship between the demand for fuelwood and the economic status of a country and the factors driving fuelwood consumption in urban areas include urbanization, rural-urban migration, and the rising cost of alternative fuels. Current information on fuelwood consumption and the factors influencing fuelwood utilization in Makurdi Metropolis is lacking. The lack of information on the tree species used for fuelwood and the factors influencing the utilization of the fuelwood could hamper planning for the conservation of the tree species by the Government, private individuals, and decision-makers. This research was initiated to provide insights into the tree species and the factors that influence the use of fuelwood in Makurdi metropolis, aiming to support decision-making and policy.

2. MATERIALS AND METHODS

2.1. Study Area

The research was carried out in Makurdi metropolis. Makurdi serves as the administrative center of Benue State, Nigeria. Situated in the Middle Belt and bordered by the River Benue, the city naturally divides into two areas: the

North and South Banks. The South Bank is further segmented into Wurukum, High Level, Wadata, Ankpa Quarters, and Old GRA (Government Reserve Area). Makurdi experiences a typical tropical climate characterized by distinct dry and rainy seasons. The dry season spans from November to March, while the rainy season lasts from April to October, with precipitation ranging from 150-180cm.

The temperature ranges from 23°C during the rainy season to as high as 38°C during the dry season [23]. The coordinates are 7°43'50"N 8°32'10"E; with a latitude of 7°44'1.50"N and a longitude of 8°31'17.00"E, and the elevation is 92 meters (302 feet).

The demographic data indicates that the primary ethnic groups are the Tiv, Idoma, Igede, and Etulo. Makurdi is the location of Benue State University, the University of Agriculture Makurdi, and the Nigeria Army School of Military Engineering Makurdi. In 2006, Makurdi had an estimated population of 300,377 according to the National Population Commission (NPC) [24].

Figure 1 Showes Map of the study area.

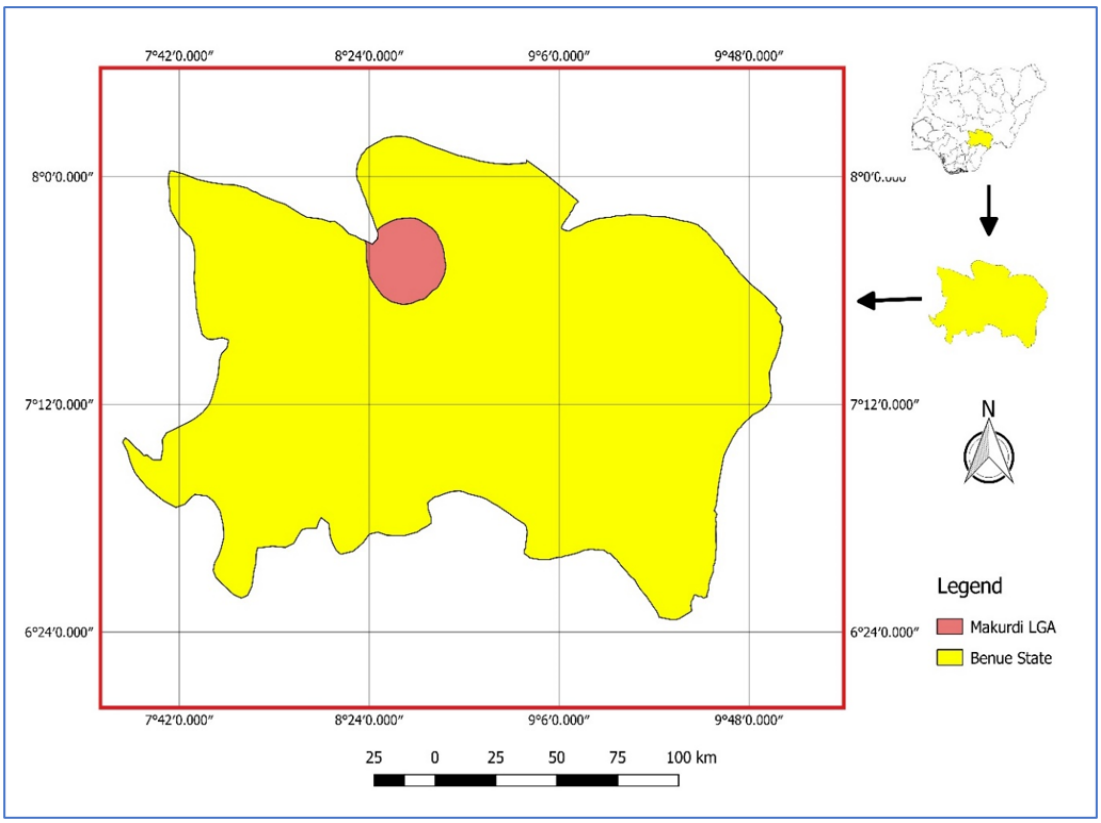

Figure 1. Map of the study area.

2.2. Population Sampling Procedure and Sample Size

The people (male and female) in the study area made up the population. Five areas of the Metropolis were randomly selected. This included North Bank, Wurukum, Wadata, High Level, and Ankpa quarters. In each area, random sampling was used to select twenty-five houses, and one person per household was interviewed thus, the sample was 125 people.

2.3. Data Collection

Primary data was collected with the use of a semi-structured questionnaire. The questionnaire sought information on the people utilizing fuelwood in the study area to know their socio-economic characteristics, the types

of fuelwoods used, and the source and availability of fuelwood. Also, the questionnaire sought information on the reasons for using fuelwood, other available alternatives to fuelwood, and why these alternatives are being used.

2.4. Data Analysis

The socio-economic characteristics of the people were analyzed using descriptive statistics such as frequency, mean, and percentage. Spearman rank correlation analysis was used to test for a significant relationship between the socio-economic variables of the people and the demand for fuelwood in the study area. The types of tree species were also analyzed using descriptive statistics. The tree species were ranked according to the magnitude of percentage occurrence. Four regression models were used to analyze the socio-economic factors influencing the demand of fuelwood in the study area.

The model with the highest R^2 value and least standard error was taken as the best model that explained the socio-economic factors influencing fuelwood utilization in the study area. The models used were;

i. Multiple linear regression

$$y = a + bx$$

$$y = a + b_1x_1 + b_2x_2 + - - - - - - - - - - - - - - - - - - - + b_nx_n + e$$

ii. Semi-log regression

$$(y) = a + logb_1x_1 + logb_2x_2 + - - - - - - - - - - - - - - - - - logb_nx_n + e$$

iii. Double log regression

$$Log(y) = a + logb_1x_1 + logb_2x_2 + - - - - - - - - - - - - - logb_nx_n + e$$

iv. Exponential

$$Log(y) = a + b_1x_1 + b_2x_2 + - - - - - - - - - - - - - - - - - b_nx_n + e$$

Where:

y= Quantity of fuelwood utilized in kg per month.

x_1---x_n= Independent variables.

b_1-----b_n= Regression coefficients.

a= Constant.

x_1= Age of the respondents measured in years.

x_2= Years spent in formal school.

x_3= Annual income of the respondents.

x_4= Number of persons per household.

x_5= Price of fuelwood.

x_6= Availability of fuelwood.

x_7= Price of fuelwood substitutes.

e= Error term.

3. RESULTS AND DISCUSSION

3.1. Results Presentation

3.1.1. Socio-economic Characteristics of the Respondents

The results from Table 1 show that 85.6% of the respondents who provided information for the study were females while 14.4% of the respondents were males. The age distribution of the respondents shows that 1.6% of the respondents were below the age of 20 years, 17.6% of the respondents were between the ages of 21-30years, 53.6% of the respondents were between the ages of 31-40 years, and 19.2% of the respondents were between the ages of 41-50years while 8.0% of the respondents were above 50 years.

The major occupation of the respondents shows that 11.2% of the respondents were civil servants, 5.6% of the respondents were farmers, 70.4% of the respondents were traders, and 7.2% of the respondents were timber dealers while 5.6% of the respondents had other occupations.

On their educational status, it was observed that the majority (88.8%) had some form of formal education, with 21.6% attained tertiary education and only 11.2% of the respondents had no formal education.

The majority of the respondents (82.2%) fell within an annual income level of ₦1,000-600,000 while (17.6%) of the respondents fell within an annual income of ₦601,000 and above. The distribution of their family size revealed that 20.8% of the respondent's family size was below 5, 78.4% of the respondents had a family size of 5-10 and 8% had a family size above 15.

Table 1. Socio-economic characteristics of the respondents in the study area.

Variable	Category	F (n=125)	%
Sex	Male	18	14.4
	Female	107	85.6
Age	<20	2	1.6
	20-30	22	17.6
	31-40	67	53.6
	41-50	24	19.2
	>50	10	8
Major occupation	Civil servant	14	11.2
	Farming	7	5.6
	Trading	88	70.4
	Timber dealer	9	7.2
	Others	7	19.2
Educational status	Primary	24	19.2
	Secondary	60	48
	Tertiary	27	21.6
	Non-formal	14	11.2
Estimated annual income	1000-200,000	9	7.2
	201,000-400,000	47	37.6
	401,000-600,000	47	37.6
	601,000-800,000	11	8.8
	801,000-1,000,000	6	4.8
	>1,000,000	5	4
Family size	<5	26	20.8
	10-May	98	78.4
	>15	1	0.8

Note: n= Number of respondents.

3.1.2. Types of Tree Species Utilized for Fuelwood

The results in Table 2 show that the most utilized tree species were *Prosopis africana* (34.0%), Terminalia spp (25.1%), *Parkia biglobosa* (14.5%) and *Daniella oliveri* (11.2%), *Vitelleria paradoxa* (9.8%). The least used tree species were *Anageicious leocapus* (3.3%) and *Burkia africana* (2.1%).

Table 2. Types of tree species utilized in Makurdi metropolis.

Tree specie	Local names	Wurukum	High level	Wadata	Ankpa quarters	North bank	Frequency	Percent %	Ranking
Prosopis africana	Gbaye	25	15	25	25	25	115	34.0	1
Terminalia spp	Kwegh	17	17	15	12	24	85	25.1	2
Parkia biglobosa	Nune	5	15	10	11	8	49	14.5	3

Tree specie	Local names	Wurukum	High level	Wadata	Ankpa quarters	North bank	Frequency	Percent %	Ranking
Daniella oliveri	Chiha	5	19	2	9	3	38	11.2	4
Vitelleria paradoxa	Chamegh	8	5	9	11	0	33	9.8	5
Anageicious leocarpus	Maaki	0	6	0	5	0	11	3.3	6
Burkia africana	Gbagbongon	7	0	0	0	0	7	2.1	7
Total							338	100	-

3.1.3. Sources of Fuelwood

The result in Table 3 shows that 82.4% of the respondents bought their fuelwood from their neighbourhood while 17.6% of the respondents got their fuelwood from the market.

Table 3. Sources of fuelwood.

Sources	F	%
Buying in the market	22	17.6
Buying in the neighbourhood	103	82.4
Total	125	100

3.1.4. Availability of Fuelwood

The result on the availability of fuelwood is presented in Table 4. The result shows that 96% of the respondents acknowledge that fuelwood is readily available while 4% of the respondents' said fuelwood was not readily available to them.

Table 4. Availability of fuelwood in Makurdi metropolis.

Availability	F	%
Yes	120	96
No	5	4
Total	125	100

3.1.5. Reasons for Utilizing Fuelwood in Makurdi Metropolis

The results in Table 5 show the reasons for the utilization of fuelwood. The majority of the respondents reported on fast cooking (30.3%), cooking large quantities of food (17.3%), readily available (14.4%), producing charcoal after use (12.4%), adding local flavour to food (8.2%),

Table 5. Reasons for utilizing fuelwood.

Reasons	Wurukum	High level	Wadata	Ankpa quarters	North bank	F	%
Adds local flavour to food	7	5	3	4	9	28	8.2
Produces charcoal after use	8	8	7	7	12	42	12.4
Readily available	12	8	13	8	8	49	14.4
Cooks large quantities of food	13	12	10	14	10	59	17.3
Lasts long	15	11	11	10	12	59	17.4
Fast cooking	25	22	21	15	20	103	30.3
Total	**80**	66	65	58	71	**340**	**100**

Figure 2 shows species of fuelwood displayed for sale at awe street Wurukum in Makurdi, Benue State, Nigeria.

Figure 2. Species of fuel wood displayed for sale at awe street Wurukum in Makurdi, Benue State, Nigeria

3.1.6. Reasons for Utilizing Fuelwood Alternatives

Results from Table 6 show the various reasons why the respondents use fuelwood alternatives. The reasons include charcoal is cheap (25.5%), makes cooking clean (17.6%), better when cooking in small quantities (17.25), substitute for fuelwood when it rains (15.5%), when fuelwood is scarce (11.3%), and energy-efficient (12.9%).

Table 6. Reasons for utilizing fuelwood alternatives in Makurdi metropolis.

Reasons	Wurukum	High level	Wadata	Ankpa quarters	North bank	F	%
Charcoal is cheap	13	14	13	5	16	61	25.5
Makes cooking clean	7	9	7	10	9	42	17.6
Better when cooking in small quantities	10	9	7	10	5	41	17.2
Substitute for fuelwood when it rains	9	6	10	6	6	37	15.5
When there is scarcity of fuelwood	11	5	5	3	3	27	11.3
Energy efficient	7	7	6	6	5	31	12.9
Total	57	50	48	40	44	239	100

3.1.7. Relationship Between Socio-Economic Variables of the People and Utilization of Fuelwood

Pearson Correlation test between the socio-economic variables of the respondents and utilization of fuelwood in Makurdi metropolis is shown in Table 7. The result showed a non-significant positive correlation between the age of the people and utilization of fuelwood demand r = 0.06, p>0.05. This implies that an increase in age leads to an increase in utilization of fuelwood. There was a non-significant negative correlation between years of schooling and utilization of fuelwood (r = 0.16, p>0.05) indicating that utilization of fuelwood decreases with an increase in the education of the people. It shows a non-significant positive correlation between the income of the people and utilization between the income of the people (r = 0.12, p> 0.05). This implies that the utilization of fuelwood increases with an increase in income. Also, the correlation between family size and utilization shows a non-significant and positive correlation (r = 0.16, p>0.05) indicating that an increase in family size leads to an increase in the utilization of fuelwood in Makurdi Metropolis.

Table 7. Relationship between socioeconomic variables and utilization of fuelwood in Makurdi metropolis.

Pearson test variables	R. value	P. value	Decision
Age Vs utilization of fuelwood	0.056	0.535	Not significant
Years of schooling vs utilization of fuelwood	-0.163	0.069	Not significant
Estimated income vs utilization of fuelwood	0.123	0.172	Not significant
Family size vs utilization of fuelwood	0.162	0.071	Not significant

Note: Significant level = 0.05.

3.1.8. Socio-Economic Factors Influencing Utilization of Fuelwood

Table 8 shows the regression estimates of factors influencing the utilization of fuelwood in Makurdi Metropolis. The multi-linear regression model was selected as the best-fit model in explaining the factors influencing fuelwood utilization based on its high r^2 value and standard error estimated. The result shows that none of the variables investigated had a significant influence on the utilization of fuelwood (P > 0.05) in the study area. However, a unit increase in the age of the people will increase the utilization of fuelwood by a factor of 2.933×10^{-5}. A unit increase in education will decrease fuelwood utilization by a factor of -5.514×10^{-5}. A unit increase in the annual income of the people will increase fuelwood utilization by 3.679×10^{-10}. A unit increase in family size will increase fuelwood utilization by 9.528×10^{-5}. A unit increase in the unit price of fuelwood will bring a corresponding increase in the utilization of the commodity by the factor of 4.211×10^{-6}. A unit increase in the availability of fuelwood will increase its utilization by a factor of 0.001. The factors were able to explain 67% of the variation in utilization of fuelwood in Makurdi Metropolis.

Table 8. Regression estimates of socioeconomic factors influencing demand of fuelwood in Makurdi Metropolis.

Variables	Multi linear regression			Exponential regression			Semi-log regression			Double log regression		
	B	T	P.value	B	T	P.value	B	t	P.value	B	t	P.value
(Constant)	0.007	4.173	0.01	-2.151	-21.162	0.000	0.004	0.003	0.639	-2.304	-6.206	0.000
Age	2.933E-6	0.167	0.867	0.000	0.178	0.859	0.000	0.010	0.106	0.011	0.122	0.903
X_1=Education status	-5.514E-5	-1.590	0.115	-0.003	-1.430	0.155	0.000	-0.076	-0.776	-0.019	-0.675	0.501
X_2 = Estimated annual income	3.679E-10	1.499	0.137	1.986E-08	1.393	0.166	0.000	0.034	0.370	0.015	0.386	0.700
X_3 =Family size	9.528E-5	1.207	0.230	0.006	1.274	0.205	0.002	0.123	1.263	0.093	1.332	0.185
X_4 =Unit price	4.211E-6	0.617	0.539	0.000	0.479	0.633	0.001	0.027	0.285	0.020	0.148	0.883
X_5 = Availability	0.001	-0.436	0.663	-0.014	-0.284	0.777	-0.001	-0.048	-0.524	-0.060	-0.368	0.713
Model fitness parameters												
R^2	0.67			0.06			0.03			0.10		
adj. R^2	0.02			0.01			0.02			0.02		
Std error	0.018			0.103			0.001			0.105		
df	6			6			6			6		
F	1.39			1.23			0.64			0.64		
P. value	0.22			0.30			0.70			0.70		

Note: Significant level = 0.05.

4. DISCUSSION

The socio-economic characteristics of respondents revealed that a higher proportion of females over the males responded to the study. This could imply that wood collection and utilization is dominated by the female gender. This finding agrees with that of Damm and Triebel [25] who reported that a large percentage of wood is collected and majorly used by women. The high age distribution of the respondents in their active ages implies that they are capable of providing reliable information on household activities that are relevant to this study. The occupation of the respondents shows that utilization of fuelwood cuts across all occupations. This result met public expectations as most people in urban areas across the world who utilized fuelwood engaged in occupations other than farming. The observed majority of respondents with formal education means that attainment of formal education or not does not determine the utilization of fuelwood. This could also mean that the educational attainment of a person especially the household head could affect the type of energy source used by the household [26]. The high proportion of respondents being low-income earners gives credence to increasing utilization of fuelwood while the distribution of family size of the majority being above five means more demand for energy consumption in households and hence increased utilization of fuelwood in Makurdi metropolis. This finding is in line with that of Bisu, et al. [27] who discovered that availability, education, income, household size, and location all influence people's choice of energy source for cooking.

4.1. Types of Tree Species Utilized

The type of tree species utilized as fuelwood in this study are in concordance with the findings of Tee, et al. [13] and Ekhuemelo, et al. [28]. The wood species utilized for fuelwood could be attributed to their burning qualities, availability, and the rising cost of modern energy. This finding is corroborated by those of Cotton [29]; Beatrice, et al. [30] and Ortserga and Pam [31]. The finding of Adeniji, et al. [32] identified *Prosopis africana* as the most preferred while the findings of Ekpo, et al. [33] study on analysis of tree species preference among commercial charcoal producers in Nasarawa State, Nigeria, also identified these species and reported *Anogeissus leoicarpus*, *Prosopis africana*, *Vittelaria paradoxa*, *Terminalia spp*, *Burkia africana* in that order were the most preferred by commercial charcoal producers. Similarly, the findings of Dadile and Sotannde [34] ranked *Anogeissus leoicarpus* as the most preferred species based on knowledge of consumers on combustion quality and fuel value Index (FVI) and this also agrees with studies by Beatrice, et al. [30] and Charlotte [35]. These tree species were most commonly used because of their high heat capacities with hot amber, high combustibility, and high-quality charcoal production. The differences in the preferences in utilization of these species could be due to availability as well as demand and other features such as the blistering nature of some species [33]. This justifies the statement by Chansa [36] that the reason for tree preference or utilization among charcoal producers is due to their particular species-specific characteristics rather than their abundance.

4.2. Sources of Fuelwood

The purchase of fuelwood from neighborhoods and markets agrees with Food and Agriculture Organisation of the United Nations (FAO) [37] which states that most of the fuelwood used is either sold or purchased from small dealers. Similarly, Orimoogunje and Asifat [38] reported that fuelwood is sourced from forest/woodland, farmlands, and surpluses resulting from agricultural and land clearing from subsistence farmers who move harvested wood to urban centres and sell to traders of consumers.

4.3. Availability of Fuelwood

The indication that fuelwood is readily available by the majority of the respondents agrees with Oluwagbenga [39] who stated that despite the shortages of fuelwood due to diminishing forests, fuelwood consumption has

increased in volume as a result of scarcity and non-availability of conventional fuels such as kerosene and cooking gas and constant increases in the prices of these fuels.

4.4. Reasons for Utilizing Fuelwood

The reasons for the use of fuelwood owe to its sustainability of livelihoods in terms of affordability and social appropriateness in developing countries. This result corroborates with that of Fuwape [40] and Adedayo, et al. [41] who reported that over 95 percent of the Nigerian population depends on wood as a domestic energy source. Also, many households choose to use fuelwood for cooking because they believe it makes the food taste better, in addition to their inability to afford modern energy sources [31].

4.5. Reasons for Utilizing Fuelwood Alternatives

The various reasons the respondents used fuelwood alternatives were the cheapness, cleanness, scarcity, and energy efficiency of the products. This finding corroborates that of Kyte [42] who stated that women mostly preferred fuelwood alternatives such as gas because it is time-saving and energy efficient. Based on cleanness, this could be due to the environmental pollution caused by firewood and the fact that it produces a lot of black soot dirt that causes stains. This finding aligns with that of Otte [43] and Mwampamba, et al. [44].

From the results, it is evident that most of the respondents used charcoal as an alternative to fuelwood. This agrees with Calen [45] who stated that firewood use is expected to remain relatively level over the next 20 years, while Charcoal use is expected to increase considerably and that the increase in charcoal demand correlates with the expected increase in urbanization, as urban dwellers use more Charcoal than rural dwellers. In the analyses of fuelwood and modern fuel prices in 19 developing countries, Barnes [46] reported trends suggesting that rising incomes rather than prices are the predominant factors for fuelwood substitution and that reducing the prices of substitute fuel (e.g. kerosene) does not minimize fuelwood prices or demand unless incomes simultaneously increase.

4.6. Relationship between Socio-Economic Variables of the People and Utilization of Fuelwood

Pearson Correlation test between the socio-economic variables of the respondents and utilization of fuelwood in Makurdi metropolis indicated that an increase in age led to the rise in utilization of fuelwood and that utilization of fuelwood decreases with an increase in education of the people. Also, the utilization of fuelwood increases with an increase in income. The correlation between family size and fuelwood utilization indicated that an increase in family size led to an increase in the utilization of fuelwood in Makurdi Metropolis.

The correlation of firewood utilization with education indicates that all respondents use firewood regardless of their level of education however, those less educated (primary and secondary education) utilize more firewood. One might assume that higher education levels would be associated with a preference for energy-efficient technology; however, all respondents who participated in the survey were not insulated. Mislimshoeva, et al. [47] the finding also corroborated the fact that the level of education influences the utilization of fuelwood. They therefore submitted that whether or not the awareness of energy-efficient technologies is related to education level needs to be investigated more explicitly. Additionally, some studies have found that the level of schooling in a household influences how much firewood is used in Nigerian and Cambodian households [48, 49].

The study by Onoja and Idoko [50] found an inverse relationship between the price of fuelwood and the quantity demanded and also a negative relationship between income and quantity demanded. This implies that as the price of fuelwood rises the quantity demanded falls, this is in line with the economic theory where the price is inversely related to the quantity demanded of a commodity. Similarly, higher incomes can lead to less consumption of fuelwood for convenience reasons. This suggests that subsidies for modern fuels are likely to encourage increased consumption of cleaner alternative fuels among the high-and middle-income households while having a negligible effect on the

fuelwood consumption of the poor. For instance, Narain, et al. [51] found that firewood use and dependence (defined as its contribution to the total 'permanent income' of households) increases with forest biomass availability irrespective of income levels.

4.7. Socio-Economic Factors Influencing Utilization of Fuelwood

The regression estimates for socio-economic factors influencing the utilization of fuelwood in Makurdi Metropolis imply that a unit increase in age, education, income, unit price, and family size of the people will increase the utilization of fuelwood. However, the finding on age agrees with the theoretical expectation that an increase in the age of households will influence fuel choice firewood through developed loyalty and reduce the adoption of other fuel choices. In terms of age, education, and income, this finding differs from those of Nnaji, et al. [48] but it agrees with their findings regarding family size. Also, this finding agrees with Ebe [52] who stated that the higher the level of income, the less the number of respondents that use fuelwood.

The finding of Onoja and Idoko [50] also corroborates the fact that an increase in family size increases the demand for fuelwood but disagrees in terms of income and price in their study on Econometric Analysis of factors influencing fuelwood demand in rural and peri-urban farm households of Kogi State. Larger households will prefer to use firewood since it is comparatively cheaper to use firewood to cook for many people as it has a lower consumption rate per unit of time compared to charcoal and kerosene [53]. The findings of Maurice, et al. [54] however, support the findings that education and family size positively influence the utilization of fuelwood.

Although, the result of the study showed that an increase in a unit price of fuelwood will increase utilization, on the contrary, studies by Aguilar and Saunders [55] and Song, et al. [49] suggest that increasing the relative price of nonwood energy would encourage households to substitute it with wood energy. This suggests that a rise in fuelwood's unit price leads to a fall in fuelwood demand.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Fuelwood utilization serves as one of the major sources of household energy among residents of Makurdi metropolis. Most of the residents utilizing fuelwood as their major energy source do so mainly because of it accessibility and affordability. Therefore, this implies that increasing the unit price of fuelwood leads to a decrease in its demand.

5.2. Recommendation

Though fuelwood is a renewable resource its overuse can quickly and easily lead to shortages unless it is used with care and caution of balancing its demand and supply. Overuse can negatively impact the economy through deforestation and declining agricultural productivity, soil erosion, and destruction of the ecological systems leading to loss of biodiversity. To address these socio-economic and ecological effects, a number of solutions have been proposed, including the development of more efficient energy technology, public awareness regarding the effects of fuelwood associated with deforestation, and lowering the cost of alternative energy sources. To improve the sustainability of the resources, the government, non-governmental organizations, and the private sector should all take part in the conservation of the preferred fuelwood species in plantation and agroforestry practices.

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Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
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