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DETERMINANTS OF HOUSEHOLD ENERGY CHOICES FOR COOKING IN RURAL AREAS: EVIDENCE FROM ENUGU STATE, NIGERIA

Nnaji, C. E,[a] Ukwueze, E. R,[b] and Chukwu, J. O[b]
[a] National Centre for Energy R & D and [b]Department of Economics, University of Nigeria, Nsukka

ABSTRACT
The study analyzed the factors determining rural energy choices for cooking in rural areas in Enugu State, Nigeria using a multinomial logit model. We emphasize on socio-economic factors that determine household cooking energy preference in rural Nigeria. Firewood remains the preferred fuel for most households in the study area; though rational, the choice is not sustainable as it portends a threat to their woodlands and green economy. Empirical results indicate that households' total income, the level of education of women, age of women, occupation of women, and existence of internal cooking facilities are essential factors that determine household cooking fuel choice. While income is an important factor, the empirical findings suggest the need for policy makers to consider socio-economic factors while addressing issues associated with household energy consumption.

KEYWORDS: Multinomial logit model; Household; Rural; Enugu State; Firewood; Fuel

INTRODUCTION

In developing countries, most of the rural communities have less access to modern and clean energy sources and mostly depend on traditional fuel /biomass(woods, twigs, leaves, charcoal, animal dung and crop residue) for virtually all their energy requirements. It has been estimated that more than 2 billion people globally depend on biomass to meet their basic energy needs and currently, biomass accounts for about 20% of the world's energy supply (FAO, 2006). Without new policies, the number of people globally that rely on biomass fuels is expected to increase to 2.6 billion by 2015, and 2.7 billion by 2030 due to population growth (IEA,2006)

Over 60% of Nigeria's population depend on firewood for cooking and other domestic uses (ECN, 2003). The rural areas, which are generally inaccessible due to absence of good road networks, have little access to conventional energy such as electricity and petroleum products. Petroleum products such as kerosene and gasoline are purchased in the rural areas at prices very high in excess of their official pump prices. The rural populace, whose needs are often basic, therefore depend to a large extent on firewood as a major traditional source of fuel. It has been estimated that about 86% of rural households in Nigeria depend on firewood as their source of energy (Williams, 1998). Firewood supply/demand imbalance in some parts of the country is now a real threat to the energy security of the rural communities (ECN, 2003). Nigeria consumes over 50 million metric tonnes of firewood annually, a rate, which exceeds the replenishment rate through various afforestation programme (ICCDD, 2000). Sourcing fire wood for domestic and commercial uses is a major cause of desertification in the arid-zone states and erosion in the southern part of the country (Sambo, 2009). The rate of deforestation is about 350,000 hectares per year, which is equivalent to 3.6% of the present area of forests and woodlands, whereas reforestation is only at about 10% of the deforestation rate (ICCDD, 2000). From available statistics, the nation's 15 million hectares of forest and woodland reserves could be depleted within the next fifty years (ECN, 2003). These would result in negative impacts on the environment, such as soil erosion, desertification, loss of biodiversity, micro-climatic change and flooding. Most of these impacts are already evident in different ecological zones in the country, amounting to huge economic losses (Sambo, 2009). The consumption of firewood is worsened by the widespread use of inefficient cooking methods that are hazardous to human health, especially to women and children who mostly do the cooking in homes.

It has been argued that households with low income levels rely on biomass fuels, such as wood and dung, while those with higher incomes consume energy that is cleaner and more expensive, such as Liquid petroleum gas (LPG). Those households in transition consume what are called transition fuels, such as kerosene and charcoal. This fuel choice and demand behaviour of households is known as the "energy ladder hypothesis". Apart from high income, one set of factors necessary for switching to other fuels particularly in poorer rural households is cheap and better availability of alternative fuels other than traditional biomass fuels. Empirical evidence has shown that for many households, the decision over which fuel to use or how much of the fuel to use, requires the consideration of several important factors. For instance Narain et al (2008) 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. Also, access to electricity has been found to be another important determinant of the energy transition (Campbell et al. 2003; Davis 1998; Ouedraogo 2006). Others are house standard, level of education of husband and wife, occupation of wife, frequency of cooking certain meals and household size (Alam et al. 1998; Ouedraogo 2005; Madubansi and Shackleton 2007; Pundo and Fraser, 2006). Current empirical evidence indicates a more complex process at work (the notion of "fuel stacking") other than the linear relationship exhibited in the energy ladder hypothesis. Fuel stacking indicates that richer rural households opt for a mix of modern and traditional fuel types to meet larger energy requirements (UNDP/ESMAP, 2003, Heltberg 2005, Masera et al., 2000).

In the light of these facts, this study seeks to describe the structure of household demand for cooking energy as a discrete choice and for this purpose to establish an econometric model suitable for policy analysis. Specifically, the study seeks to investigate the different cooking fuel mostly in demand by households of rural communities in Enugu State, Nigeria and to determine the different factors that affect a household's probability of choosing one cooking fuel over another. The study will help us to design policies for promoting fuel switching, thereby increasing household welfare and reducing indoor air pollution. We also contribute to literature by providing an up –to-date evidence for Nigeria by studying some selected rural communities in Enugu State.

MATERIALS AND METHODS

In this section, we present the data source and also discuss graphical relations between fuel choice and some variables. This is followed by the specification of the model and description of the exogenous variables.

Data Source and Descriptive Statistics

The data set is based on an extensive survey in which structured interviews and questionnaires were administered to selected rural communities in Nsukka zone of Enugu State. Specifically, the communities covered in the study are Ubollo-Afor, Imilike, Opi and Ede-oballa communities. The population of study comprises more than 30 villages and encompasses people of the same cultural but different socio-economic backgrounds. On the whole, 600 questionnaires were administered using the simple random sampling technique. During the process of data cleaning, 6 questionnaires were found to be missing and 18 questionnaires were rendered invalid while the remaining 576 were valid. Among those rendered invalid, some had one or more key variables missing, while some had inconsistent information and were discarded. The study was conducted between September 2009 and January 2010. The data collected relate to household's socio- economic characteristics and their expenditures.

Household Cooking Choice

Fig.1 indicates that the dominating source of household cooking energy in the study area is wood-energy which is used by 93% of the households; 79% mainly use firewood and 14% use charcoal. Kerosene is used by 7% of the households.

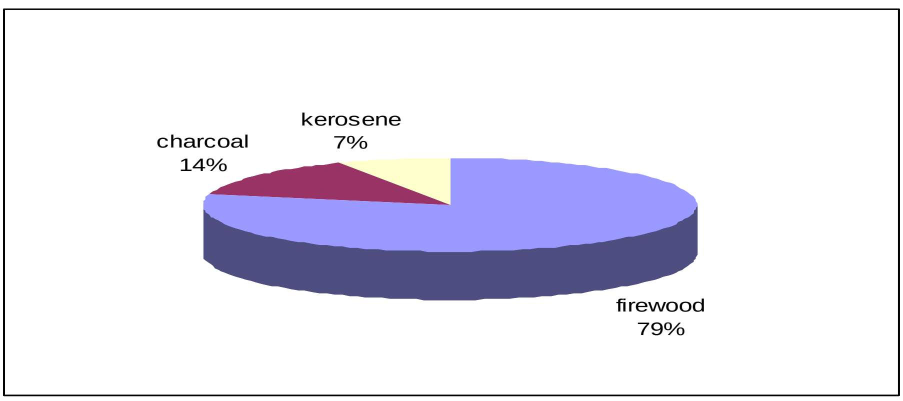

Fig.1 Distribution of households by cooking energy choice

Although LPG, electricity and other solid fuels were included as energy options in the survey questionnaires, they recorded zero response as none of the respondents utilized them as their main source of fuel.

Household size, income and fuel choice

Fig. 2–3 depicts the relationships between the use rates of energy types (firewood, charcoal and kerosene), household income and household size. Fig. 2 shows that the poorest households are the main users of firewood with an average total monthly income of about NGN7000.00. We observe a pattern reversal for kerosene. The use rate of kerosene is highest among the richest household with an average total monthly income of at least NGN17000.00 indicating a movement to cleaner fuel as income increases. The survey also indicates that the users of firewood also use kerosene as a major source of fuel for

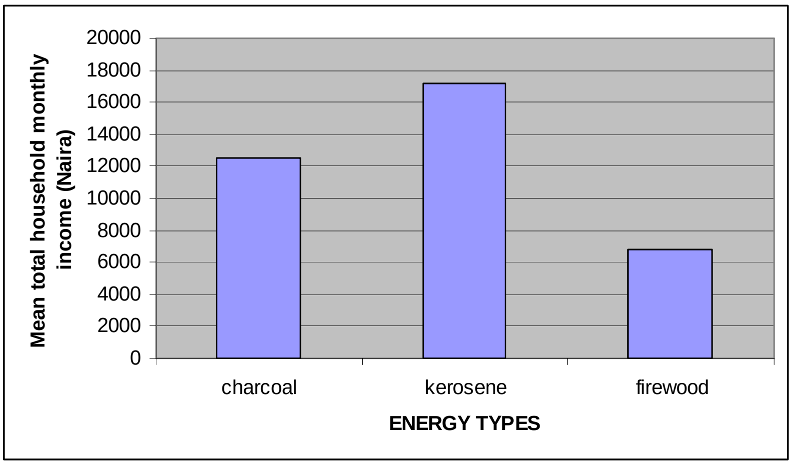

Fig.2 Energy use rate and Household income

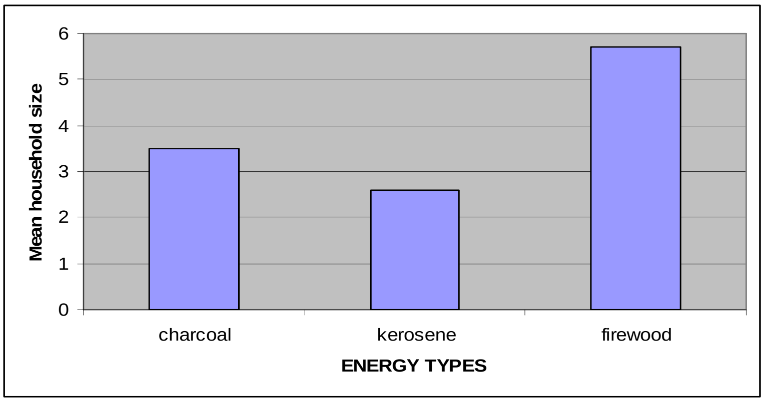

Fig.3 Energy use rate and Household size

lighting and to facilitate wood combustion. Fig. 3 shows that those with the largest families are the main users of firewood while the use rate of kerosene is highest among those with the smallest number of family members. The figure depicts that as the family size increases, the use rate of dirty fuels increases and vice versa.

The Model

The study uses multinomial logit model (MLM) to estimate the significance of the factors suspected to influence a household's choice of cooking fuel in rural areas of Nigeria. Multinomial logit model describes the behaviour of consumers when they are faced with a variety of goods with a common consumption objective. The choice of the model was based on its ability to perform better with discrete choice studies (McFadden, 1974 and Judge, *et al*., 1985). However, the goods must be highly differentiated by their individual attributes. For example, the model examines choice between a set of mutually exclusive and highly differentiated cooking fuels such as firewood, charcoal, kerosene, other solid fuels, gas and electricity. If only two discrete choices have to be analysed, the multinomial logit model reduces to a logit model.

The probability that a household chooses one type of cooking fuel is restricted to lie between zero and one. The model assumes no reallocation in the alternative set and no changes in fuel prices or fuel attributes. The model also assumes that households make fuel choices that maximize their utility (McFadden, 1974). The model can be expressed as follows:

$$\Pr[Yi = j] = \frac{\exp(\beta_j X_i)}{\sum_{j=0}^{j} \exp(\beta_j X_i)} \quad \text{……………………………………………………..(1)}$$

Where:

- Pr[Yi = j] is the probability of choosing either charcoal, kerosene, other solid fuels, gas or electricity with firewood as the reference cooking fuel category,
- *J* is the number of fuels in the choice set,
- *j = 0* is firewood,
- Xi is a vector of the predictor (exogenous) socio-economic factors (variables)
- βj is a vector of the estimated parameters.

When the logit equation above is rearranged using algebra, the regression equation is as follows:

$$P_i = \frac{e^{(b_o + b_1 x_1 + ...b_v x_v)}}{1 + e^{(b_o + b_1 x_1 + ...b_v x_v)}} \quad \text{………………………………………………….(2)}$$

The equation used to estimate the coefficients is

$$\text{In} \left[\frac{P_i}{1 - P_i} \right] = b_0 + b_1 x_1 + \ldots b_v x_v \quad \text{……… (3)}$$

From equation 3, the quantity Pi/ (1 – Pi) is the odds ratio. In fact, equation 3 has expressed the logit (log odds) as a linear function of the independent factors (Xs). Equation 3 allows for the interpretation of the logit weights for variables in the same way as in linear regressions. For example, the variable weights refer to the degree to which the probability of choosing one firewood alternative would change with a one-year change in age of respondent. For example, e^{bv} (in equation 2) is the multiplicative factor by which the odds ratio would change if X changes by one unit.

The model follows from the assumption that the random disturbance terms are independently and identically distributed (i.i.d) (McFadden, 1974). In addition, Judge et al (1985) show that even if the number of alternatives is increased (from 2 to 3 to 4 etc) the odds of choosing an alternative fuel remain unaffected. That is, the probability of choosing the fuel remains the same if it is compared to one alternative or if it is compared to two alternative fuels. The dependent variable is the cooking fuel choice (firewood, charcoal, or kerosene) with firewood as the reference choice. Estimated coefficients measure the estimated change in the logit for a one-unit change in the predictor variable while the other predictor variables are held constant. A positive estimated coefficient implies an increase in the likelihood that a household will choose the alternative fuel. A negative estimated coefficient indicates that there is less likelihood that a household will change to alternative fuel.

P-value indicates whether or not a change in the predictor significantly changes the logit at the acceptance level. That is, does a change in the predictor variable significantly affect the choice of response category compared to the reference category? If p-value is greater than the accepted confidence level, then there is insufficient evidence that a change in the predictor affects the choice of response category from reference category. The explanatory variables are defined in Table 1.

Table 1: Definition of the exogenous variables of the multinomial logit model

Variables (x_i)	Unit of account (Definition)
Size of household	Number of household members (quantitative)
Education of respondent[a]	1-Primary; 2- Secondary and higher; 3-None;
Gender of household	0-Female; 1-Male
Age of household	Years in number
Marital status of respondent	0-Others; 1-Married
Household total income	Household total monthly income(Naira)
Occupation of respondent[b]	1-Farming; 2-Trading; 3-Others
Existence of external cooking facilities	0-Otherwise; 1-Exists
Existence of internal cooking Facilities	0-Otherwise; 1-Exists
Weekly frequency of cooking foods requiring long hours	Weekly number of cooking foods requiring long hours of cooking
Percentage of total income spent on energy for cooking	% of household total income spent on energy for cooking (₦) Naira

[a]For the variable "Education of respondent", households whose variable has "none" as outcome are used as reference.
[b]For the variable "Occupation of respondent", households whose variable has "others" as outcome are used as reference.
[c]For variables ''Existence of cooking facilities'' in household, the variable ''without any kitchen'' is used as reference.

RESULTS AND DISCUSSION

The empirical analysis starts by the presentation of the mean characteristics of households in the survey. In order to ensure a fair representation of situation in the study area, the study targeted women rather than men and thus more than 80 percent of the sampled respondents were women. From experience and field observations, to a large extent, only women and girls collect or buy firewood and prepare food. We observe that most firewood users in the area obtain firewood from the forest and buy little quantity once or twice monthly to augment those collected from the forest. To be interviewed, one had to be self catered/living alone (for singles) or be either a husband or wife. Gas, electricity and other solid fuels were dropped from the analysis because they were not utilized at all as principal fuel by households.

Table 2. Mean characteristics of households in the survey

Variable name and description	N	Distribution		Mean
AGE (Age in years of the respondent)	576	Minimum: Maximum:	29 80	50.98
GENDER (The sex of respondent)	576	Female: Male:	485 91	_
OCCUP (Occupation of the respondent)	576	Farming: Trading: Others:	348 191 37	_
HHPOP	576	Minimum:	1	5.18

(Household size)		Maximum:	9	
EDU (Level of education of respondent)	576	None: Primary: Secondary and higher:	123 276 177	_
PTE (Percentage of total income spent on energy for cooking)	576	Minimum: Maximum:	1.67 7.28	_
ICKFAC (Existence of internal cooking facilities)	576	Exists: Otherwise:	47 529	_
ECKFAC (Existence of external cooking facilities)	576	Exists: Otherwise:	531 45	_
INCOME (Household total monthly income)	576	Minimum: Maximum:	₦ 3000 ₦ 30000	₦ 8376
MARITAL (Marital status of correspondence)	576	Married: Others:	508 68	_
CKFREQ (frequency of cooking food requiring long hours)	576	Minimum: Maximum:	1 3	1.84
PRINCIPAL HOUSEHOLD COOKING FUEL	576	Firewood as principal: Charcoal as principal: Kerosene as principal:	453 80 43	_

Table 3.Multinomial Logit analysis for charcoal and kerosene as compared to firewood

Variable name	**Charcoal**			**Kerosene**		
	Parameter coefficient	**P-value**	**Odds Ratio**	**Parameter coefficient**	**P-value**	**Odds Ratio**
Intercept	-28.225	-	-	-20.812	-	-
Age in years of the respondent	.107	.023**	1.113	.003	.966	**1.003**
Marital status of respondent	-.240	.651	.787	-1.626	.093*	**.197**
Frequency of cooking food requiring long hours	.640	.460	1.897	1.015	.129	**2.759**
Household average total income	.020	.001***	1.020	.001	.000***	**1.001**
Existence of internal cooking facility	25.013	.000***	7.296	11.979	.992	**1.593**
Existence of external cooking facility	21.784	-	2.890	8.739	.994	**6.241**
Percentage of total	.209	.198	1.233	-.207	.511	**.813**

income spent on energy for cooking						
EDU: Primary: Secondary and higher:	 .515 1.8580	 .677 .001***	 1.673 6.4115	 7.841 12.111	 .974 .959	 **2.542** **1.819**
Gender of respondent	.316	.575	1.372	-.006	.995	**.187**
Household size	-1.575	.000***	.207	-2.349	.000***	**.095**
Occupation of respondent: Farming: Trading:	 -.055 -1.643	 .952 .092*	 .946 .193	 -2.770 -2.357	 .084* .065*	 **.063** **.095**
χ^2 (sig) 26 degree of freedom **507.866(0.000)***** **Mc Fadden pseudo-R^2**					 **0.671**	

Notes: ***significant at 1% level; **significant at 5% level; *significant at 10% level.
Source: Results from the logit multinomial regression output

Table 2 presents the estimates of the b coefficients of the multinomial logit model and some test statistics. Tests make it possible to measure the quality of the estimates. The χ^2 statistic tests the null hypothesis of all estimated coefficients taken together being equal to zero. It constitutes for the multinomial logit model what the Fisher statistic represents for the linear models. The value of the χ^2 statistic for the model is 507.87 and is significant at the 1% confidence level. We therefore reject the null assumption.

We retain the McFadden pseudo-R^2 for the simplicity of its calculation. The measurement of R^2 by Mc Fadden (1974) based on the likelihood ratios is as follows:

$$R^2 = 1 - \frac{Log(L_{UR})}{Log(L_R)},$$

L_{UR} is the maximum of the likelihood function of the model without constraints, and L_R is the maximum of this same function by forcing the coefficients of all exogenous variables to be zero. In our case, McFadden's pseudo-R^2 gives R^2 a value of 0.671. In other words, 67.10% of the energy choices of the households of the study areas are explained by the exogenous variables selected. This value of the pseudo-R^2 suggests a reasonable efficiency of the model.

The regression result show that the age of the respondent has positive coefficients both for charcoal and kerosene but only the p-value of charcoal is significant at the 5% confidence level. Though theoretical expectation is that increase in age of household will influence fuel choice through developed loyalty for firewood and reduce the adoption of other fuel choices. However, a possible argument is that when a respondent becomes older, the lack of adequate physical strength needed to gather and use firewood may force the household to switch to charcoal.

Household size has a negative estimated coefficient for charcoal and kerosene and both are also statistically significant at the 1% confidence level. This supports the theoretical expectation that 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 (Punder and Fraser, 2006). Moreover, it is believed that larger household sizes may mean larger labour input, which is needed in firewood collection. Larger households are more likely to have extra labour (for example children's labour) that can be used to freely collect firewood from public fields and thus may lower the price of firewood relative to alternatives which cannot be obtained freely.

Being married compared to not being married and other marital status has a negative estimated coefficient for charcoal and kerosene. Specifically, the odds ratio shows that the probability of changing from firewood to kerosene for married people compared to others is .197 lower. This may arise from the fact that married people are expected to have larger families, all things being equal and therefore may desire to decrease the use rate of other fuels since firewood is comparatively cheaper for larger families.

The positive estimated coefficients for the existence of internal cooking facilities support the study's theoretical expectation that if a household has internal cooking facilities, the household will be more likely to use charcoal or kerosene. The p-value of charcoal is statistically significant indicating that there is enough evidence to believe that a change in the non existence of internal cooking facility to existence of internal facilities is likely to make a household change from using firewood to using charcoal and kerosene. Infact, the odds ratio shows that the probability of changing from firewood to charcoal with the change in the status of internal cooking facility is more than seven times higher. However, the p-value of existence of internal cooking facilities compared to absence of internal cooking facilities is not statistically significant for kerosene.

The level of education concurs with the hypothesized theoretical expectation of a positive effect on the choice of charcoal and kerosene due to an increase in the level of education of respondents. This is evident since a highly educated respondent (especially, a woman) is likely to lack time to collect firewood due to her involvement in other activities and thus may prefer to use firewood alternatives. However, only the level of secondary and higher education is significant for charcoal at the 1% confidence level. Specifically, the odds ratio shows that the probability of changing from being illiterate to acquiring secondary education and higher with the change in the education level of household is higher by a factor of 6.4 or 6.4 times higher.

Occupations of households have negative estimated coefficients for charcoal and kerosene relative to firewood in support of the study's theoretical expectation that if households, especially in rural areas are employed in white collar jobs (office jobs), they are more likely to use firewood alternatives than their counterpart who are mainly peasant farmers, fishing households or petty traders. It is believed that this behaviour is caused by improvements in income, which elevate households in white collar jobs to higher social class.

Table 3 shows a binary logit analysis of firewood and charcoal. Firstly, kerosene has been excluded from the analysis because comparatively, few households chose it as their preferred cooking fuel (Table 2). Secondly, it has been dropped to allow for the analysis of choice differences between firewood and charcoal since they are close substitutes: they are produced from trees .The same variables in Table 3 have been analysed in Table 4

Table 4: Binary logit analysis for charcoal as compared to firewood

Variable	Parameter Coefficient	P-value	Odds Ratio
Intercept	-22.890	-	**-**
Age in years of the respondent	.135	.006***	**1.144**
Marital status of respondent	-.112	.869	**.894**
Frequency of cooking food requiring long hours	.507	..281	**1.661**
Household average total income	.001	.001***	**1.001**
Existence of internal cooking facility	18.391	.000***	**9.711**
Existence of external cooking facility	15.026	-	**3.354**
Percentage of total income spent on energy for cooking	.216	.187	**1.242**

EDU: Primary: Secondary and higher:	.558 1.669	.653 .001***	**1.747** **5.3199**
Gender of respondent	..492	.398	**1.64**
Household size	-1.74	.000***	**.175**
Occupation of respondent: Farming: Trading:	-.007 -1.714	.994 .073*	**.993** **.180**
χ^2 (sig) 13 degree of freedom		**309.923(0.000)*****	
Mc Fadden pseudo-R^2		**0.688**	

Notes: ***significant at 1% level; **significant at 5% level; *significant at 10% level.
Source: Results from the Binary logit regression output

The value of the χ^2 statistic for the model is 309.92 and is significant at the 1% confidence level. We therefore reject the null hypothesis of all estimated coefficients taken together being equal to zero. Similarly, the value of pseudo-R^2 of 0.688 suggests a reasonable efficiency of the model.

Age of respondent, household average total income, existence of internal cooking facility, and secondary and higher education level of respondent; all have positive estimated coefficients and are statistically significant at the 1% confidence level. Their odds ratios are similarly strong. These results support the theoretical framework, except for age, which was expected to have a negative influence with the use of charcoal. However, a possible argument for this has been explained in the analysis of table 3. Marital status of respondent, household size, farming occupation and trading occupation of respondent all have negative estimated coefficients. However, only household size and trading occupation are statistically significant at the 1% and 10% confidence level respectively. These variables also conform to apriori expectations as has been explained for the results of Table 3.

CONCLUSION

The main thrust of this study has been to investigate the proposition of determinants and implications for cooking energy and to test how well these postulations explains the observed behaviour of household energy choices for cooking in rural areas of Nigeria. We used Multinomial logit model to identify the determinants of energy for cooking as well as sociological and economical variables influencing major energy sources in the study area.

Empirical investigation revealed that apart from household income, household cooking energy choices also depends on sociological and other economical factors such as household size, age, occupation and existence of internal cooking facilities. The study shows that firewood is by far the fuel of choice for a majority of households in the study area. The study further revealed that as household income increases, households switch to cleaner fuels; from charcoal to kerosene as implied by the energy ladder hypothesis. The dependence on firewood in this region has far-reaching implications on the environment: deforestation, soil erosion and declining agricultural productivity and lose in the natural habitat.

In the light of the above, we suggest that apart from improving household income, policy design also need to focus on other factors in addressing the challenges of rural energy exploitation. One solution to the environmental consequences of unsustainable wood exploitation requires that modern cooking fuels be made more accessible and affordable and firewood and charcoal use be made sustainable.

Moreover, improvement in income and education enhance the likelihood of the household to increase the consumption of other fuels. This will help reduce consumption of wood, implying a reduction in the pressure of wood resources and contributing towards mitigating deforestation.

Furthermore, measures should be taken by stakeholders in the energy sector to develop and promote renewable, clean technologies to lesson the burden of economic activities on the ecosystem, reduce pollution and meet the demand in rural areas. Such measures should promote the use of energy carriers other than biomass as well as the use of biomass in modern ways.

Finally, since firewood is the fuel of choice by a majority of the rural populace, a permanent programme of reforestation that provides for the planting of wood species that are ecological suitable, socio-culturally compatible and economically feasible and products harvested under controlled and best practices should be adopted by the government as an avenue to address rural energy demand issues and other-interrelated concerns like food production, soil erosion and desertification.

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Corresponding author
Nnaji, C. E,
National Centre for Energy R & D, University of Nigeria, Nsukka
E-mail: nnajidal@yahoo.com