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ASSESMENT OF FACTORS INFLUENCING FIREWOOD CONSUMPTION IN BAUCHI STATE, NIGERIA

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Abstract: Firewood is the main source of fuel for the majority of households in Bauchi state, whereby about 95% of households use firewood as their main source of cooking fuel. This study was conducted with the main aim of analysing the socio-economic factors influencing the quantity of firewood use in Bauchi state, Nigeria. A total of 750 households were selected out of which responses from 539 households were analysed. Ordinary least squares (OLS) regression model was used as the tool of data analysis. The result indicates that household head being male and the number of rooms in the home have positive impact on the quantity of firewood consumption. On the other hand, price of firewood and kerosene as well as the level of education of the household head; have negative impacts on the quantity of firewood consumption. Therefore, a policy that will increase the cost of firewood bundle and the level of education of the people in the study area will reduce the consumption of firewood in Bauchi state, Nigeria.

KEYWORDS: Determinants, household, firewood, consumption, ordinary least squares

Introduction

It is argued that about more than two and a half billion people world over depend majorly on the traditional biomass fuel as their source of energy for cooking, heating and lighting; mainly in developing countries (Kowasari & Zerriffi, 2011). Likewise in Africa, solid biofuels are reported to account for about 50% of Africa's energy needs (IEA, 2011). In Bauchi State, firewood serves as the main source of fuel for the majority of households whereby about 95% of households use firewood as their main source of cooking fuel (NBS, 2012). On average, the use of firewood per a household in Bauchi State is about 600 kg monthly which are predominantly obtained from friends' farmlands, forest reserve and or purchase from the market (Akpan *et al.,* 2010). However, the use of firewood for cooking purpose has negative impacts on the atmosphere, environment and peoples' lives (Nlom & Karimove, 2014). Acute respiratory infections (ARI) in children are one of the leading causes of infant and child morbidity and mortality (Schirnding *et al.,* 2002; Emmelin & Wall, 2007). Studies have found associations between firewood use and lung cancer. A 30 year old woman cooking with straw or wood has an 80% increased chance of having lung cancer later in life (Hong, 1991; WHO, 1991).

The rampant use of firewood as a fuel source for the majority of the households in Bauchi State has posed negative impacts to the inhabitants of the State. The first negative impact of wider use of firewood as the main source of fuel in Bauchi State is the systematic destruction of the State's forest reserves and wood lands (Ay *et al.,* 2011). The rapid environmental problems in the State such as; soil erosion and the persistent desertification are some of the consequences of such rapid felling of trees (Danlami *et al.,* 2017a). In fact, Bauchi State government argued that the State loses on average not less than one kilometre of land area because of desertification mainly caused by high rate of felling trees for cooking fuel and some other relevant uses (Tide, 2010). The underlying rational here is to encourage households to reduce the use of firewood to the adoption of other cleaned fuels (Ritche *et al.,* 1981). This is due to so many benefit of doing so, such as; improvement in living standard, consumption of less fuel per meal and less time for gathering fuel leading to access to education, healthcare and other beneficial activities (Smith *et al.,* 2005; Wilkinson *et al.,* 2007; Yamamoto *et al.,* 2009; Ganchimeg & Havrland, 2011; and Lee, 2013).

Though there are studies on household

firewood consumption in both developed and developing areas, there exist inconsistencies on the findings and conclusions of such studies. For instance, some studies (Oyekale *et al.,* 2012; Lee, 2013; Nlom & Karimove, 2014; Danlami *et al.,* 2018a) found that income has a positive significant relationship with household use of firewood. On the other hand, some studies (Mekonon & Kohlin, 2008; Onoja, 2012; Song *et al.,* 2012) found the relationship to be negative. While Couture *et al.* (2011) and Jingchao and Kotani (2011) concluded that there is no any significant relationship between income and household firewood consumption. Additionally, variables like; age of the household head, level of education of the household head, household size, occupation, size of the dwellings; were concluded to be positively related to household firewood consumption by studies like Ganchimeg and Havrland (2011), Nnaji *et al.* (2012) and Onoja (2012). On the other hand, Heltberg (2005), Jingchao and Kotani (2011) and Song *et al.* (2012), found these relationships to be negative. Additionally, some studies such as Jumbe and Angelsen (2010) and Laureti and Secondi (2012) concluded that there is no significant relationship that exists between these variables and household firewood consumption.

This implies that the findings of one study from a particular specific area cannot be generalised to another area due to environmental cultural and socio-economic differences. Hence none of these studies conducted took Bauchi State as the case of analysis. Therefore, this study will analyse determinants of firewood consumption in Bauchi state, Nigeria. The remaining parts of the paper are explained as follows; section two consists of literature review, section three indicates the methodology adopted by the study, section four is the discussions of results and findings. The last section is the conclusions of the study.

Literature Review

Analysing Household consumption of firewood is one of the areas that attracted the interests of researchers. For instance, Abdurrazak *et al.* (2012) found that over the years, households keep on increasing their consumption of firewood because of availability and cheapness. On the other hand, there has been decreased in the consumption of modern clean fuel. However, this study is limited by the use of only descriptive statistics in its analysis with no econometric estimation to support their arguments. Similarly, Danlami *et al.* (2015) analysed the factors that influences household firewood consumption. However, the analysis is limited to conceptual analysis with no econometric tool of data analysis

On the other hand, Onoja (2012) indicated that distance from the firewood source and household income are the variables that have negative impacts on the consumption of firewood, while price of kerosene and household size are positively related to the consumption of firewood respectively. Logit analysis by Danlami *et al.* (2017a) shows that income, number of rooms and nature of the home building are negatively related to the odds of adopting firewood sources. Age of household head, gender of household head and home appliances are positively related to the odds of adopting firewood sources.

Oyekale *et al.* (2012) found that price of firewood and the households' heads' levels of education have a negative relationship with the adoption of firewood use by the households. On the other hand, level of income of the household has a positive relationship with the use of firewood by the households respectively, this conforms the findings of Onoja (2012). Couture *et al.* (2012) conducted a study to investigate the determinants of fuel wood consumption in France. The result indicates that fuel wood consumption is positively related with homes where there exists an open fire place, while the fuel wood price is negatively related to the fuel wood consumption.

Osiolo (2010) used OLS regression to estimate the determinants of household fuel wood expenditure in Kenya. Out of the seven variables estimated, only two were found to be statistically significant in influencing household's consumption of fuel wood. These

variables are older household head with 40 years and above, and also household head with only primary education. The conclusion is that households with head that has one or both of these two characteristics tend to consume more firewood than otherwise.

Furthermore, Song *et al.* (2012) conducted a study to identify factors affecting wood energy consumption by US households. The study found that the size of household have positive significant influence on household wood consumption. Pundo and Fraser (2006) concluded that education level of both the husband and wife, as well as nature of dwelling encourages households to adopt more energy source from charcoal instead of firewood. Danlami *et al.* (2018b) found that increase in income and living in urban areas reduce the probability of using firewood as the main source of cooking fuel in developing areas. Similarly, Link *et al.* (2011) used logit model to analyse the determinants of households' adoption of firewood. Factors like; household income, number of adults in the household and the distance from the source of fuel, increases the probability of households to adopt firewood source of energy than otherwise. Abebaw (2007) concluded that as household size and level of education of the household's head exact negative impact on fuel wood consumption, per capita income and the household's head being male encourage the consumption of fuelwood.

The inconsistencies in the findings of these studies indicated that not all factors are equally important in different areas and locations as per influencing household energy consumption. The findings from one area cannot be generalised to another area due to geographical, environmental, and socio-demographic differences from one area to another. Therefore, analysing household firewood consumption in a new area of study is an additional contribution to the existing literature.

Materials and Methods

Being analysing the pattern and determinants of household firewood consumption in Bauchi State, this study considers the households living within the boundary of Bauchi State, Nigeria. The total estimated number of households as at 2014 was 769,960 (UNFPA, 2014). These households are spread in the three geopolitical zones of the State namely; Bauchi zone, Ningi zone and Katagum zone. The sampling technique used in this study is the multistage cluster area sampling. The reason for adopting this sampling method is that though the sampling frame for the various clusters of Bauchi State is available and was obtained from the National population commission office, there is no available frame containing the list of households living in Bauchi State. Hence in this situation, area sampling is one of the most suitable techniques of data collection. In the first stage, the whole of the study area was divided in to three groups (clusters) based on the geo-political zonal categorisation of the state, the various categories are; Bauchi south, Bauchi central and Bauchi north. In the second stage, two clusters (Bauchi south and Bauchi north) were selected randomly out of the three clusters.

In the third stage, these two clusters were further categorised into two sub clusters; urban and rural areas. Then a total of ten (10) wards were randomly selected from the urban areas while a total of thirteen (13) wards were selected randomly from the rural areas. This gives a total of twenty-three (23) selected wards used as the sampling wards. In the fourth stage, six communities were selected randomly from each of the selected wards of urban areas which made a total of sixty (60) communities from the urban areas. On the other hand, another six communities were randomly selected from the selected wards of the rural areas making a total of seventy-eight (78) communities used from the rural areas. This gives a total of one hundred and thirty-eight (138) sampled communities used in the study. In the last stage, six households were systematically selected from each of the selected communities of the urban areas making a total of three hundred and sixty (i.e. 60*6 = 360) households selected from the urban areas. On the other hand, five (5) households were selected systematically from each of the

selected communities of the rural areas making a total of three hundred and ninety (i.e. 78*5 = 390) households selected from the rural areas. Though finally, a total of 548 households participated in the study (i.e. the number of the returned questionnaires).

A total of seven hundred and fifty (750) questionnaires were issued out of which a total of five hundred and forty eight (548) (more than 70% response rate) questionnaires were received back, out of which nine (9) questionnaires were discarded, thereby leaving the analysis to depend on the remaining total of five hundred and thirty nine (539) samples.

The Model

The objective of this study was to assess the determinants of household consumption of firewood in Bauchi state, Nigeria, using the OLS regression method. Following Petersen (1982), Lee (2013) and Danlami (2014; 2017b); the implicit form of the relationship between households' consumption of firewood and its determinants can be expressed as:

$$Y_i = \beta_0 + \sum_{i=0}^{k} \beta_i X_i$$

Where; Yi (the dependent variable) is household i's consumption of firewood. The Y = {firewood}. i.e. the average monthly quantity of firewood consumption by the household.

β_i = the various parameters to be estimated, and

X_i = the variables used in the regression which constitute socio-economic characteristics of households. The estimated empirical OLS model for households' firewood consumption is expressed as:

$$\ln FWD_i = \alpha_0 + \beta_1 HHGEND_i + \beta_2 MSTATUS_i + \beta_3 EDUHHH_i + \beta_4 HHSIZE_i + \beta_5 HHHI_i + \beta_6 LOCATION_i + \beta_7 HOWNS_i + \beta_8 NROOMS_i + \beta_9 DSHARE_i + \beta_{10} UPFW_i + \beta_{11} UPKERO_i + \varepsilon_{ij}$$

Where:
lnFWD = log of quantity of firewood bundle consume monthly.
$HHGEND_i$ = Gender of the head of household
$MSTATUS_i$ = Marital status of the head of household
$HHEDU_i$ = Level of education of the head of household
$HHSIZE_i$ = Size of the household
$HHHI_i$ = Monthly income of the head of household
$LOCATION_i$ = Home location of the household
$HMOWN_i$ = Home ownership of household
$NROOMS_i$ = Number of rooms in the home of household
$DWELSHARE_i$ = Sharing dwelling with other households
$UPFW_i$ = Unit price of firewood per bundle
$UPKERO_i$ = Price of kerosene per litre

Results and Discussions

In this section, Ordinary Least Square (OLS) regression model was used to estimate the impacts of some factors on the amount of households' firewood consumption in Bauchi state, Nigeria. Table 1 exhibits the result of the estimated model

Table 1: Determinants of Firewood Household Consumption

VARIABLES	Coefficients	Standard error
Gender	0.239*	(0.122)
Marital status	-0.206***	(0.070)
Education	-0.018***	(0.006)
Household size	0.008	(0.005)
Income	0.001	(0.001)
Location	0.144*	(0.079)
Home ownership	0.008	(0.041)
Lnnumber of rooms	0.167***	(0.059)
Share of dwelling	0.027	(0.066)
Price of firewood	-0.002*	(0.001)
Price of kerosene	-0.00281**	(0.00112)
Constant	3.579***	(0.241)
Observations	255	
R^2	0.18	
F-value	4.19	
P-value	0.0000	
Ramsey RESET Test (Specification test) F(3, 244) = 1.23		
Prob > F = 0.298		
Note: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1		

Table 1 contains the estimated OLS result of household firewood consumption in Bauchi state, Nigeria. The result shows that overall, the model is statistically significant at 1% level with an estimated F-value=4.19 and the corresponding probability value P>F=0.0000. Additionally, in order to further ascertain the validity of the estimated OLS model, post estimation tests for multicollinearity, heteroscedasticity, normality and specification of the model were conducted, and the results of these tests are presented below.

Post Estimation Tests

To further ascertain the validity of the estimated OLS model, the following post estimation tests were conducted

Specification Test

Here we conducted a test to see whether the estimated model is correctly specified or not, using Ramsey RESET test. The result of this test is shown in the bottom part of Table 1. The null hypothesis tested is:

H0: model has no omitted variables

Based on the result of the model specification test (Table 1), we fail to reject the null hypothesis that the estimated model has no omitted variables and therefore conclude that the model has been correctly specified.

VIF Test for Multicollinearity

Table 2 contains the VIF test for measuring the extent of multicollinearity among the independent variables

Table 2: VIF test for multicollinearity.

Variable	VIF	1/VIF
home ownership	1.31	0.760952
location	1.28	0.783432
income	1.21	0.828796
lnnumber of rooms	1.21	0.829858
education	1.16	0.859508
price of firewood	1.16	0.865640
share of dwelling	1.14	0.876450
marital status	1.14	0.880264
household size	1.14	0.880993
price of kerosene	1.13	0.884766
gender	1.10	0.907299
Mean VIF	1.18	

Based on the result of the VIF test of variables multicollinearity shown in Table 2, since none of the VIF value reached a value of 10, there is no problem of multicollinearity among the included variables in the model and therefore, we maintained all our variables for the purpose of estimation.

Tests of Heteroscedasticity and Normality

Here, Cameron and Trivedi's tests of heteroscedasticity and normality were used. The result of this test is shown in Table 3.

Table 3: Cameron and Trivedi's Decomposition of IM-test

Source	X^2	df	p
Heteroskedasticity	63.24	73	0.7854
Skewness	21.17	11	0.0317
Kurtosis	6.39	1	0.0115
Total	90.80	85	0.3135

H0: homoskedastic variance and normal coefficient

Based on the overall result of the test statistic shown in Table 3 with P=0.3135, the normality and the homoskedastic assumptions cannot be rejected. Furthermore, it is important to note that this model was estimated using robust standard error estimates which are free from heteroscedasticity, therefore, the test was performed in order to further validate the homoscedasticity assumption in the estimated result. The following are discussions of the result of the estimated model.

Gender

This refers to the gender of the household head, coded as 1, for male otherwise, 0. The result has shown that this variable is statistically significant at 5% level. It was found to have a positive relationship with the amount of firewood consumption. A household that are headed by a male tend to consume firewood by about 23.9% higher than the households that are headed by female when other factors are held constant. This is in line with a priori expectation because households that are headed by a male may be economically stronger to buy firewood for domestic use than female headed households. Additionally, a male household head may not have the strong feeling of replacing firewood with other cooking fuel source because he is not in direct contact with the smoke compared to women. This finding is in line with the earlier findings of Abebaw (2007).

Marital Status

This variable represent whether the household head is married or not. It is coded; 1 for a married household head, otherwise, 0. The result has shown that the estimated coefficient of this variable is statistically significant at 1% level. On average, the households that are headed by a married person consume less firewood by about 20% lower compared to the households that are headed by a non married person. This does not conform to a priori expectation because the expectation is that when the head of a household is married, it means more number of household members which necessitates the use of more firewood. However, this may be because the married household head has more responsibility on him making him to have lower budget on firewood purchase to cater for other family responsibilities compare to the non married individual. Or it may be because a married household head in some cases signifies that he is at least more economically stronger to buy cleaner fuel than firewood. This is because based on the culture of the people of the study area, a person usually married when economically can afford the marriage responsibilities of which the purchase of cooking fuel is among. This finding supports the outcomes of other previous studies (Oyekale *et al.,* 2012).

Education

This is the maximum level of education attainment of the household head measured in terms of number of years of formal education. Based on the estimated regression result, this variable was found to be statistically significant at 1% level. The result established that there is a negative relationship between the level of education of the household head and the amount of the household firewood use. On average, a 1 year increase in the years of studies of the household head leads to about 1.81% decrease in the amount of firewood consumption when other factors are held constant. This is in line with a priori expectations due mainly to two reasons. Firstly, as more educated is the household head, the more he has health consciousness and also the more he take the danger of using firewood serious which consequently discourage him from using more of firewood. Secondly, the level of education attainment usually has serious impacts on earning of individual. The more the household head is educated, the higher will be the income and the stronger will be the household to adopt modern cleaned source of energy, all things being equal. This finding supports the earlier findings of Abebaw (2007) and Lee (2013), but contradicts the findings of Ganchimeg and Havrland (2011).

Household Size

This variable represents the number of individuals at home living together as one family under the leadership of a single person (household head) measured in number of individuals per head. The result of the regression indicates that the estimated coefficient of this variable is statistically significant at 5% level. The result has shown that there is a positive relationship between the amount of firewood consumption and this variable. Increase in the size of the household by 1 individual increases the amount of firewood consumption of the household by about 1.25% when all other factors are held constant. This can be viewed from two perspectives. Firstly, increase in the size of the household necessitate that the aggregate amount of consumption items to increase of which firewood is inclusive. Secondly, increase in the size of the household without increase in the earning of the household head means more responsibility on the household head which may increase the probability of the household's use of firewood (since is one of the cheapest cooking fuel source) in order to cater the needs of the family. This result is tally with the findings of earlier previous studies like; Onoja (2012); Song *et al.* (2012) and Lee (2013); but contradicts the findings of Jingchao and Kotani (2011).

Number of Rooms

This refers to the number of rooms in the home in which the household live and which under their ownership or use measured in terms of

total number of rooms available at home. The estimated result of the regression indicates that this variable is statistically significant at 10% level. The variable is positively related to the amount of firewood use, the higher the number of rooms available to the household at home, the higher the amount of firewood consumption when all other variables are held constant. This is because more rooms in the home means more available possible space for household to use firewood, unlike some situations whereby some households are forced not to use firewood because they don't have a space for firewood use at home, because the use of firewood requires relatively more space. This result is consistent with the findings of Song *et al.* (2012).

Price of Firewood

This variable represents the price at which a bundle of firewood is sold to the household, measured in Naira value. Based on the result of the regression, the estimated coefficient of this variable was found to be statistically significant at 10% level. The result has shown that there is a negative relationship between the amount of firewood use and the price per bundle of firewood. The result indicates that a ₦ 10 (USD 0.04) rise in the price of firewood per bundle reduces the amount of firewood consumption by about 2.61 %. This is tally with a priori expectation because as the price of firewood increases, the household may try to substitute the use of firewood with the available and cheaper source of fuel thereby reduces the consumption of firewood. Similarly, when the price of a commodity rises, the purchasing power of buyers decreases, leaving the consumer with the ability to buy less of that commodity. This finding is in line with the traditional law of demand and also supports the findings of previous studies (Ganchimeg & Havrland, 2011; Couture *et al.,* 2012; Lee, 2013).

Conclusions

This study analyses the impact of socio-economic factors on household firewood consumption in Bauchi State, Nigeria. OLS regression model was used to estimate the factors that influence the households' consumption of firewood in Bauchi State, Nigeria. In this case, the dependent variable is the monthly average quantity of the consumed firewood bundles. Out of the total number of eleven variables analysed, seven were found to exact significant impact on the consumption of firewood by households in the study area. For instance, the study found that households that are headed by a male consume more firewood than the households headed by females. Similarly, the number of rooms in the home was also found to have positive significant relationship with the household consumption of firewood. On the other hand, level of education has a negative relationship with the consumption of firewood. The higher the level of education of the household head, the lower the amount of firewood consumption by such household. Moreover, marital status of the household head was found to have a negative relationship with the amount of firewood consumption. The study also found that price of firewood is negatively related to the amount of firewood consumption. This lends support to the argument of the theory of demand. However, the variables that were found to be statistically insignificant are; household size, income, home ownership and share of dwelling.

Policy Implications of Findings

The study found that the level of formal education attainment by the household head has a significant influence on firewood use. The higher the level of education, the lower the quantity of firewood uses. Therefore, government should embarked upon policies to encourage higher education attainment of people leaving in the study area, especially rural areas whereby there are large number of illiterate people. High rate of school enrolment can be increased via policies like; free education policies, education enrolment at a subsidised rate, construction of more schools near to the people especially in rural areas, provision of more scholarships at higher levels. Moreover, employing adequate number of teachers to meet the growing number of pupils and increase

in expenditure on educational facilities. The curriculum of the educational system should emphasize on the danger of high rate of deforestation in the environment. Moreover, as part of education, strong and continuous awareness campaign should be embarked upon regarding the health and environmental danger of high rate of firewood use especially in rural areas whereby the rate of awareness is very low. Furthermore, the study found that there is a negative relationship between price of firewood and the quantity of firewood consumption. Government should try to embark on policies that will ensure increase in the firewood price to discourage the rampant use of firewood in the study area, especially by imposing higher taxes on sales and purchase of firewood. Lastly, based on the findings of the study, the price of alternative energy sources that are more cleaned should be kept as low as possible to encourage the use of such cleaner energy thereby reducing the rate of firewood consumption.

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