The Impact of Fuel use on the Environment: A Case Study of the Household in Borno State

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Abstract

The type of energy used by household has an impact on the environment, social, health and economic growth of a nation. Hence it has become more relevant now than ever from a policy standpoint to encourage the households to shift to the use of clean and efficient fuel sources. However, not much has been done in understanding the types of fuel used in Borno state Nigeria. Therefore, this study explored it via the use of primary data (field survey, 2020) obtained from some selected local government of Borno State based on a structured questionnaire. Descriptive statistics and multinomial logistics regression were used to analyze the data. The results reveal that the mean age of the household head and size were 41 years and 7 respectively. About 94% were married while 44% had secondary education with an average income of ₦21, 430 and most of them are farmers. The findings suggest that households' socio-economic characteristics strongly influence the likelihood of household choice for fuel use in Borno state. All the households use more than one fuel at a time with the combination of fuelwood and other sources of fuels for cooking. Charcoal had the highest mean expenditure of ₦5, 432. With regards to fuel for lighting, 58% of the households use other forms of alternative fuels other than electricity with the mean expenditure share for generator being the highest ₦2, 045. The conclusions were; fuel stacking model is superior for the households in this study area; also there is over-dependence of dirty fuels, which means more environmental degradation and pollution. The study recommends that both the private and public sectors should consider vigorous policies to reduce the incidence of poverty, to improve LPG use and electricity supply and to thrusts interventions aim at balancing biomass production and utilization.

Keywords: Household, fuel use, environment, Borno
JEL Code: Classification: C32, Q11, H56

Contribution/Originality
This study is one of its kind in the study area. Most studies done were either for one local government, region, the entire country or based on one energy source or strictly on cooking fuel types. Thus, this study contributes to literature by assessing the likelihood of using energy sources for both cooking and lighting homes in Borno State. Also, it debunks the famous energy ladder model in favour of fuel stacking model.

1.0 Introduction

The primary environmental concern in most developing countries centres on household cooking choices. The types of energy sources used are more relevant than ever before from a policy standpoint. Thus, Most countries have embarked on campaigns aimed at encouraging households to shift their

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energy types towards clean and efficient energy use that have less impact on the environment, social and health (Assa, Maonga & Gebremariam, 2015). The over-dependence on biomass fuel by households has contributed significantly to various environmental problems such as deforestation and forest degradation. Economic growth is also affected through the acceleration of soil erosion and the use of crop residue as fuel instead of manure to improve soil fertility which consequently leads to low food productivity (Food and Agricultural Organization [FAO], 2016). Similarly, the use of biomass as cooking fuel is associated with indoor air pollution leading to household respiratory health problems (Ezzati & Kammen, 2002). About 1.5 million people die prematurely annually due to indoor air pollution related to solid fuels use (International Energy Agency, 2006).

Household energy sources are classified into clean and dirty fuels (Maina, 2018). Clean energy sources include electricity generated from all renewable energy types such as wind, solar, Hydro and Geothermal (Quaschning, 2016). These clean fuels harm the environment minimally and are replenished continuously (Europa, 2015). Liquefied Petroleum Gas [LPG] on the other hand is also considered as a clean fuel source, although it originates from natural gas, it is non-toxic, and a high proportion of its energy content is converted into heat. It is more efficient than biomass fuels. Thus, it results in less energy wastage and more efficient use of natural resources (Nett technology, 2017). Dirty energy sources, on the other hand, include all forms of fossil fuels that significantly affect the environment and ~~to~~ the planet in general (Ciolkosz & Wallace, 2011). These dirty fuels include coal, oil, and natural gas. Burning these fuels release a substantial amount of Green House Gases [GHG] such as Carbon-dioxide CO_2, Carbon monoxide (CO) and Methane that accelerate Climate Change (CC) impact (Greenpeace, 2016 & James & Alhaji, 2017).

The households in the Northeast zone of Nigeria, where the study area (Borno) lies, rely heavily on dirty energy sources. The major factors influencing such energy used pattern include affordability, availability and accessibility. The use of electricity for cooking is very low in the urban areas due to the epileptic nature of its supply while the situation in the rural areas, is most households are not even connected to the National Electricity Grid. With regards to LPG., its relatively high cost hinders its acceptability (Maina, 2018). Thus, it makes the households too dependent on alternative source of fuels that are environmentally dirty. Similarly, Borno state the study area, despite being well endowed with a renewable energy source, e.g. solar energy, still the households use alternative fuels for cooking and lighting (FAO, 2019).

Apart from the aforementioned factors, the household's socio-economic characteristics such as monthly income, family size, age of household head and rural-urban dichotomy (area of residence) also do influence the pattern and the expenditure energy sources (Kavi & Brinda, 2007 & Maina, 2018). Hence, there is the need to understand the types of energy used by these households, whether clean or dirty, because their consumption pattern could have an implication on the environment.

Numerous studies have been conducted on energy use to mention, but a few are a study by Bello (2011), which assessed the impact of wealth distribution on energy consumption in Gombe state. Another study by Ojo, & Chuffor (2013) was on the accessibility to domestic energy but was among rural households of Damboa, which is a local government in the study area of this work. While Maina, Dantama & Kyari, and (2017) looked at determinants of energy demand in the northeast zone of Nigeria. Each of these studies has some shortfalls. Therefore, this paper bridges a gap by classifying the types of energy used in the study area as clean or dirty and their implications on the environment. This study considers three objectives it; examines the socio-economic characteristics of household heads, it assesses the determinants of the major factors influencing the likelihood of using a particular fuel, and it examines the pattern of energy used and its implication on the environment.

2.0 Conceptual issues and Literature Review

2.1 Effect of Fuel Consumption on the Environments

The exploitation of any energy source has an impact on the environment. However, the excessive use of dirty fuels generates more harmful greenhouse gases such as carbon dioxide (CO_2), which has serious environmental impacts. In Nigeria, due to the epileptic electricity supply, it has forced most households to resort to the use of numerous alternative fuels that are mostly dirty. Some of the energy sources for lighting include power generating plants that use petrol and diesel, candles and battery torchlight, while the fuels available for cooking include fuelwood, charcoal, kerosene and LPG (General Household survey [GHS], 2019). Each of these fuels emits a given quantity of CO_2. i.e. A KG or Litre of Petrol emits 2.4kg, LPG, 0.16kg, diesel, 2.7kg, kerosene, 2.6kg, charcoal, 3.6kg, firewood, 1.7kg and electricity, 0.10lbs (0.22kg) (Maina, 2018). Based on these conversion factors, only electricity and LPG are regarded as clean because of their minimal emission while all the rest are regarded as dirty fuels (Maina, Kyari & Jimme, 2020).

Aside from their impact on the Environment through CO_2 emission, the consumption of fuelwood and charcoal results to indiscriminate cutting down of trees, which results in several environmental impacts. Although the use of such fuels is considered “carbon neutral," i.e., the carbon released into the atmosphere through burning them is recaptured during the growth of the biomass (Kavi & Brinda 2005). However, the case is different in Nigeria; due to the non-replacement of trees, there is a high rate of deforestation and desertification. Out of the 909,890 km^2 of the country’s land area, about 580,841 km^2 accounting for 63.83% of total land impinged on by desertification (Olagunju, 2015). In fact, the country loses about 350,000 to 400,000 hectares of land per year to deforestation, which is caused by indiscriminate cutting down of trees without replacement (FAO, 2019). Consequently, it results in a high concentration of CO_2 in the atmosphere. Furthermore, the incomplete combustion as a result of burning of biomass fuels releases what is known as “black carbon” particles, which is a significantly stronger greenhouse gas pollutant than CO_2 (Kavi & Brinda, 2007).

Moreover, there is a rapid reduction in vegetation cover, which has significantly reduced the potential vegetative productivity of the zone’s land area (Mohammed, 2015). Apart from that, weather-related disasters have become more frequent in the last four decades, and the trend continues. This includes Severe flooding, which affects many households, including the urban area and has rendered numerous residents homeless, destroyed farmlands and causes loss of lives and properties (Enviro News, 2019). Thus, there is the need to assess the types of fuels used by the households of Borno state in order to influence policy decision on sustainable energy consumption in the study area.

2.2 Literature Review

Household socio-economic factors significantly influence the decision of fuel choices. However, variation exists as to whether the influence is positive or negative. Numerous studies conducted have established the relationship between the gender of household head and fuel choice decision (Ojo & Chuffor, 2013; Olaleye & Akinbode, 2012). It has been noted that a female-headed household would prefer to use a clean energy source than its male counterpart. This is because the women are responsible for cooking; hence, would opt for convenience as a choice option (Maina & Kyari, 2020 & Mensah, 2013).

Similarly, Family size has an influence on the choice of dirty fuel choices (Bello, 2011 & Maina, Kyari & Maina, 2019 & Buba *et al*. 2017). A household with more family members goes for cheaper fuels to compliment the financial burden of cooking for more household members. Hence, a small family size uses clean fuels; electricity and LPG, whereas fuelwood and other fuel sources are considered by larger families. Similarly, there is a positive relationship between rural households and dirty fuel sources than urban households, this is due to the availability of such dirty energy sources like an animal dunk, straws and fetched fuelwood in nearby bushes. (Maina, 2018 & Sa'ad & Bugaje, 2016).

Also, a positive relationship exists between the households' income and the choice for clean fuels (Danlami & Islam n.d. & Sa'ad & Bugaje, 2016). Poorer households in both rural and urban households opt for dirty fuels such as fuelwood, plant residues, and animal dung. In contrast, more affluent families tend to opt for clean energy sources (Assa *et al*., 2015 & Buba *et al*. 2017). Furthermore, a household head that is in his active age to support his family tends to use clean fuels, while he opts for dirty energy source when he is older (Mensah, 2013). Another factor is the educational level of the household head. The higher the educational level, the more he is aware of the negative impact of dirty fuels on the environment, the more he adopts clean energy source and vice versa (Assa *et al*. 2015). Similarly, there is a link between the type of job a household head does and the type of fuel to be used. A big executive or an entrepreneur adopts the use of clean fuel, while farmers and traders tend to opt for fuelwood and other dirty energy sources (Heltberg, 2005).

Moreover, the pattern of energy uses among Nigerian households revealed that there is the prevalence of multiple fuels for cooking among the households in Nigeria in both rural and urban among all the income groups. However, households opt for clean energy (LPG) as incomes increase (Maina & Kyari, 2019). In comparison, the use of power generating plants that use petrol and diesel for lighting among urban higher income earners have also been observed (Olaleye & Akinbode, 2012, Omolade, Nwosa, & Amassoma, 2019 & Maina, Kyari & Dori, 2020).

3.0 Methodology

3.1 Study Area

The study was conducted in some selected Local Government Areas of Borno State, Nigeria. It lies between latitude $11^0 49`$ and $59^0$ 99` North of the equator and longitude 13 9` to $0^0$ 00` East of the Greenwich Meridian. The average high temperature in April is $36^0c,$ while the average low temperature in December is12^0c. The population of the area was 4,171,104 according to the census (2006). This figure is projected to increase to 6,196,137 at the end of the year 2020 (NPC, 2006).

3.2 Sampling Techniques and Sample Size

The State is divided into three senatorial zones; Borno Central, North and South. The first stage involved the purposive selection of three Local Government Areas due to the activities of the Boko Haram insurgents. Therefore, Maiduguri, which comprises of the Metropolitan Council and some part of Jere were chosen to represent the urban area. In contrast, Askira/Uba and Magumeri represent the Southern and Northern zone, respectively as the rural areas. The second stage was the random selection of six wards in Maiduguri urban area (Maisandari, Gwange II, Bolori I, Polo, Gomari custain, Bulaburin garannam). Twenty-six households were proportionately selected from each of the wards, making it 156 houses in the urban area. In the rural areas, four wards were randomly selected, and 24 households from each making a total of 96. The wards include from Askira Uvu/Uda and Lassa while from Magumeri (Magumeri and Gaji gana). In total 252 households were considered for the study, however two questionnaires were not retrieved; hence the sample size used was 250.

3.3 Data Collection

The data for the study were obtained using primary source collected using well-structured questionnaires, administered to the respondents, with the assistance of trained enumerators in the study area. The questionnaires involved both open and close-ended questions. The information collected includes the socio-economic characteristics of the household's head and the types of fuels used for cooking and lighting.

3.4 Analytical Technique

3.4.1 Descriptive Statistics

Descriptive statistics were used to describe the characteristics of the data set through the use of frequencies, mean and measurement of variability in the form of standard deviation. It was used to present the various socio-economic factors of the household heads and the pattern of energy consumption in the study area.

3.4.2 Multinomial Logistic (MNL) Regression

A consumer derives his utility from the consumption of a good by disaggregating it into attributes that cannot be attained independently. These attributes create options from which he can choose from. These choices are modelled in consumer theory and presented by using a multinomial logit model (random utility theory) as proposed by Lancaster (1966). This study, therefore, adopts this model to estimate the utility associated with mutually exclusive and highly differentiated fuels among households in Borno state as adopted by Assa *et al*. (2015).

An n household chooses from a set of mutually exclusive fuel choices, $j = 1 \ldots\ldots J$. Utility is achieved at U_{nj} from each alternative. The discrete choice model is built on the belief that a household chooses the outcome that maximizes utility. The study did not assess households' satisfaction but the satisfaction derived from the various fuels considered based on their qualities from which the households choose from. Therefore, the utility is decomposed into deterministic Vnj and random part εnj:

$$U_{nj} = \Psi_{nj} + \varepsilon_{nj} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{[1]}$$

The error term ε_{nj} is unobservable and makes the prediction of an individual's choice not to be exact. However, we derive the probability of any particular outcome. The stochastic part has a density $f(\varepsilon_{nj})$. The joint density for a vector of the stochastic portion is denoted as $f(\varepsilon_n)$. To map out household n's choice of alternative i on a range of J alternatives, we use probability:

$$P_{ni} = \Pr(U_{ni} > U_{nj}, \forall\ j \neq i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{[2]}$$

$$P_{ni} = \Pr(U_{ni} + \varepsilon_{ni} > U_{nj} + \varepsilon_{nj} \forall_j \neq i)$$

$$P_{ni} = \int I(U_{ni} + \varepsilon_{ni} > U_{nj} + \varepsilon_{nj} \forall_j \neq i) f(\varepsilon_n) d\varepsilon_n$$

Where I (.) is the indicator function, which is 1 when the term in parenthesis is true and 0 otherwise, this is a multidimensional integral over the density of the unobserved portion of utility f (ε_{nj}). The density for each unobserved component of utility and the cumulative distribution is given, respectively, by (McFadden, 1974);

$$\lambda(\varepsilon_{nj}) = e^{-\varepsilon nj} e^{-e^{\varepsilon nj}} \text{ .... [3]}$$

$$\Lambda(\varepsilon_{nj}) = e^{-e^{-\varepsilon nj}}$$

The probability that household *n* chooses alternative *i* among the *J* alternatives to cooking fuel is given by (McFadden, 1974);

$$P_{ni} = \Pr(\varepsilon_{nj} < V_{ni} - V_{nj} + \varepsilon_{ni} \forall_j \neq i) \text{ .... [4]}$$

$$= \int \prod_{j \neq i} \Lambda(V_{ni} - V_{nj} + \varepsilon_{ni}) \lambda(\varepsilon_{ni}) d\varepsilon_{ni}$$

Thus, the choice probability is the integral over all values of ε_{nj} weighted by its density λ (.) as defined in equation (3). It is hypothesized that an individual's choice of an attribute is determined by a vector of socio-demographic characteristics. This relationship between the vector of socio-demographic characteristics and the dependent variable is established by the estimation vector of parameters φ using the log-likelihood method. Maximizing log-likelihood function for the parameter vector yields (Stern, 1997);

$$\ln L(\phi) = \sum_{n=1}^{N} \sum_{j=1}^{J} y_{ni} \ln P_{nj} \text{ .... [5]}$$

In equation (5), y_{ni} is 1 when fuel *j* is chosen and 0 for all other strategies that are not chosen. Assuming each error term ε_{nj} for all alternatives *j* is identically and independently distributed, the logit probability that an individual will choose alternative *j* will be; = Ψ_{nj} + $\dot{x}_n$ β_j

$$P_{ni} = \frac{e(x'_n \beta_i)}{\sum_j e(x'_n \beta_j)} \text{ .... [6]}$$

Since M.N.L. is a model where regressions do not vary over choices, coefficients are estimated for any choice. The dependent variable is the cooking fuel choice (firewood, charcoal, kerosene, electricity, LPG, and generator). M.N.L. requires identification: one of the choices, say *j*, is treated as the base category (correspondent is constrained to equal 0). Use of firewood is set as the reference choice in this study while other predictor variables are held constant. The estimated coefficients give a measure of the change in the logit associated with a unit change in the predictor variable.

Table 1 Independent Variables measurement

Variables	Measurement
Fuel use	This is the dependent variable for this study. It is measured in a dummy form given as =1 for households who use a particular fuel source and zero (0) for those who did not use it.
Household monthly income	Household Monthly income is proxied by total household monthly expenditure.

Household size	The variable is measured as the total number of individuals dwelling in the same house and sharing meals together.
Age	This variable is measured in years as the total number of years since the person was born.
Sex	Sex of respondent is a binary variable representing a value of 1 for male and 0 for female.
Rural-Urban dichotomy	This is also a dummy variable representing 1 for urban and 0 for rural.
Educational level	The variable is measured by the number of years spent in formal schooling.
Fuel expenditure	This represents the budget share allocated to a particular fuel type. It is measured in Naira (₦)

4.0 Results and Discussion

4.1 Socio-economic Characteristics of the Household Heads

This study examines the classification of the household heads' socioeconomics factors in order to assess their influence on the likelihood to use a particular fuel for cooking or lighting. Table 2 presents the result.

Table 2 Socioeconomic Characteristics of the Household Heads

Socio-economic Factors	Frequency	Percentage	Mean
Marital status			
Single	13	5.2	
Married	234	93.6	
Divorced	1	.4	
Separated	2	.8	
Educational			
Primary	83	33.2	
Secondary	112	44.8	
Post-secondary	44	17.6	
Vocational	11	4.4	
Gender of household head			
Male	210	84.0	
Female	40	16.0	
Age			
<20	4	1.6	
20-30	60	24.0	
31-40	67	26.8	41
41-50	66	26.4	
51-60	35	14.0	
>60	18	7.2	
Household size			

<3	110	44.0	
3-6	26	10.4	
7-10	87	34.8	
11-13	19	7.6	
>13	8	3.2	7
Income			
<₦ 20000	72	28.8	
₦ 20001-₦ 40000	68	27.2	
₦ 40001-₦ 60000	51	20.4	
₦ 60001-₦ 80000	44	17.6	
₦ 80001 and above	15	6.0	₦21,430.50
Major occupation			
Farming	115	46.0	
Farm labourer	33	13.2	
Civil Servant	29	11.6	
Artisan/Craftsman	24	9.6	
Trader/Business	39	15.6	
Clergy	9	3.6	
Uniformed personnel	1	.4	

Source: Field Survey 2020

Table 2 shows that the majority (93.6%) of the households were married. This shows that most of these households use one fuel type or another for cooking or lighting their homes because a married household comprises of a head, wife and children, hence the need to use one fuel or the other. This result is in line with the marital status of the farming households in Odede local government of Ogun state (Adepoju, Oyekale & Aromolaran, 2012). The education level of the household head showed that 44.8% have secondary education. This could influence the household's fuel choice decision as it translates to the level of awareness. The more informed they are about the effect of fuels on the environment, the better their fuel choices. This coincides with the findings of Maina *et al.* (2017) for Nigerian households.

Similarly, male gender constitutes the highest with a mean of 84%. This coincides with that of the household heads in the northeast zone of Nigeria (Maina *et al.*, 2019). The study area is located in the northern part of the country whereby the norm, tradition and culture of the area give the male gender the role as the household head. Thus, he is responsible for taking all the household decision due to his economic importance (FAO, 2010). Age of the household head, on the other hand, showed an average of 41 years. This falls within the active period identified by FAO (1992). Thus he can influence the energy decision of his household. The mean household size was seven which is similar to the result of Maina *et al.* (2019). This could imply that a small household size would use clean energy source than a large household, due to the financial burden that comes with such size. The average monthly income of the household head was ₦21, 430.50. This is lower than the report of Maina & Kyari, (2020). Income is a significant factor, as depicted by the energy ladder model. Hence, a higher level of income influences the choice of clean fuels. The occupational status of the household heads shows that majority of them are farmers. This coincides with the job classifications of the households in Gombe, as shown by Bello (2011). The implication of this is, the nature of one's occupation determines the type of fuel to be used as it relates to income.

4.2 Socio-economic Factors Influencing the Likelihood of Using Fuel in Borno state

This study examined the socio-economic factors influencing the likelihood of a household to choose one fuel over the other. The results presented in tables 3 and 4.

Table 3: Multinomial Logit Estimates

	Charcoal	**Kerosene**	**Electricity**	**Gas**	**Generator**	**touch/candle**
Firewood	base outcome					
Region	0.103	0.14***	0.256**	0.476***	0.157***	0.164***
	(0.0073)	(0.0034)	(0.108)	(0.091)	(0.036)	(0.05)
M. status	0.168***	0.294***	0.216**	0.651**	0.98	1.687
	(0.038)	(0.071)	(0.109)	(0.03)	(2.365)	(3.41)
Education	0.207**	0.394***	0.566**	0.304**	0.075**	0.075
	(0.055)	(0.051)	(0.091)	(0.04)	(0.023)	(0.123)
Sex	0.493	0.393	-0.245	0.875	1.521	-1.902
	(1.69)	(1.398)	(2.33)	(1.698)	(1.498)	(2.909)
Age	0.061	-0.082	0.809***	0.251**	0.657***	0.415**
	(0.623)	(0.614)	(0.128)	(0.022)	(0.021)	(0.019)
Income	0.709**	0.803**	0.118**	0.489**	0.264**	0.652***
	(0.274)	(0.039)	(0.025)	(0.112)	(0.052)	(0.197)
	-0.1162**	-	-0.1850**	-0.4145***	-0.2138***	-0.7325***
Family size	(0.0232)	0.0204**	(0.0289)	(0.0189)	(0.0522)	(0.0934)
		(0.0089)				
E.	-0.0883***	0.2135	0.1881	0.0456**	-0.1866	0.7604***
expenditure	(0.0236)	(0.2043)	(0.0122)	(0.0231)	(0.2419)	(0.2401)
	3.904**	3.41***	2.977***	4.78***	0.499***	4.78***
_cons	(0.045)	(0.0470)	(0.1350)	(0.3372)	(0.0953)	(0.3372)
Number of observations = 250						
LR χ2(54) = 1543.2						
Pseudo R-Squared = 0.5888						

Source: Field Survey, (2020), ****** p<0.01, ** p<0.05, the values in parenthesis are standard error.***

The coefficient results from the estimation of the multinomial logit model described in Section 3.4.2 is presented in Table 3, and the corresponding marginal effects are shown in Table 4. Table three shows the directional relationship between fuelwood as the reference group and the other fuel sources.

Table 4: Marginal Effects of Multinomial Logit Estimates

	Charcoal	Kerosene	Electricity	Gas	Generator	**Touch/candle**
Firewood	base outcome					
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Region	0.001	0.0014***	0.0026**	0.0048***	0.0016**	0.0016**
	(0.0073)	(0.0003)	(0.0011)	(0.0009)	(0.0004)	(0.0005)
M. status	0.0017**	0.0029**	0.0022**	0.0065***	0.0098	0.01687
	(0.0004)	(0.0007)	(0.0011)	(0.0003)	(0.0236)	(0.0341)
Education	0.0021**	0.0029**	0.0057***	0.0030***	0.0008**	0.00075
	(0.006)	(0.007)	(0.0009)	(0.0004)	(0.0002)	(0.00023)
Sex	0.0049**	0.0039**	-0.00245	-0.0088**	0.01521	-0.019**
	(0.0017)	(0.0043)	(0.0233)	(0.0016)	(0.015)	(0.0029)
Age	0.0006	-0.0008**	0.00809	0.00251	0.0066**	0.00414
	(0.0062)	(0.061)	(0.0013)	(0.02)	(0.0002)	(0.19)
Income	0.0071)***	0.008***	0.0012***	0.0049**	0.0026***	0.0065**
	(0.0024)	(0.0004)	(0.0003)	(0.0011)	(0.0005)	(0.00197)

Family size	-0.0012***	-0.00020***	-0.00185***	-0.00414***	-0.00214***	-0.00733***
	(0.00023)	(0.00009)	(0.00029)	(0.00019)	(0.00052)	-(0.00093)
Fuel expenditure	0.0009**	0.0021	0.00188	0.00046	0.0024**	0.0023
	(0.0002)	(0.002)	(0.99912)	(0.023)	(0.0067)	(0.301)

Source: Field Survey, (2020), ****** p<0.01, ** p<0.05, the values in parenthesis are standard error.***

Table 4 shows the marginal effects of a unit change in a given explanatory variable (or a switch in the case of dummy variables) on the probability of choosing each one of the six types of fuels. These marginal effects are interpreted as the measure of the probability that the factors have on influencing the choice of household fuels. The first variable considered in the equation was a region or area of residence. It was a dummy variable with the allocation of one for urban residence and zero for rural. The empirical results from the study as presented in table 4 indicate positive and significant coefficients for kerosene, and LPG at 1% respectively, while it is 5% significant for electricity, generator and candle/torchlight. These suggest that the urban households in Borno would prefer to use these fuels other than fuelwood for cooking and lighting homes. The results imply that there are differences in the choice behaviour of households living in the different areas of the study area with urban households using more of other alternative fuels instead of fuelwood in their home. This coincides with the findings of *Assa et al.* (2015). Thus, a 1% increase in the population of the urban household is more likely to increase kerosene use by 0.14%, electricity 0.26%, LPG 0.48%, 0.16% and candle/torchlight at 0.16%

Similarly, the coefficients of marital status were positive and significant for charcoal, kerosene, and electricity at 5% levels while LPG at 1% as their fuels combinations for cooking and lighting homes instead of fuelwood. This is in line with the findings of Maina (2018) for cooking fuels & Maina *et al.* (2020) for alternative energy sources for lighting. A 1% increase in a married household in the study area has the tendencies of using increasing charcoal use by 0.17%, kerosene 0.29%, electricity 0.22% and LPG by 0.65%. The results from table 4 present positive and significant coefficients for charcoal, kerosene, LPG, and generator at 5% levels respectively, while LPG at 1%. This suggests that the more educated the household head is more the probability of using these fuels. Similar results were reported by Buba *et al*. (2017). A higher level of education increases the likelihood of the household head to use the alternative fuels charcoal by 0.21%, kerosene 0.29%, electricity 0.57%, LPG 0.30% and generator 0.08%. This implies that the more the household head is educated, the less likely he uses fuelwood, hence lower tendencies of environmental degradation through deforestation. Although the use of charcoal and generator, also have their negative effects. However, the frequency of usage would be less, especially for generating plant when compared with that of fuelwood.

Furthermore, the findings reveal that the coefficients of sex (male) are significant for charcoal and kerosene at 5% respectively. In comparison, LPG and candle/torchlight are negative but significant to the female-headed household at 5% respectively. This implies that a male-headed household would prefer to use charcoal and kerosene than fuelwood. In contrast, the female-headed household has more probabilities of using fuelwood instead of LPG and candle/torchlight. Thus, a 1% increase in a male-headed household will increase the use of charcoal and kerosene by 0.17% and 0.43%.respectively. In contrast, an addition of a female-headed household would reduce the use of LPG and candle/torchlight by 0.16% and 0.29% respectively. The less use of LPG by the female-headed household is contrary to the findings of Maina and Kyari (2020) for female-headed households in Nigeria. The coefficient of age for the generator was positive and significant at 5% suggesting that as the household head grows old, he is more likely to use a generator in lighting his home than fuelwood. In comparison, the result of kerosene was negative but significant at 5%. It shows that the probability of using kerosene is less compared to that of fuelwood among young household heads. The use of the generator as household head's age increases could be due to the unreliable nature of electricity supply in Nigeria; thus, they have resorted to the use of the generator as an alternative fuel to light their homes. However, the increase in fuelwood use as against kerosene for cooking among the young household heads implies that they are in their active age to fetch fuelwood in nearby bushes at no cost. This agrees with the findings of Maina *et al.* (2017). Hence, an increase in the age of a household head will raise the share of generator users by 0.66% while decreasing the share of kerosene use by 0.88%.

Furthermore, the result also shows that as income increases the likelihood of using all the energy sources increases at 1% level respectively. This implies mostly low-income household uses fuelwood; this confirms the energy ladder model. The result is in line with the findings of Bello (2011). A 1% increase in income will increase the probabilities of using charcoal, kerosene, electricity, LPG, generator and candle/torchlight by 0.71%, 0.08%, 0.12%, 0.26% and 0.65% respectively.

Similarly, the coefficients of all the estimate are significant at 1% respectively. They indicate a positive relationship between an increase in family size and the probability of using fuelwood all the other fuels. The result agrees with the findings of Adepoju *et al*. (2012). It means that with no increase in the income of the household, an addition of a member places an extra financial burden. Thus, it becomes difficult for them to use other fuels but fuelwood which is comparatively cheaper to use in lighting homes and cooking for many people as it has a lower consumption rate per unit of time compared to the other fuels. Hence, an addition of one person to the household will decrease the share of all the fuels by charcoal, kerosene, electricity, LPG, generator, candle/torchlight by 0.12%, 0.02%, 0.185%, 0.414%, 0.214% and 0.733% respectively. Also, the results in Table 4 suggest that the coefficients of expenditures on charcoal and generator are positive and significant at 1%. A similar result was reported by Heltberg (2005). It indicates that a unit increase in expenditure on these fuels would decrease the probability of a household's choice of firewood to charcoal and generator by 0.09% and 0.24% respectively. The highest mean expenditure shares can be justified in Table 5 and 6.

4.3 The Pattern of Fuel Use and its Implication on the Environment

In order to determine the implication of energy used by the households of Borno state on the environment, this study examined the pattern of both cooking and lighting fuels. Tables 4 and 5 present the results.

Table 5 Pattern of Cooking Energy in the Study Area

Number of Cooking Fuels used	Frequency	Percentage
Two Fuels Users	130	52
Three Fuels Users	120	48
Total	250	100
FUEL USE COMBINATIONS		
Firewood/Electricity	61	28
Firewood/Kerosene	45	20.6
Firewood/Gas	42	19.3
Firewood/Crop Residue/Saw Dust/Animal Dung	21	9.7
Firewood/Electricity/Kerosene	21	9.6
Firewood/Electricity/Gas	21	9.6
Firewood/Electricity/Crop Residue/Saw Dust/Animal Dung	7	3.2
Total	218	100

Expenditure on Energy	Frequency	Percentage	Mean	ST.DEV.
Firewood	55	26	3,132.40	1223.2
Electricity	44	18	2,341.40	876.5
Kerosene	20	8	2,193.66	1097.6
Gas	36	14	1,234.30	675.4
Charcoal	81	32	5,432.10	2341.5
Crop Residue/Saw Dust/ANIMAL DUNG	4	2	348.75	104.95

Source: Field Survey 2020

Table 5 presents the number of cooking fuels used by the household in Borno state at a time. The number of fuels with the highest frequency is the combination of two fuels which constitute (52%) of the households while those that used three fuels were (48%). A similar range was reported by Maina and Kyari (2020) for the female-headed households in Nigeria. The use of biomass fuels charcoal, fuelwood and crop residues/animal dung constitute the highest with the sum total of 58%. It can be observed that all the households use fuelwood combined with some other fuel. This confirms that fuel stacking exists among households. The mean expenditure shares show that the households spend more on the use of dirty fuels, charcoal and fuelwood for cooking. The highest mean expenditure was allocated to charcoal, followed by fuelwood, electricity, kerosene, generator plants while LPG and animal dunk/sawdust were the least. Similar results were reported by Maina, Kyari and Jimme (2019) for Nigerian household. Moreover, all the values of their standard deviation were lower than their means values. This implies that the expenditure shares do not vary among the households.

Table 6: Pattern of Lighting Fuels

Number of Fuels for Lighting	Frequency	Percentage		
Two Fuels Users	180	72		
Three Fuels Users	70	28		
Total	250	100		
Fuel Combinations				
Firewood/Electricity	45	18		
Electricity/Generator	112	45		
Firewood/Candle	15	6		
Firewood/Touch battery	3	1		
Firewood/Electricity/candle	32	13		
Firewood/Electricity/Touch battery	44	17		
Total	250	100		
Expenditure on Energy			**Mean**	**St.dev**
Firewood	50	20	1152.7	572.3
Electricity	104	42	1528.9	572.4
Generating plant	56	22	2045.5	798.7
Touch Battery	36	14	354.7	80.6
Candle	4	2	100.8	56.5

Source: Field Survey 2020

Similarly, table 6 represents the combination of fuels used for lighting homes in the study area. Just like fuels for cooking, all the households use more than one fuel for lighting their homes at a time. Majority 72% use two fuels while the remaining 28% use up to three. A similar result of using multiple fuels for lighting was reported by Maina *et al.* (2020) for Nigerian households. About 42% of the households use the two dirty fuels (fuelwood and generator). The mean expenditure shares show that a larger share of ₦2045.5 was allocated to the use of power generating plant than on electricity. The high mean expenditure on generator use could be justified by the fact that it is fueling it daily, weekly or monthly costs more or takes greater budget share allocation than any other energy type. More so, the values of their standard deviation were also lower than their means, implying that there no variation in the expenditure shares among the households.

4.3.2 The Implication of the fuels Used patterns on the environment

It can be observed that all the households use fuelwood and some other fuels for cooking. On the part of the fuels for lighting homes, only 45% of the households used the combination of electricity and generating plants while the rest 55% combined fuelwood with other sources of lighting as fuels. This justifies the high mean expenditure of fuelwood, although that of charcoal was also very high. This means that there is overdependence on biomass fuel for cooking and lighting in the study area.

Undoubtedly the exploitation of biomass results to the loss of tracts of natural forest which causes deforestation and when such is even done on a commercial scale for urban fuelwood and charcoal markets it threatens the forests and certainly contributes land degradation. Similarly, in agricultural regions, where more general resource pressures are felt, such as in rural areas, fuelwood gathering for local use has a marginal impact on land resource quality. It is a problem precisely where the rural economy and environment are most vulnerable, especially in localities, where the resource is already under threat and where the community has the fewest resources to counter this threat.

There is also an impact on the part of the household members collecting fuel wood. It is time-consuming and above all a strenuous burden on the women who are typically more responsible for collecting it in most rural areas, despite their other activities such as fetching water, caring for children and doing agricultural work. Besides, cooking with biomass produces smoke which affects the health of these women (Sana *et al*., 2019). Consequently, it affects their productivity on the farm, thereby resulting in food shortages, rise in poverty and in return, more environmental exploitation for survival (Waris & Antahal, 2014).

The use of power generating plant, on the other hand, also has its effect on the environment. The more petroleum or diesel is burnt in the process of power generation, the more it creates environmental pollution, which is harmful to the atmosphere (Maina, 2018). Hence, the higher the concentration of the pollutants in the form of greenhouse gases in the atmosphere, the more they deplete the ozone layer which causes global warming and consequently climate change (International Panel on Climate Change [IPCC], 2001). While climate change results to change in temperature and seasonal duration in the form of rainfall duration, which leads to flood or drought. It consequently causes food scarcity, diseases etc. and the circle continues until it is mitigated (The Nature Conservancy, 2013).

5.0 Conclusion

Majority of the household heads in Borno state are male in their active age characterized by small family size mostly had secondary education. Almost all the household heads are married, characterized by low-income level, and most of them are farmers. Concerning the likelihood to choose fuels, our findings suggest that households' demographic characteristics strongly influence the likelihood of household choice for fuel use in Borno state. Furthermore, most households use two or more fuels for both cooking and lighting their homes with over-dependence on biomass use. Making fuel-stacking model the superior for their fuel consumption pattern. The mean expenditure of charcoal and fuel wood were the highest for cooking fuels while generator has the highest for lighting energy source. The implication of the pattern of their fuel use on the environment is that too much reliance on biomass causes indiscriminate cutting down of trees and the burning of petrol to generate light in power plants contributes to the high concentration of pollutants in the atmosphere.

6.0 Recommendations:

- Firstly, the socio-economic characteristics of household heads influence fuel choices in Borno state. To effectively reduce the use of dirty fuels, there is a need for vigorous policies to reduce the incidence of poverty through provision for social security insurance scheme to improve the living condition of the households.
- Secondly, an increase in income increases the likelihood of using all the alternative fuel sources studied but fuelwood. However, only electricity and LPG are regarded as clean fuels. Therefore, the government should improve the use of LPG at the household level. It can be achieved by making the installation costs cheaper, by the importation of cylinders and other equipment required duty-free so that it can be relatively cheap compared to the other cooking fuel sources. With regards to lighting fuels, the expenditure on the use of the generator is the highest. This places a higher financial burden on households. Therefore, to mitigate such impact too, the government should improve electricity supply by investing in solar energy since the study area is blessed with abundant solar radiation.
- Finally, in terms of the most used fuel based on the household pattern in Borno state, fuelwood is the most used. Hence to mitigate its implication on the environment, there is a need for a policy that thrusts interventions aim at balancing biomass production and utilization. It can be achieved by advocating for households and communities to establish their woodlots and to promote improved and fast regenerating trees to maintain sustainable production.

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