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HOUSEHOLDS' COOKING ENERGY PREFERENCES AND DETERMINANTS OF TRANSITION TO NON-BIOMASS FUELS IN RURAL NIGERIA.

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ABSTRACT

The increasing dependence on unclean traditional biomass fuels is critically challenging to human health and environmental sustainability. The importance of transition to modern clean sources of energy on the social, economic and political development of any nation cannot be overemphasized. This study investigates households' cooking energy choices and the determinants of transition to clean modern sources of energy in rural Nigeria. Using the cross-sectional data, the rural household's energy choice and transition behaviour is modelled using multinomial logistic regression model. Biomass related fuels including firewood and charcoal remains the dominant cooking energy choice of the surveyed households. Though, economically rational, this choice poses serious threat to human survival and the environment. Empirical estimates indicates that income is a key factor influencing the households' likelihood of switching to cleaner sources of energy providing credence to the energy ladder hypothesis. Further, demographic and economic factors such as household head's age and education, household size, monthly expenditure on cooking energy, residential status as well as farmland possession used as a proxy for asset are important determinants of fuel choice and transition. The study suggests policy measures aimed at poverty reduction, enlightening the rural households in having a moderate family size to reduce their economic burden and public enlightenment of the potential health and environmental benefits of using cleaner cooking energy sources. Programmes such as reforestation that will help to strike a balance between biomass production and consumption rate is also critically required as transition to cleaner sources of energy cannot be achieved overnight.

Keywords: Cooking Energy, Biomass, Multinomial logit, Rural, Nigeria.

INTRODUCTION

Energy is a vital requirement for human existence due to its daily dependence by human for domestic (lighting, cooking, heating) and industrial (mechanical, transportation and communication) activities. According to the International Energy Agency (2006), cooking is the main households' use of energy in developing countries such as Nigeria. In addition, Oyedepo (2014) asserted that the household cooking sector is the largest energy consuming sector in Nigeria, consuming more than half (about 65%) of the total available energy in the country. As evidenced by Adepoju, Oyekale and Aromolaran (2012), Nigeria is naturally blessed with abundance of energy resources, both renewable and non-renewable. However, this has not translated to a steady access to clean sources of energy among the citizens of the country (Oyekale, 2012; Adegbulugbe, 2006; Adepoju et al., 2012) which has been found to underlie the achievement of economic development in any nation (United Nations, (2005); Adegbulugbe, (2006); Adepoju et al., (2012); Oyedepo, (2014)). Households are faced with various cooking energy alternatives ranging from the unclean traditional biomass fuels (for example, crop residue, fire wood and charcoal) to clean modern fuels such as the Liquefied Petroleum Gas (LPG), kerosene and electricity. However, the unclean traditional biomass fuels is the dominant cooking energy types consumed by more than half (67%) of the Nigeria households (WHO, 2007).

Heavy reliance on solid biomass fuels has far reaching social, health and environmental consequences with resultant effect on economic development through increased deforestation, forest degradation, land degradation, air pollution and climate change (World Energy Council (1999); Faye (2002); WHO, (2010); Assa, Maonga and Gebremariam (2015)). FAO (2010) estimated rate of deforestation in Nigeria between 2005 and 2010 was 4% which was higher than previous estimates of 3.33% for the period of 2000-2005 and 2.68% within 1990-2000. This shows that the rate of deforestation in Nigeria is continuously increasing with wood gathering for fuel identified as one of the notable drivers of deforestation (United Nations Framework Convention on Climate Change (UNFCCC), 2007). This poses serious threats to environmental sustainability as well as the social, economic and political development of the country. Similarly, Sambo (2009) asserted that firewood collection for both domestic and commercial purposes is primarily responsible for desertification and erosion in the northern and southern part of the country respectively. The incomplete combustion of biomass fuels releases pollutants such as methane, carbon dioxide and black carbon particles into the atmosphere which further aggravates the growing issue of global warming and climate change (Bizzarri, 2009; WHO, 2011). The household sector has been identified as a significant source of greenhouse emissions with direct CO_2 emissions resulting from energy combustions estimated to constitute about 18% of global CO_2 emissions in 2008 (OECD and IEA, 2010; WHO, 2011.

In developing countries, indoor air pollution from biomass fuels combustion has been identified as the most dangerous killer diseases next to malnutrition, unsafe sex and lack of safe water and sanitation, estimated to be responsible for 3.7% of the overall disease burden in 2004 (WHO, 2004). About 1.5 million premature deaths in 2002 (5.3% of which are associated with Nigeria) was attributed to indoor air pollution resulting from the use of biomass related fuels (WHO, 2007). In 2004, the premature deaths from indoor air pollution rose to about 2million and to about 4.3 million in 2012 (WHO, 2014). The women and children have been identified as the most susceptible to these deaths (WHO, 2014; IEA. 2006; Heltberg 2005) as they spend more time at home and are traditionally saddled with the responsibility of cooking for the entire households which increases their exposure to smoke from the biomass fuels. Indoor air pollution poses a great threat to human survival via a myriad of diseases such as stroke, heart disease, lung cancer, chronic and acute respiratory diseases (including asthma), cardiovascular disease, tuberculosis low birth weight and perinatal mortality and otitis media. UNEP (2006) estimated that about 22% and 36% of lower respiratory infections and chronic respiratory diseases respectively is as a result of indoor air pollution from the use of biomass fuels. The absence of the establishment of new and strong policies to expand access to clean source of energy coupled with rapid growth in population has been projected to increase the present global reliance on biomass fuels by 3.8% by 2030 (IEA, 2006). Most of these increase has been envisaged to be most evident in sub-Saharan Africa, having the highest projected increase of 14.8% among the various regions of the world (IEA, 2006).

Households' fuel choice and transition from unclean traditional biomass fuels to clean modern sources of fuels has frequently been conceptualized using the energy ladder model. The model is based on the consumer behavior theory that households do not only consume more of the same good with improved living standards (a rise in income), rather they also shift to more sophisticated and higher quality goods (Hosier and Kipondya, 1993). The model established income as a primary determinant of fuel choice and switching among households (Heltberg, 2003). It describes the process of fuel switching using three linear progressive stages hypothesizing income as the basis for moving up the ladder (Heltberg, 2003). The first stage is characterized by low income households who predominantly rely on unclean biomass fuels in the form of wood, dung and agricultural residues. In the second stage are the middle income households that switch to transition fuels such as kerosene and coal. The last stage consists of the high income households that utilize clean modern sources of fuels such as the LPG, natural gas and electricity (Heltberg, 2004).

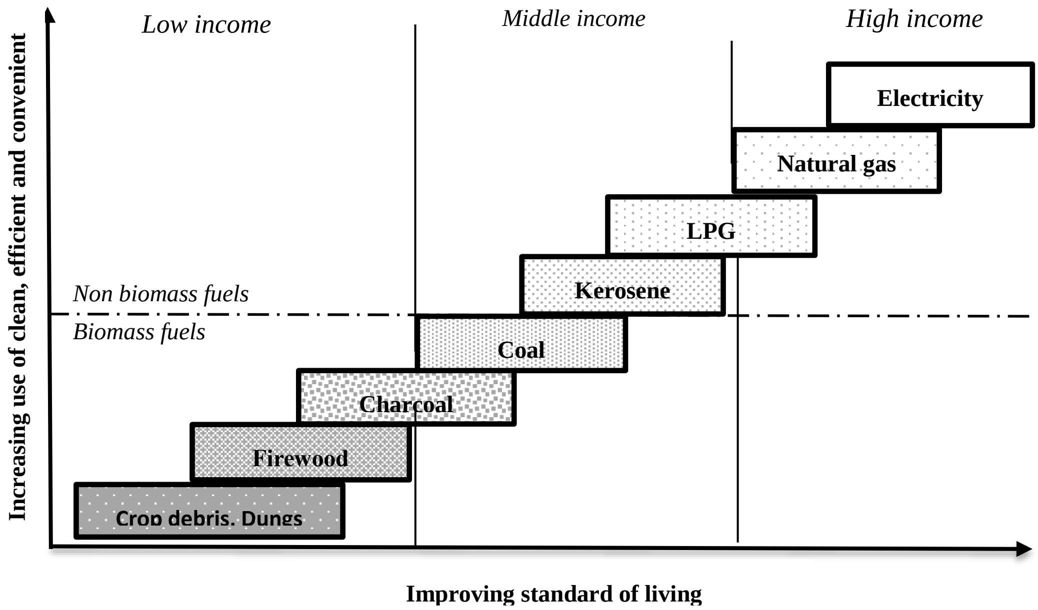

Figure 1: The energy ladder model ***(Adopted from WHO, 2006)***

The energy ladder model has often been criticized as being too rigid ignoring other factors (social, cultural and behavioral) that equally determines households' choice of fuel (Jebra and Iniyan, 2006). In addition, Masera, Saatkamp and Kammen (2000) is of the view that with rising economic status, households do not completely leave the traditional fuels, rather they use a mix of cooking fuels (known as fuel stacking) on both the lower and upper rungs of the energy ladder, hence, introduced the multiple fuel model. However, while efficiency, cleanliness and convenience benefits are associated with the use of modern fuels, these fuels are costly to use, thereby indicating the importance of a household's economic status in the energy transition profile. Hence, examining the relationships between households' choice of cooking energy and their income level given the energy ladder hypothesis becomes important especially for the Nigerian situation where about 64.4% of the population still live below the recommended 1 dollar per day (WHO, 2010). Further, while the dependence on biomass is not limited to the rural areas, these areas due to lack of the basic infrastructural facilities such as good road networks have little access to clean modern sources of energy such as electricity, kerosene and gasoline. Thus, they depend largely on biomass related fuels such as firewood and charcoal as the primary fuel for cooking compared to the urban counterpart. For example, as estimated by IEA (2006), 76% of the sub Saharan African households as at 2004 rely on biomass resources as their primary fuel for cooking out of which 93% are rural as against 58% that are urban. It is in view of the foregoing that this study intends to empirically assess the factors that influence households' choice of cooking energy with specific reference to the rural Nigeria where more than 70% of the population resides (Oyedepo, 2014). This study aims to contribute to existing literature by providing an up to date evidence on rural Nigeria and come up with new policies that will help reduce dependence on unclean traditional biomass fuels and enhance transition to cleaner sources of energy.

MATERIAL AND METHODS

Study data

The data for this study is based on a cross-section survey of rural households in Ogun state, Nigeria. Ogun State lies within latitude 6°N and 8°N and longitude 2° E and 15° E. The state is bounded to the west by the Republic of Benin, to the east by Ondo State, to the north by Oyo State and to the south by Lagos State and the Atlantic Ocean. It covers a total land area of 16,409.26 sq. km. Ogun state has an estimated population of 3,751,140 (National Population Commission (NPC), 2006) and a total of twenty (20) Local Government Areas (LGAs) with farming as the major occupation of the people particularly those in the rural areas. Following the definition of rural areas by Eneh and Owo (2008) as sparsely populated areas whose major occupation is farming and mostly depend on natural resources, the five LGAs with the least population according to NPC (2006) out of the twenty local government areas in the state were selected for the study. Specifically, these LGAs include Remo North, Ogun Waterside, Imeko Afon, Ewekoro and Ijebu East. Multistage simple random sampling technique was used to select the rural households from more than 30 villages from the selected LGAs interviewed for the study. On the whole, 400 semi-structured questionnaires were administered to the household heads and the data were collected using interview guide. In situations where the household head was not available at the time of data collection, the information was solicited from their spouses. During the process of data cleaning, 8 questionnaires were found missing and 15 questionnaires were rendered invalid due to incomplete information particularly relating to the key variables. The analysis was based on the remaining 377 valid questionnaires. The data collected relate to the households' socio-economic characteristics, the primary or dominant fuel used for cooking by the household, cost of cooking fuel per week and reason(s) for choosing cooking fuel.

Modeling household choice of cooking energy

The multinomial logistic regression model was used to examine the factors that influence the rural households' choice of primary cooking fuel. The multinomial logistic regression model is a discrete choice model that describes the behavior of decision makers such as people, households and firms when faced with making a choice from more than two alternatives (Train, 2009). In this study, there a basket of cooking energy commodities from which the rural households have been observed to choose. A household n chooses from a set of mutually exclusive energy choices, $j = 1,\ldots..,J$ and derive a certain level of utility U_{nj} from each of the chosen alternative. It is hypothesized that a decision maker's choice of an attribute is determined by a vector of socio-demographic characteristics such as age, level of education, income, residency status, e.t.c. Thus, for the n_{th} household faced with j_{th} choice, the utility function can be specified as:

$$U_{nj} = \beta' x_n + \boldsymbol{\varepsilon}_{nj}, \;\; j = 0,1,2,3.$$

Where n indexes the household, j indexes the cooking energy choices, β' represents the coefficients' vector, x_n is a vector of households' socio-demographic characteristics, and '$\boldsymbol{\varepsilon}_{nj}$' are the model disturbances that are assumed to be independently and identically distributed with extreme value distribution (Greene, 2002).

In this study, the dependent variable, the households' primary cooking fuel is defined over a set of four exhaustive alternatives labeled as 0, 1, 2 and 3 representing fuel wood, kerosene, electricity and gas respectively. Fuel wood comprises of the two biomass related fuels identified in the study area, including firewood and charcoal. These cooking fuels are lumped together in this study to examine the factors that will determine transition to cleaner non-biomass coking fuels in the study area. Discrete choice models are based on the assumption that consumers are rational, thus a household will chose an outcome that maximizes utility (Train, 2009; Cameron and Trivedi, 2005; Deaton, 1997). The household *n* will choose to use *j* energy option only if the perceived benefit from option *j* is greater than the utility from other options (say, i) depicted as:

$$U_{nj} > U_{ni}, \forall\, j \neq i$$

The observed energy choice y_n of a household n is defined as a vector of $Y_n = [Y_{nj}]$ of four dummy variables taking a value of 1 if the households choice falls on the j_{th} alternative and value of 0 otherwise. The probability that a household n chooses alternative j is specified as:

$$p_{nj} = p(y_n = j/x_n) = \frac{e^{\beta'_j x_n}}{\sum_{i=0}^{j} e^{\beta'_i x_n}}, \;\; j = 0,1,2,3$$

In multinomial logit, it is impossible to identify parameter vectors β_0 to β_3 simultaneously. Hence, the parameters relating to a given category are usually set to zero, known as the reference category. The reference category chosen in this study is fuel wood, that is, to say category 0. Consequently, vector β_0 is normalized to zero. Hence, the above model can be written as:

$$p_{nj} = p(y_n = j/x_n) = \frac{e^{\beta'_j x_n}}{1+\sum_{i=1}^{j} e^{\beta'_i x_n}}, \;\; j = 1,2,3.$$

In multinomial logit model, the ratio of the probabilities known as the odds ratio (P_{nj}/P_{ni}) depends log-linearly on x_n written as:

$$\log\left(\frac{P_{nj}}{P_{ni}}\right) = x'_n(\beta_j - \beta_i)$$

Hence, the multinomial logit models are estimated by a maximum likelihood method.

The explanatory variables included in the multinomial logit model used to analyse the determinants of households' primary choice of cooking fuel in rural Nigeria are defined in Table 1.

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

Variables (x_n)	**Definition**	**Unit of measurement**
Age	Age of household head	Years in number
Gender	Sex of household head	1- Female; 0- Male
Household size	Number of persons in the household	Number
Formal education	Highest educational level attained by household head	Years in number
Major occupation	Major occupation sector of the household head	1- Farming Sector 0- Otherwise
Total household income	Total household monthly income in naira (₦)	Number
Energy expenditure	Monthly amount spent on chosen primary energy for cooking in naira (₦)	Number
Residence dummy	Community status of the household head	1-indigenous residency status 0-Otherwise
Farm land possession	Ownership of farm land used as a proxy for asset	1- Owned a farm land; 0- Otherwise

RESULTS AND DISCUSSION

Households' primary choice of cooking energy

Figure 2 shows the distribution of the rural households by the principal source of energy used for cooking. Five cooking energy alternatives both biomass including firewood and charcoal as well as non-biomass including kerosene, electricity and gas were identified in the study area. The two biomass fuels identified including firewood and charcoal are lumped together as fuel wood energy in our study since they are both derived from wood. Fuel wood energy is the main source of cooking energy used by more than half of the rural households' (63%) in the study area. The second most dominant source of cooking energy is kerosene, used by about 21% of the rural households as primary cooking fuel. Gas is principally used for cooking by about 12% of the rural households while electricity serves as a major source of cooking energy by only 4% of the rural households.

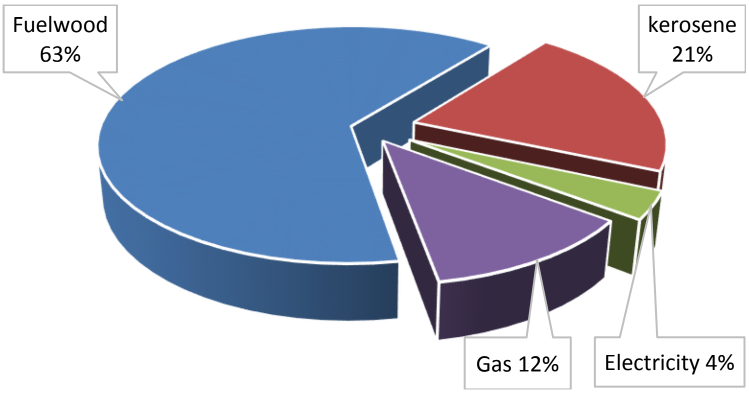

Figure 2: Distribution of households by primary choice of cooking energy

Cooking energies and households' socio-economic characteristics

Table 2 shows the distribution of the rural households by their socio-economic characteristics in relation to their main source of energy used for cooking. Accordingly, the table revealed that while fuel wood is used across all age brackets in the study area as a primary source of cooking energy, its usage is common among the older headed households. Fuel wood is mostly used among households having heads above 50 years constituting about 42.3% of the total number of households that utilizes fuel wood as the main source of cooking energy in the study area. The proportion of households that utilizes cleaner source of energy as a main cooking energy type decreases with higher age brackets. Majority of the rural households that utilizes fuel wood as their main cooking fuel is headed by a male (81.6%). Proportion of households that utilizes cleaner sources of energy are higher for households headed by female compare to their male counterparts. Majority (78.8%) of the household heads' were married. Households with higher number of persons above 4 (86.2%) depends on fuel wood as the main source of cooking energy while cleaner sources of energy are used by households with small household size. This is similar to the findings of Ouedraogo (2006) and Nnaji, Ukwueze and Chukwu (2012) that the use rate of cleaner sources of energy is higher among the smallest households. Households whose heads major occupation is from the farming sector, mostly uses fuel wood for their coking while those whose heads majorly work in the non-farm sector such as civil servant, artisanship and trading use more of the clean sources of energy. The use rate of cleaner sources of energy are higher for households whose heads have a higher level of education. The utilization rate of fuel wood as a source of cooking energy decreases with increase in income and fuel wood is not utilized at all in households with a total monthly income of above ₦30,000/month. Fuel wood are mostly used within the poorest households with monthly total household income of less than ₦10,000. This corroborates the findings of Ouedraogo (2006) and Nnaji et al., (2012) that cleaner source of energy are utilized among the wealthiest households.

Table 2: Households socio-economic characteristics and cooking energy types

Characteristics	Cooking energy types				
	Fuel wood	**Kerosene**	**Electricity**	**Gas**	**Total**
Household head's age (years)					
≤ 30	21 *(8.8)*	14 *(17.7)*	4 *(28.6)*	9 *(20.0)*	**48 *(12.7)***
31-40	52 *(21.8)*	36 *(45.6)*	2 *(14.3)*	21 *(46.7)*	**111 *(29.4)***
41 – 50	65 *(27.2)*	19 *(24.1)*	5 *(35.7)*	9 *(20.0)*	**98 *(26.0)***
>50	101 *(42.3)*	10 *(12.7)*	3 *(21.4)*	6 *(13.3)*	**120 *(31.8)***
Households head's gender					
Female	44 *(18.4)*	52 (65.8)	9 *(64.3)*	27 *(60.0)*	**132 *(35.0)***
Male	195 *(81.6)*	27 (34.2)	5 *(35.7)*	18 *(40.0)*	**245 *(65.0)***
Household head's marital status					
Married	194 *(81.2)*	59 *(74.7)*	14 *(100.0)*	30 *(66.7)*	**297 *(78.8)***
[a] *Otherwise*	45 *(18.8)*	20 *(25.3)*	0 *(0.0)*	15 *(33.3)*	**80 *(21.2)***
Household size					
≤ 4	33 *(18.8)*	31 *(39.2)*	7 *(50.0)*	26 *(57.8)*	**97 *(25.7)***
5 – 8	186 *(77.8)*	47 *(59.5)*	7 *(50.0)*	19 *(42.2)*	**259 *(68.7)***
9 – 12	20 *(8.4)*	1 *(1.3)*	0 *(0.0)*	0 *(0.0)*	**21 *(5.6)***
Household head's major occupation sector					
Farming	155 *(64.9)*	14 (17.7)	4 *(28.6)*	11 *(24.4)*	***184 (48.8)***
Non farming	84 *(35.1)*	65 *(83.2)*	10 *(71.4)*	34 *(75.6)*	**193 *(51.2)***
Household head's formal education					
No formal education	84 *(35.1)*	7 *(8.9)*	0 *(0.0)*	0 *(0.0)*	**91 *(24.1)***
Primary education	109 *(45.6)*	12 *(15.2)*	4 *(28.6)*	1 *(2.2)*	**126 *(33.4)***
Secondary education	33 *(13.8)*	44 *(55.7)*	7 *(50.0)*	8 *(17.8)*	**92 *(24.4)***
Tertiary education	13 *(5.4)*	16 *(20.3)*	3 *(21.4)*	36 *(80.0)*	**68 *(18.0)***
Total household income (₦)					
≤ 10,000	193 *(80.8)*	44 *(55.7)*	9 *(64.3)*	1 *(2.2)*	**247 *(65.5)***
10,001 - 20,000	43 *(18.0)*	18 *(22.8)*	2 *(14.3)*	7 *(15.6)*	**70 *(18.6)***
20,001 - 30,000	3 *(1.3)*	11 *(13.9)*	2 *(14.3)*	20 *(44.4)*	**36 *(9.5)***
30,001 - 40,000	0 *(0.0)*	2 *(2.5)*	0 *(0.0)*	14 *(31.1)*	**16 *(4.2)***
>40,000	0 *(0.0)*	4 *(5.1)*	1 *(7.1)*	3 *(6.7)*	**8 *(2.1)***

[a] *Otherwise include the singles, widowed and divorced.*

Figures in parenthesis are percentage within cooking fuel types

Field Survey, 2015

Determinants of households' choice of cooking energy

The empirical estimates (odd ratios and marginal effects) obtained from the multinomial logit model are presented in Tables 3 and 4. The diagnostics statistics indicated that the model has a good fit in assessing the factors that influences rural households' choice of primary cooking energy. The likelihood ratio value of 383.20 statistically significant ($p<0.01$) indicates that the predictor regression coefficients are significantly different from zero. Also, the high pseudo R squared value of approximately 52% above the McFadden (1979) satisfactory range of 20 to 40% equally confirms that the model has an excellent fit. It was established from Table 3 that across all the cooking energy choice categories, indigenous and high income households are more likely to use cleaner sources of cooking fuels (kerosene, electricity and gas) compared to fuel wood, while households with large number of people will prefer fuel wood to other choices of cooking energy. Specifically, with respect to each of the cooking energy alternatives, we found that households with well-educated and younger heads have higher probability of choosing kerosene rather than fuel wood. In terms of electricity as a choice of cooking energy, the result revealed that the head of a household being a female and monthly expenditure on energy choice positively influence the likelihood of using the most efficient and clean source of electricity for domestic cooking as opposed to fuel wood. Furthermore, households possessing farmland as an asset and whose heads are more educated are very likely to prefer gas to fuel wood for domestic cooking.

Additionally, the marginal effect estimates from Table 3 show that age of the household head in years have a negative statistically significant ($p<0.05$) effect on the choice of kerosene as a main source of cooking energy indicating that one-year increase in the household head's age will reduce the probability of a household using kerosene for cooking by 0.6%. This implies that young headed household are more likely to use kerosene compared to fuel wood. This may particularly be so because younger household heads are expected to have strength to work more and thus have higher earnings advantage, which may translate to better economic ability to purchase and use kerosene for cooking than the older household heads. This corroborates the findings of Wickramasinghe (2011) and Assa et al., (2015). In contrast, Nnaji et al., (2012) obtained a positive relationship between the age of the household head and the probability of adopting cleaner sources of energy as against firewood. In line with Mekonnen and Köhlin (2008), Mensah and Adu (2013) and Assa et al., (2015), the estimated coefficient of household heads' education was found to be significantly ($p<0.01$) and positively related to households' use of gas for cooking but negatively to kerosene and fuel wood. This finding could be attributable to high level of enlightenment and access to relevant health and environmental sustainability related information pertaining to the use of cleaner cooking energy sources. We will like to draw attention to the fact that higher education have a negative (although non-significant) impact on the household's likelihood of transition to electricity. This is however not surprising given the poor and erratic supply of electricity in the country as only few of the sample households (which could probably be the non-educated/less educated households) had access to electricity use for domestic cooking. This implies that the usage of electricity as a main source of cooking fuel greatly depends on its availability in addition to being educated. This is particularly so in Nigeria where 85 million people in both the urban and rural areas do not have access to electricity, which accounts for about than half (52%) of her population in 2013 (IEA, 2013).

A unit increase in the number of rural households headed by a female will increase the use of electricity for domestic cooking by 5%. This implies that female headed households will prefer to use cleaner sources of energy which could be attributed to the fact that the females are more at risk to the adverse health effects associated with using unclean inefficient sources of fuel compared to their male counterparts. A percent increase in household income was found to be capable of increasing the probability of households' kerosene cooking use by approximately 18.1%, increasing usage of gas for cooking by 18.6%, while reducing the probability of households' fuel wood use for cooking by approximately 36.6%. This positive relationship and high value of marginal effects is a validation of the energy ladder hypothesis that income is an important determinant of households' transitioning to cleaner sources of energy. Several studies have also empirically tested and confirmed the energy ladder hypothesis in the Northern part of our study area as well as in other countries. Ouedraogo (2006) found a positive significant relationship between household income and firewood usage in Burkina Faso. Bello (2011) and Nnaji et al., (2012) also asserted that the economic status of a household is a major determinant of the households' transitioning up the energy ladder in Northern Nigeria. Similar findings were obtained in India by Gangopadhyay, Ramaswami and Wadhwa et al., (2003) and Farsi, Filippini and Pachauri (2005) and by Campbell, Vermeulen, Mangono and Mabugu (2003) in Zimbabwe. A person increase in household size of the interviewed rural dwellers will significantly decrease gas use by 2.1% while increasing fuel wood use by 3.4% for domestic cooking. This direction of relationship was found in previous research findings (Mensah and Adu, 2013; Bamiro and Ogunjobi, 2015; Mwaura, Okoboi and Ahaibwe 2014), and this relationship could be explained by the welfare burden usually experienced by households with many members. This could also be as a result of the availability of more labour to freely gather firewood which consequently reduces expenditure on firewood as against other energy choices that are not freely available as opined by Nnaji et al., (2012) who found that an increase in the number of persons in the household increase the probability of using firewood as the main source of cooking energy. Examining the stepwise change effects of rural households' monthly expenditure on cooking energy, we found a slightly negative significant effect on the choice of kerosene use but very little significant positive effect each on electricity and gas use. This implies that a naira increase in the price of any of the cooking energy choice will reduce the likelihood of kerosene but increase electricity and gas use a bit slightly, indicating the level of knowledge of the potential benefits of using clean cooking energy sources by rural dwellers irrespective of a unit positive change in price thereby making price increase to favor gas and electricity use which is cleaner, more efficient and more convenient as opposed to kerosene use. This implies if the rural households have a steady access to cleaner sources of energy such as electricity and gas, they will prefer to utilize it for their cooking despite the associated increase in cost.

In addition, as the number of indigenous rural households increase by a unit, the likelihood of kerosene use will increase by 6.3% while that of fuel wood use will decrease by 9.5%. This could imply that the indigenous households are more conscious of the adverse effect of using fuel wood on the environment, hence more willing to switch to cleaner sources of energy to protect the environment and ensure its sustainability. An interesting relationship worthy of note is the effect of households' farmland possession as used as a proxy for the households' asset endowment on their choice of cooking energy. It was found in this regard that a unit increase in the number of farmlands a household possesses, the likelihood of the rural households using electricity for cooking increases by 4.5%, but with the likely to use gas for domestic cooking decreasing by 7.9%. This implies that for agricultural households, farmland possession could be an indication of wealth which may likely enhance their economic ability to afford the use of more electricity source for domestic cooking by those few households who had access to electricity supply. On the other hand however, the negative influence of farmland possession on gas use could indicate the availability of cheaper energy choices such as firewood, charcoal and kerosene to them compared to gas use. It is also worthy of note that from the marginal effects estimates, most of the coefficients for electricity are not significant due to the situation of electricity supply in the country.

Table 3: Empirical estimates of determinants of rural households' cooking energy choices in Nigeria

Dependent variable: Households' cooking energy choices

Base Category: Fuel wood

Other Choices	**Kerosene**		**Electricity**		**Gas**	
Variables	**Odd ratio**	**z-value**	**Odd ratio**	**z-value**	**Odd ratio**	**z- value**
Constant	-2.70E-19*** (1.57E-18)	-7.37	4.84E-18*** (4.45E-17)	-4.33	2.39E-39*** (2.88E-38)	-7.39
Household head's Age	-0.9505* (0.0266)	-1.81	1.0037 (0.0478)	0.08	-0.9969 (0.0529)	-0.06
Household head's Gender (Base category: Male)						
Female	1.1993 (0.5213)	0.42	17.5851** (20.9769)	2.40	3.0485 (2.1634)	1.57
Household size	-0.7034*** (0.1047)	-2.36	-0.5828** (0.1404)	-2.24	-0.4414*** (0.1093)	-3.30
Household head's formal education	1.0815* (0.50)	1.70	1.1437 (0.0961)	1.60	1.8503*** (0.2398)	4.75
Household heads' major occupation (Base category: Non-farming)						
Farming sector	-0.4133 (0.2223)	-1.64	-0.9023 (0.7330)	-0.13	-0.6383 (0.600)	-0.48
Log of total household income	81.8350*** (49.7935)	7.24	26.8468*** (25.2352)	3.50	2915.07*** (3290.07)	7.07
Households' monthly expenditure on chosen cooking energy	-0.9999 (0.0002)	-0.28	1.1008** (0.0004)	1.99	1.0006 (0.0004)	1.61
Households' residence dummy (Base category: non-indigene)						
Indigenous residential status	3.413*** (1.596)	2.63	3.5872* (2.7678)	1.66	4.5387** (3.1088)	2.21
Households' farmland possession (Base category: non-possession)						
Possess a farm land	-0.8385 (0.4075)	-0.36	6.2079 (7.0818)	1.60	0.1871** (0.1501)	-2.09
Diagnostic Measures						
Number of Observations	377					
Log-likelihood value	-182.548					
Likelihood Ratio Chi^2 value	383.20					
Probability > Chi^2	0.0000					
Pseudo R^2 value	0.5121					

Note: Values in parenthesis are robust standard errors

*** *Statistically significant at 1% level*

** *Statistically significant at 5% level*

* *Statistically significant at 10% level*

Table 4: Elasticity estimates of determinants of rural households' cooking energy choices in Nigeria

Dependent variable: Households' cooking energy choices

Other Choices	**Kerosene**		**Electricity**		**Gas**		**Fuel Wood**	
Variables	**Marginal effects**	**z-value**	**Marginal effects**	**z-value**	**Marginal effects**	**z-value**	**Marginal effects**	**z-value**
Household head's Age	-0.0056** (0.0028)	-2.02	0.0008 (0.0015)	0.56	0.0015 (0.0021)	0.73	0.0033 (0.0021)	1.53
Household head's Gender (Base category: Male)								
Female	-0.0440 (0.0384)	-1.15	0.0532*** (0.0163)	3.27	0.0307 (0.0230)	1.33	-0.040 (0.033)	-1.20
Household Size	-0.0047 (0.0131	-0.36	-0.0076 (0.0068)	-1.10	-0.0212*** (0.0086)	-2.47	0.0335*** (0.0112)	2.97
Household head's formal education	-0.0135*** (0.0046)	-2.94	-0.0004 (0.0024)	-0.15	0.0237*** (0.0040)	5.95	-0.010*** (0.0034)	-2.89
Household heads' major occupation (Base category: Non-farming)								
Farming sector	-0.0833 (0.0520)	-1.60	0.0116 (0.0290)	0.40	0.0084 (0.0367)	0.23	0.0633 (0.0449)	1.41
Log of total household income	0.1809*** (0.0402)	4.50	-0.0014 (0.0198)	-0.07	0.1861*** (0.0298)	6.24	-0.3656*** (0.0287)	-12.74
Households' monthly expenditure on chosen cooking energy	-0.0004* (0.0002)	-1.86	0.0000* (0.0000)	1.81	0.0000* (0.0000)	1.71	-8.89E-6 (0.0000)	-0.54
Households' residence dummy (Base category: non-indigene)								
Indigenous residential status	0.0631* (0.0362)	1.74	0.0133 (0.0206)	0.65	0.0184 (0.0234)	0.79	-0.0949*** (0.0304)	-3.12
Households' farmland possession (Base category: non-possession)								
Possess a farm land	0.0285 (0.0434)	0.66	0.0453*** (0.0161)	2.80	-0.0799*** (0.0317)	-2.52	0.0062 (0.0369)	0.17
Diagnostic Measures								
Number of Observations	377							
Log-likelihood value	-182.548							
Likelihood Ratio Chi^2 value	383.20							
Probability > Chi^2	0.0000							
Pseudo R^2 value	0.5121							

Note: Values in parenthesis are robust standard errors

*** Statistically significant at 1% level

** Statistically significant at 5% level

* Statistically significant at 10% level

CONCLUSION AND POLICY SUGGESTIONS

The study used rural households' cross sectional data in Ogun State, south western Nigeria to analyse households' choice of cooking energy using descriptive statistical measures and multinomial logit model. The study found that well above half (63%) of the rural households rely on fuel wood as their primary cooking energy, with about 21% of the remaining part of the population using kerosene, 12 percent using gas, while only 4 percent use electricity as their main source of energy for domestic cooking. The empirical estimates show that the rural households' choice of cooking energy and probability of switching to cleaner sources of fuel is greatly influenced by income validating the energy ladder hypothesis which postulates that income is an important factor for households' transitioning to cleaner, more efficient and more convenient sources of energy. The study also identified that other demographic and economic factors such as household head's age and education, household size, monthly expenditure on chosen cooking energy source, having an indigenous residential status as well as households' farmland possession equally significantly affects the rural households' energy choice.

In the light of the above, the study suggests policy measures aimed at poverty reduction as its impact on reducing rural households' dependence on unclean, solid, inefficient sources of cooking energy cannot be overemphasized. Increasing access to cleaner sources of energy such as electricity and gas will help reduce pressure on Nigeria forest resources and ensure environmental sustainability as the rural households are more likely to use these sources for their domestic cooking even with associated cost increase. Campaigns aimed at enlightening the rural households in having a moderate family size to reduce their economic burden will also increase the likelihood of households' transitioning to clean modern sources of energy. Since formal education positively influences the likelihood of using cleaner cooking energy sources, encouragement of the use of cleaner cooking energy sources through public enlightenment of the potential health and environmental sustainability benefits of using cleaner cooking energy sources should be put in place. Finally, given that the traditional biomass fuels such as firewood and charcoal constitute the dominant source of cooking energy used by the rural households', policies and programmes such as reforestation that will help to strike a balance between biomass production and consumption rate is critically required as transition to cleaner source of energy cannot be achieved overnight. This is particularly important in Nigeria where the rate of deforestation is continuously increasing.

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