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Rural Household Fuel Consumption and Energy Crisis: A Synopsis of Poverty Trend in North Central Nigeria

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ABSTRACT

Nigeria has enormous energy resource potentials and endowment, but could not provide affordable energy for majority of its citizenry and, poverty remains critical developmental challenges. The study examined rural households' fuel consumption pattern in two States of North Central Nigeria. Primary data using a structured questionnaire and interview were administered to select randomly 180 rural farming households. The result revealed a link between forests, agricultural production and poverty as about 73% of sampled respondents titled towards using biomass for their energy sources and about three-fifth (58%) rural households could be considered to have a low energy expenditure pattern because they fell below poverty line of ₦987 ($6.2). Result also estimated the log-likelihood ratio to be -28.7, the adjusted R^{-2} of 0.557 implies that the explanatory variables were collectively able to explain about 56% of the total variation in energy consumption pattern among the rural households. The study recommend designing more economical, efficient and less pollutants cooking stoves and lighting equipments that uses local bio-fuels (renewable) and harnessing modern energy source to supplement the use of biomass for rural farming households to reduce poverty level.

Key words*:* Bio-fuel, poverty, Nigeria, renewable, Shea butter oil

INTRODUCTION

Energy is considered as an indispensable force and vital to virtually all economic activities and indeed industrial production, technological and social development. A supply of clean, secure, efficient, equitable, affordable, reliable and sustainable energy services, and have minimal impact on the environment is vital to Nigerian future prosperity. The main goal of all energy transformations is to provide energy services that improve quality of life such as health, life expectancy and comfort, and productivity (Hall *et al*., 2004 in sims *et al.,* 2007), invariably reduce poverty and offer long-term security of sustainable supply.

Nigeria energy has been very volatile, in oil prices in the last two decades despite the fact that its energy resources, particularly petroleum products and Liquefied Natural Gas (LNG), are one of 0.62, 0.69, 0.55 and 0.46 respectively also exhibit high correlation with the average power per capita of these countries in 2011 (UNDP, 2011). Therefore, high grade energy resources will impact positively on technological development, social and economic growth. Hence, the scale of energy consumption per capita is an important indicator of economic modernization (Adegbemi *et al*., 2013). It can be concluded that countries which have higher per capita energy consumption are more developed than those with low level of consumption.

According to Solar Cooking Archive (2011), the estimated Nigeria's fuel wood and charcoal (traditional biomass) consumption was about 87% of total energy consumed. Suffice to note that less than 40% of Nigerians have access to electricity (ECN/UNDP, 2005). With an installed grid capacity of 6,000MW, less than 4,000MW of electricity is generated presently, which is even lower than what India generates from nuclear power plants alone (IAEA, 2009). This is grossly insufficient for Nigeria's growing population where the per capita the leading net exports in the world. The implication of its volatility was unprecedented increase in domestic fuel prices of petrol and diesel from about ₦3.25K/litre and ₦3/litre respectively in 1993 to ₦97 and ₦135/litre in 2012 with attendant upsurge in transport fare and prices of goods and services (Oladimeji *et al*., 2013). This is also manifest by the epileptic supply of electricity and over dependence on generators as a fossil fuels and biomass as major source of fuel for household use. The average power per capita (in watts) in USA, Japan, South Africa, China, India and Nigeria were 1,363, 774, 496, 397, 85, and 12 while their Gross National Income per capita were US$43,017; US$32,295; US$9,469; US$7,476; $3,468 and US$2,069 respectively. Both the GNI per capita and their estimated Human Development Index (HDI) of 0.91, 0.90, electricity consumption is 4 times less than the average in Africa and about 19 times less than the average in the world (Sambo, 2009). The capacity of potential energy resources to upset energy imbalance, create employment and alleviate poverty depends on the adoption of appropriate technology strategies. This will also ensure energy sustainability to avoid wanton exploitation which prone both the renewable and non-renewable energy resources to intense pressure and depletion.

Problem Statement

Nigeria is one of the most energy resource endowed nations in the world. These comprise of energy resources which are renewable such as solar, wind, nuclear, tar sand,uranium, geothermal, hydro and biomass as well as non-renewable such as petroleum, coal, and natural gas. Nigeria has an estimated 176 trillion cubic feet of proven natural gas reserves, giving the country one of the top ten natural gas endowments in the world and the largest endowment in

Africa (Sambo, u. d). Natural gas is a natural occurring gaseous mixture of hydrocarbons gases found in underground reservoirs. It consists mainly of methane about 70% - 95% with small percentage of ethane, propane, butane, pentane and other heavier hydrocarbons with some impurities such as water vapour, sulphides and carbon dioxides (Sambo, u. d).

With proven oil reserves exceeding 9 billion tons, Nigeria is one of the largest hydrocarbon feedstock producers in Africa, and ranks twelfth place worldwide. The country relies heavily on its petroleum industry for economic growth, the sector accounts for about 80% of government revenues and provides 95% of foreign exchange (Iwu, 2008 in Adegbemi *et al*., 2013). It is also endowed with rich vegetation and abundant water resource, about 214 billion m^3 of surface water and 87 km^3 of ground water both of which are capable of generating hydro-electric power. According to the Forest Resources Assessment (FRA), 2005, total wood removals from Nigerian forests in 2005 amounted to 86,626,797 m^3, and removals for wood fuel from forests in the year 2005 were 72,710,935 m^3, the difference being made up by industrial round wood, which accounted for 13,915,862 m^3. In many parts of this region, more than 90% of the rural population relies on fuel-wood and charcoal, and the reality is that the correlation between forests and poverty is strong (Sunderlin *et al*., in World Bank, 2008). With a reserve of over 2 billion metric tonnes of coals, Nigeria produces about 200,000 to 600,000 tonnes yearly. Despite these enormous energy resource potentials and endowment, the country could not provide affordable energy for majority of its citizenry and, poverty remains critical developmental challenges. Suffice to note that the development and exploitation of such energy sources have been skewed in favour of the fossil fuels mainly petroleum products, and of recent natural gas which are non-renewable resources. Energy services are fundamental to achieving sustainable development. In many developing countries, provision of adequate, affordable and reliable energy services has been sufficient to reduce poverty and improve standards of living. To provide such energy services for everyone in an environmentally sound way will require major investments in the energy-supply chain, conversion technologies and infrastructure particularly in rural areas (Sims *et al*., 2007).

Currently, the Nigerian energy crisis has thwarted the socio economic activities of both rural and urban dwellers. Biomass materials are used since millennia for meeting myriad human needs including energy. Main sources of biomass energy are trees, crops and animal waste. Until the middle of 19th century, biomass dominated the global energy supply with a seventy percent share (Grubler and Nakicenovic, 1988 in Sims *et al*., 2007). Among the biomass energy sources, wood fuels are the most prominent. With rapid increase in fossil fuel use, the share of biomass in total energy declined steadily through substitution by coal in the nineteenth century and later by refined oil and gas during the twentieth century. Thus, according to the WHO, energy-poverty, marked by lack of sustainable energy and access to modern cooking fuels, creates obstacles to achieving the Millennium Development Goals (MDGs), the global targets for reducing extreme poverty and improving health and welfare (WHO, 2007 in Bolaji, 2012). Despite its declining share in energy, global consumption of wood energy has continued to grow. The study was aimed at domestic energy consumption pattern of rural farming households in selected States of North Central Nigeria. Specifically, to:

(i) Examine socio-economic characteristics that influence rural farming households shift from different energy source,
(ii) identify various energy sources among rural households; and
(iii) Assess the factors that determine poverty among the rural households base on energy source.

Theoretical framework

A simplified conceptual model that leads to our empirical specification follows the spirit of the theoretical models such as Keynes, (1936) and logit model by Berkson, (1944) in Kramer, (1991). Consumption function, that is, a functional relationship between total consumption and income introduced by Keynes is based on his statement of a fundamental psychological law that consumers, on the average, tend to increase their consumption as their income increases, but not as much as the increase in their income. This relationship is based on the *ceteris paribus* assumption, other possible influences are held constant. Symbolically, the relationship is represented as:

$$C = f(Y), \qquad (1)$$

where: C is consumption and Y is income. Although, Keynes listed a number of factors affecting consumption, he indicated that the income variable, especially disposable income is the most important one. Although, this study considered other factors including the one held constant by Sir Keynes.

A simplified consumption function can be represented as

$$C = a + bY \qquad (2)$$

Where: $a > 0$ and $b < 1$. The coefficient b is the Marginal Propensity to Consume (MPC). Keynes further assumed that the short-run MPC is less than the long-run MPC, since over the longer period of time a consumer's living standard is more flexible. One of Keynes's controversial conclusions is that, in the long run, a greater proportion of income will be saved as real income increases. A number of aggregate-consumption functions found that the ratio of consumption to disposable income C/Y stays constant over several decades. On the other hand, cross-section data for the household-consumption pattern shows that the C/Y ratio decreases as income increases. These conflicting findings resulted in a number of modified consumption theories.

Duesenberry's theory, known as the relative-income hypothesis, assumes that an individual's consumption does not depend on his absolute income, but rather on his percentile position in the income distribution. Further, an individual has the habit of persistence in his consumption pattern, so that he will continue to base his consumption pattern partially on higher previous levels of income if his current income falls. Therefore, Duesenberry's hypothesis can be formulated as:

$$\frac{C_t}{Y_t} = a + b\left(\frac{Y_t}{Y^0}\right) \qquad (3)$$

where C_t and Y_t are current consumption and income respectively and, Y^0 is the peak previous income.

Friedman introduced his permanent-income hypothesis, which assumes that it is an individual's permanent income that affects his consumption. This hypothesis can be formulated as the following:

$$C_p = K(i, w, u)Y_p \qquad (4)$$

$$Y = Y_p + Y_t \quad \rho(Y_p Y_t) = 0 \quad \bar{Y}_t = 0 \qquad (5)$$

$$C = C_p + C_t \quad \rho(C_p C_t) = 0 \quad \bar{C}_t = 0 \qquad (6)$$

$$\rho(Y_t C_t) = 0, \qquad (7)$$

Where Y is the measured income, Y_p is the permanent income, Y_t is the transitory income. C is the measured consumption, C_p is the permanent consumption, C_t is the transitory consumption, K is the marginal propensity to consume between permanent consumption and permanent income, i is the interest rate, w is the ratio of non-human wealth to permanent income, u *is the other economic and demographic factors affecting* K, ρ is the correlation coefficient, and $\overline{Y}_t$ and $\overline{C}_t$ are the mean values of Y_t and C_t.

However, several studies on consumption (Sabur *et al.*, 1997; Ikurekong *et al.*, 2009; Begum *et al.*, 2010; Anthony *et al.*, 2012; Olatinwo and Adewumi, 2012) have employed the regression models such as multiple and logit regressions. Following Gujarati (2003), the logistic distribution for the energy consumption was specified as:

$$P_i = \frac{1}{1+e^{-z_i}} \tag{8}$$

Where, P_i is a probability of rural farming household energy consumption pattern for the i^{th} farming household and ranges from 0 to 1, e represents the base of natural logarithms and Z_i is the function of a vector of n explanatory variables and expressed as:

$$Z_i = \beta_0 + \sum \beta_i X_i \tag{9}$$

Where: β_0 = intercept; β_i = vector of unknown slope coefficients.

The relationship between P_i and X_i, which is non-linear, can be written as follows:

$$P_i = \frac{1}{1+e^{\beta_0+\beta_i X_i+ \dots\dots\dots\dots + \beta_n \beta_n}} \tag{10}$$

The slopes tell how the log-odds in favour of achieving threshold of expending 2/3 of mean total energy consumed/month as independent variables change. If P_i is the probability of household expending at least 2/3 of total of mean energy consumed/month, then 1- P_i represents the probability of spending less than 2/3 of mean total energy consumed/month and can be written as:

$$1 - P_i = \frac{1}{1+e^{-z_i}} = P_i = \frac{e^{z_i}}{1+e^{-z_i}} = P_i = \frac{1}{1+e^{z_i}} \tag{11}$$

Dividing equation (8) by equation (11) and simplifying gives:

$$\frac{P_i}{1-P_i} = \frac{1+e^{z_i}}{1+e^{-z_i}} = e^{z_i} \tag{12}$$

Equation (12) indicates simply the odd-ratio in favour of non-poor rural household energy consumers. It is the ratio of the probability that the rural farming households will achieve a threshold of the 2/3 of mean total energy consumed/month to the probability that household spend less than 2/3. Then, the log it model was obtained by taking the logarithm of equation (12) as follows:

$$l_i = \frac{P_i}{1-P_i} = Z_i = \beta_0 + \beta_i X_i + \cdots \dots\dots\dots\dots\dots\dots + \beta_n X_n \tag{13}$$

Where l_i is log of the odds ratio, which is not only linear in X, but also linear in the parameters: Thus, if the stochastic disturbance term $u_i$is taken into account, the logistic model becomes:

$$Z_i = \beta_0 + \beta_i X_i + \cdots \dots\dots\dots\dots\dots + \beta_n X_n + u_i \tag{14}$$

MATERIALS AND METHODS

Data Collection and Sampling size

The study was carried out in randomly selected villages of Kwara and Niger States, North Central Nigeria. The study area has two distinct seasons with mean annual rainfall ranges from 800mm to 1600mm, concentrated between the months of April and October with two peaks in July and September which serves as a condition that facilitates growing of herbs, shrubs and economic trees for fuel wood production. Economic trees found in the area includes: *Citrus sinensi, Parkia biglobosa, Butyrospermum parkii, Azadiracta indica, Mangifera indica, Acacia species, Delonix regia and Anacardium occidentale.* Primary data were obtained using a structured questionnaires and interview. A multi-stage random sampling technique was employed for selecting the representative of rural farming households in North Central, Nigeria. The first stage involved the purposive selection of 2 States: Kwara and Niger States from the list of the six States in the region (See Oladimeji *et al*., 2013). Kwara Stat lies in two geo-ecological zones; the derived and the Guinea savanna and Niger State though share the Guinea savanna characteristics (only) with other North Central States, but chosen because the land mass (76, 469.903 km^2) is about 10% of the total land area of Nigeria or 57% of that of North Central States, out of which about 85% is arable (NPC, 2006). The second stage involved the random selection of three Local Government Areas (LGAs) each, in chosen States; viz. Baruten, Moro, Patigi LGAs (Kwara); and Agwara, Borgu and Mokwa (Niger). Two villages each were randomly selected from each of the 6 LGAs. Then, the list of rural farming households in each village selected was compiled through their farmers' co-operatives for random selection (through combined efforts of Agricultural Development Project staff and '*Sarkin Ruwa*' or village heads). Finally, 15 farming households were randomly selected from each of the farmers' co-operatives list (12 villages) making a total of 180 farming households for the study. **The size of the sample frames of the 12 villages chosen have little variability, give room for uniform respondents*

The selected villages were Ngurumi-Gwanara, Shia (Baruten); Onipako, Beriberi (Moro); Ellah, Sunkuso (Patigi) in Kwara State and Kokoli, Mago (Agwara); Kaya, Garafini-kodo (Borgu); Bokani and Ndafu (Mokwa) in Niger State respectively. Primary data were obtained using a structured questionnaires and interview. Information on the sources of energy used for cooking, heating and lighting include: fuel wood, charcoal, dung, saw dust, crop residue (traditional); and kerosene and electricity (modern) were sought from sampled correspondents.

Analytical techniques

Energy poverty line was generally considered to be the value of energy consumption that is needed to meet the minimum energy needed for an individual or household to be acceptable in the community. Energy poverty line was measured as either:

$$\text{Per capita energy consumption} = \frac{\text{Total household monthly energy expenditure}}{\text{Adjusted Household Size}} \quad (15)$$

or mean per capita energy

$$\text{expenditure} = \frac{\text{Total per capita household energy expenditure}}{\text{Total number of adjusted households}} \quad (16)$$

The poverty line that was used for this study was defined as the two-thirds of mean energy expenditure per adult equivalent. Adult equivalent was generated from Organization for Economic Corporation and Development, ***OECD*** (See Oladimeji *et al.*, 2013). In logistic regression, the probability of a household consuming 2/3 of mean energy consumption was determined by an underlying response variable that captures the true economic status of rural farming households. It is assumed that rural farming households that consumed above the 2/3 has tendency to adopt modern energy or shift in favour of modern energy source. The underlying response variable y* in the case of binary choice is defined by the multivariate logit regression relation:

$y^* = \Sigma x_i \beta_j + \mu$

Where: $\beta_j = \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$, and $X_i = X_{i1}, X_{i2}, X_{i3}, X_{i4}, X_{i5}$,

The relevant logistic expressions are given as:

$$Prob(y* = 1) = 1 - F*(\Sigma X_i \beta_j) = \frac{e^{\Sigma X_i \beta_j}}{1 + e^{\Sigma X_i \beta_j}} \quad (17)$$

$$Prob(y* = 0) = F*(\Sigma X_i \beta_j) = \frac{e^{\Sigma xi\beta j}}{1 + e^{\Sigma xi\beta j}} \quad (18)$$

Where: 1 = If household spent at least 2/3 of mean total energy consumed/month (₦),

0 = If household spent less than 2/3 of mean total energy consumed/month (₦),

F = the cumulative distribution function for μ_i.

The explicit logit model was expressed as:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots + \beta_5 X_5 + u \quad (19)$$

Where: Y =Mean energy expenditure per adult equivalent of household (₦) per month; X_1 = Age of household head (years); X_2 = Education (years of formal schooling); X_3 = Adjusted household size by OECD scale; X_4 = Total amount spent on energy divide by total expenditure (₦) per month and X_5 = distance travelled per month to energy source (km); $\beta_1 - \beta_5$= The coefficients for the respective variables in the logit function and u = error term.

The underlying statistical assumptions that the logit model has to satisfy are those related to the principles the explanatory variables in the equation have been generated. These assumptions which are crucial to the estimation process are that no exact linear relationship exists among the explanatory variables (multicollinearity) and serial correlation among residues. Multicollinearity is inherent likelihood of joint movement of economic variables over time at the same point in time (Oladimeji, 1999). An exact linear relationship is said to exist if the following condition is satisfied in equation:

$$\lambda_1 X_1 + \lambda_2 X_2 + \dots\dots + \lambda_k X_k = 0 \quad (20)$$

where: $\lambda_1, \lambda_2 \dots\dots, \lambda_k$ are constant such that not all of them are zero simutaneasouly, or where the X independent variables are inter-correlated but not perfectly as in equation:

$$\lambda_1 X_1 + \lambda_2 X_2 + \dots\dots + \lambda_k X_k + v_i \ne 0 \quad (21)$$

v_i is a stochastic error term

One of the consequences of multicollinearity is that we shall be unable to isolate the separate effects of the individual explanatory variables on the dependent variables. Therefore, Farrar glauber test to check the Correlation Matrix (C. M.) and find a matrix of pairwise coefficient of all independent variables was used to detect multicollinearity. For the purpose of this study, we would take any pair of correlation co-efficient that is up to 0.50 and above as posing serious multicollinearity problems. In addition, the Durbin Watson (D. W.) statistic was used to test for the serial correlation in the residuals denote by $E\ (U_t\ U_{t-1}) \neq 0$ (22) Therefore, DW of less than 1.5 was assumed to pose a serial correlation.

In capturing the degree of poverty among the rural faming households, a Foster-Greer-Thorbecke (FGT) index (Foster *et al*., 1984 in Oladimeji *et al.*, 2013) was used to describe influence of expenditure from energy source (output) and/or whether energy source was local or modern techniques on welfare of rural households. It is important to test whether the sub-group of ranking above is robust to the choice of the poverty line. The simplest way for the robustness of poverty comparisons based on the headcount index of poverty is to plot the Cumulative Distribution Function (CDF) of expenditure for two household groups (modern or traditional) at a defined poverty line. It is needed to observe whether the curves intersect or not. If they do not intersect, then the group with highest curve is poorer than other group (World Bank, 2005 and Oladimeji *et al*., 2013). The test of robustness of poverty line was carried out by plotting the CDFs of the two distributions against the specified range of poverty line, 0.7-1.45.

RESULTS AND DISCUSSION

Descriptive variables used in the Logit Model

Analysis of summary of socio-economic and living condition variables used in the Logit Model is presented in Table 1. Results revealed that rural farming household heads in the study area dominated by average productive age of 48 years with mean adjusted household size of 7 and estimated mean years of schooling of rural households of 1.1 years, skewed towards informal education and below 2011 UNDP mean education index of 5 years for Nigeria. Seventy percent of rural households travelled at least 1 Km to search for energy either cooking or lighting and 95% of sampled households engaged in farming. Therefore, lack of access to affordable, reliable and modern energy service (poverty) often accompany by travelling a long distance to search for biomass may have adverse effect on ecosystem such as deforestation, desertification, soil erosion and reduced agricultural productivity by devoting productive time for searching for fuel wood. In addition, fuel-wood, roots, agricultural residues and animal dung all produce high emissions of carbon monoxide, hydrocarbons and particulate matter which are linked to acute respiratory infections, chronic obstructive lung diseases, low birth weights, lung cancer and eye problems, primarily, among women and children (WHO, 2007 in Bolaji, 2012). The result of the analysis of amount spent on energy as a part of household expenditure is on Table 2. The result showed that 58% of sampled respondents were below poverty line denoting by at least 2/3 of mean total energy consumed/month. The result also showed that the bulk value ₦675 (45.6%) of energy expenditure went for firewood an only 8% of households' energy expenditure was captured by kerosene. The analysis further revealed that modern energy source (electricity and kerosene) gulped only 24%. Traditional method of energy sources dominated the bulk of energy viz. Fuel wood, charcoal, dung and crop residue, saw dust (cooking) and locally made lantern such as "Jango" and "Fitila" that uses fuel such as Shea butter oil, palm oil and kernel residues and kerosene (lighting). This shows a link between forests, agricultural production and poverty as about 73% of sampled respondents titled towards using biomass that comprises of traditional energy sources.

Table 1: Definition and dominance indicators of the variables used in the Logit Model

Variables description	Dominance indicators	Mea	Min	Max	*a priori*
Age (years)	72% below 50 years	48.0	23	71	positive
Level of education (years)	57% had no primary educ.	1.09	0	12	positive
Adjusted household size	68% had adjusted size of 7-9	7.0	4	15	positive
Distance travelled (km)	70% travelled above 1km	1.8	0.5	8.0	negativ
Energy expenditure (₦)	52% spent < 10% of total Ex.	1480	350	2850	positive
Monthly expenditure (₦)	67% had > ₦8750/PAE	8750	4508	22,540	-
OOO Major occupation	95% engaged in farming	-	-	-	-
Energy Expenditure (₦)	58% below 2/3 monthly/PAE	dependent variable			-

Source: Field survey, 2014 *Ex. is expenditure & PAE connotes Per Adult Equivalent;* Note: ₦ denote Nigeria currency (Naira) and 1US$ = N159 during field survey

It is very clear from the result of the analysis of energy source that the bulk of rural households depend largely on biomass for cooking and local or improvised lighting source. The rural household that uses electricity as a means of lighting portray higher level of well-being and measure of good health, and invariably reduced poverty status, because the multiplier effect of electricity may enable the rural households to have access to farming related information, nutrition and health matter through gadgets such as television, telephone and radios. However, the bulk of households who are only exposed to local lamps portend higher poverty status, since they may be exposed to high emissions of carbon monoxide, hydrocarbons and particulate matter and deprived of some privileged health and farming information through radio battery only. The study is comparable with findings of Kamara, 1986 in Ikurekong *et al*., 2009; Olatinwo and Adewumi, (2012); Oladimeji *et al*. (2013).

Table 2: Distributions of average energy consumed (₦)/month Per Adult Equivalent

Sources	Amount (₦)	Percentage (%)	Frequency (%)
Firewood	675	45.6	180 (100)
Charcoal	260	17.6	142 (78.9)
Saw dust	50	3.4	69 (38.3)
Crop residue	90	6.1	167(92.8)
Kerosene	120	8.1	49 (27.2)
Electricity	235	15.9	109 (60.6)
Others	50	3.4	45 (25)
Total	1480	100.0	180
Energy poverty line	987		

Source: Field survey, 2014

Figure 1 show households' distribution based on distance to energy source. About 37% of respondents travelled between 1 and 2 km before they could obtain either biomass or modern energy such as kerosene, while about 33% would travel as far as 2 or 8 km to acquire energy for cooking or lighting. This could be attributed to a number of factors such as distance of gasoline station and, arbitrary prices and scarcity of fuel commodity to the respondents' house or village, near absence of adequate gasoline and electricity facilities in the study area. Therefore, non-utilization of modern energy facilities is an indication of low level of well-being. It suffices to note that far distance to energy has significant opportunity cost on time (Bolaji, 2012) and could expose rural households to hazards such accumulated stress and body pains which may be aggravated to ailments.

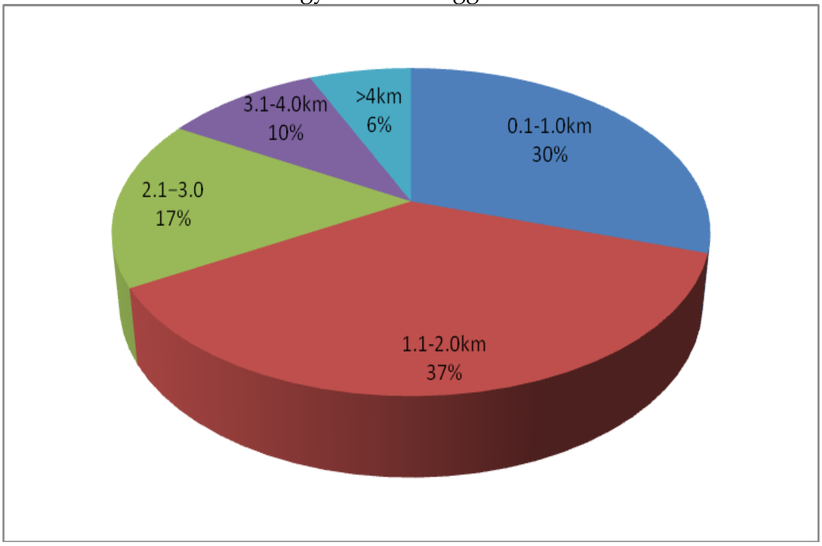

Figure 1: Distribution of households' base on distance to energy source**.**

The rural farming households' mean per adult equivalent expenditure disaggregation is presented in Table 3. The result shows that energy expenditure value had a range of ₦312 to ₦2900 per adult equivalent per month with a mean of ₦1480. About three-fifth (58%) rural households could be considered to have a low energy expenditure pattern because they fell below poverty energy expenditure of ₦987. Further analysis revealed that more than two-fifth (42%) of the rural households was above the poverty threshold consisting of 18.9%, 12.8 and 10% energy expenditure subgroups respectively. Therefore, the energy expenditure subgroup is also another pointer towards poverty status of rural farming households in the study area. For example, energy expenditure range of ₦1.0–₦329 could be classified as extremely poor; ₦330–₦658 as moderately poor; ₦659–₦986 and ₦987–₦1,326 as poor while the other two sub-groups, ₦1,327−₦1656 and those above ₦1656 may be identify as rich and very rich respectively.

Alternatively, the expenditure pattern with a poverty threshold of ₦987 drew a demarcation between poor and non-poor. While the poor rural farming households were indicated by those below poverty line (about 58%), the non-poor could be described as households above the poverty bench mark (about 42%). This result collaborate the view of Hulme and Shepherd (2003) who posited that analysis of poverty status identifies and groups those who experience poverty most intensely, deepening the understanding of poverty and ensure that key groups are not neglected in analysis and action.

Table 3: Poverty status and expenditure of energy consumed (₦)/month/AE

Amount (₦)	Frequency	Percentage (%)
1.0- 329	09	5.0
330 - 658	39	21.6
659 − 986	57	31.7
987 – 1326*	34	18.9
1327- 1656	23	12.8
>1656	18	10.0
Total	180	100

Field survey, 2014*; Note: Energy poverty line=₦987; * =Poverty class interval*

The use of logit model enabled us to look at how a particular variable affect the extent of household energy poverty. The logistic regression result of the determinant of energy poverty among the rural household is shown in table 4. An additional insight was also provided by estimating the log-likelihood ratio to be -28.7, the Adjusted R^{-2} of 0.557 and the LR (Chi-square) of 37.5 (significant at 1% level) implies that the overall model is fitted and the explanatory variables used in the model were collectively able to explain the correlates of energy poverty, about 55.7% of the total variation in energy consumption pattern among the rural households. The result of correlation matrix for all possible pairs of exogenous variables (C. Ms. <0.5) Presents no serious multi Co linearity between the independent variables while D. W. Statistic (2.24) confirmed no serial correlation in the residues. The results depict that the signs of most of the estimated parameters conformed to *a priori* expectations with the exception of Age (X_1) and level of education (X_2) and the duo were statistically insignificant (P>0.10). Among the 3 statistically significant explanatory variables, adjusted household size (X_3) and distance travel to obtain energy (X_5) were in line with *a priori* expectations and found to be positively related to energy consumption. And expenditure ratio (X_4) was also positively related but marginally significant at 10%.

However, the regression co-efficient for adjusted household size (0.085), expenditure ratio (0.502) and distance travel (0.402) implies that increase in these variables would reduce the poverty level. Therefore, an increase in expenditure above 2/3 will decrease the propensity of a household falling below the poverty line and the rural farming household may likely to use more of the modern energy types (for cooking and lighting) such as kerosene and electric stoves, electric boilers and rechargeable lamp, and electricity. The use of modern energy such as electricity and generator powered by petrol and diesel are also health and information driven since household would be opportune to use gadgets such as fan, television, radio and mobile phones. The result is comparable to Ikurekong, *et al.,* (2009); Olatinwo and Adewumi, (2012) that estimated R^{-2} of 62.50% as the total variation in energy consumption of the households in Patigi and Edu LGAS of Kwara State and confirmed that age of the household head and distance travelled to obtain fuel were statistically significant at 5% and 10% respectively.

Table 4: Maximum likelihood estimation of the logit model for artisanal fishing poverty

Variables	**Co-efficient (β)**	**Standard error**	**t-value**
Constant	0.412 *	0.222	1.852
Age of household head (X_1)	-0.190	0.174	-1.09
Level of education (X_2)	-0.009	0.007	-1.25
Adjusted household size (X_3)	0.085 * * *	0.021	3.96
Expenditure ratio (X_4)	0.502 *	0.297	1.69
Distance travelled (X_5)	0.402 * * *	0.139	2.90
No of observation	180		
Log likelihood	-28.7		
LR Chi^2	37.5		
Prob > Chi	0.000		
Pseudo R^2	0.598		
Adjusted R^2	0.557		

Source: logit result, 2014; Note ***; * significance at 1% and 10% respectively

Table 5 presents the profile of the poverty status of the rural farming households based on source of energy for lighting and cooking. There was prevalence of poverty among rural farming households that utilize local or traditional methods (0.85) for lighting in their houses. The use of local or traditional lighting materials however has negative implication on pollution and health hazards for the rural households as was observed by several studies such as World Bank, (2005), Jetter and Kariher, (2009) in Bolaji, (2012) and Oladimeji *et al*. (2014). The households that utilize either kerosene stove (P_0 = 0.52) or electrical appliances (P_0 = 0.23) had lower poverty incidence compared to the households that utilize traditional method. Further, about 13% of rural households that utilize kerosene stove for cooking were poor while only 2% of the households that utilize electric burners and boilers (electricity) were poor and this is far from households that use fuel wood, charcoal and crop residue that contributed about 85% to share of poverty (Table 5). Therefore, rural households that have access to and utilize modern sources of energy such as electricity for lighting and cooking is an indication of higher level of well- being for the rural household.

Suffice to note that rural households in the study area have low income and barely lived above subsistence level. Installation of modern energy facilities such as electrical and LNG gas appliances are virtually non-existent since it required fund which might not be readily available to the rural households. This resulted in the use of impoverished local/ traditional cooking stove that uses fuel wood and charcoal, and lighting (lantern) materials such as ''Jango'' that uses kerosene and seldom, shea butter oil and palm kernel residue with possible negative effect on their health status (Oladimeji *et al.*, 2014). The result confirmed that the assertion that fuel wood and charcoal account for over 80% of national energy consumption (Foley in Ikurekong, *et al.*, 2009).

Further, the World Health Organization (WHO), (2007) in Bolaji, 2012 confirmed that rural households in developing countries that uses biomass tend to expose to significant amounts of pollutants that causes about 1.5 million premature deaths per year and more than 4 000 deaths per day, and biomass use is directly responsible for more deaths than malaria, almost as many as tuberculosis and almost half as many as HIV/AIDS (figure 2).

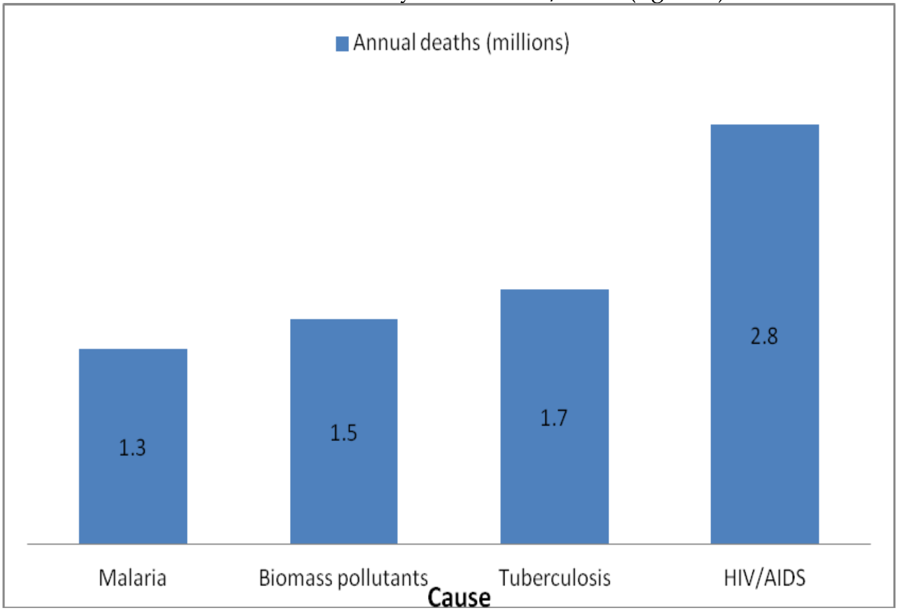

Figure 2: Comparative global deaths and cause (Source: Figure from WHO, 2007)

Table 5: Identified Poverty Sub-groups based on sources of energy

Variables	P_0	P_1	P_2	n	Share of poverty	
					q	%
Source of Energy (lighting)						
Local/traditional	0.850	0.090	0.009	80	68	64.8
Kerosene (intermediate)	0.521	0.097	0.007	48	25	23.8
Electricity	0.231	0.013	0.000	52	12	11.4
Source of Energy (cooking)						
Fuel wood/Charcoal/crop residue	0.640	0.058	0.013	139	89	84.8
Kerosene stove	0.438	0.012	0.005	32	14	13.3
Electrical appliances (electricity)	0.222	0.006	0.000	09	02	1.9

Field survey, 2014 ; note: P_o, P_1, P_2 were the headcount, poverty gap & squared poverty gap indices and Energy poverty line (₦987) was used to identified households as either poor or non-poor

The result of decomposition of poverty based on energy sources (traditional or modern) in Table 5 was reinforcing in Figure 3. The CDF of households that utilise modern energy for cooking and lighting lay completely above other households with traditional energy facilities. This gave an indication of presence of stochastic dominance meaning that this sub-group of households with local energy source will always be poorer than their counterparts. It further implies that the head count ratio was robust to all possible choices of poverty lines within the specified range. Therefore, rural households that utilize modern energy will always maintain a better standard of living compared to households that utilize traditional energy sources.

Table 6 presents all the possible pairs of the energy categories have their poverty incidences, gaps and severity, significantly different from one another (0.01>P < 0.01). This implies that both energy sources (lighting and cooking) affect the level of poverty incidence, gaps and severity.

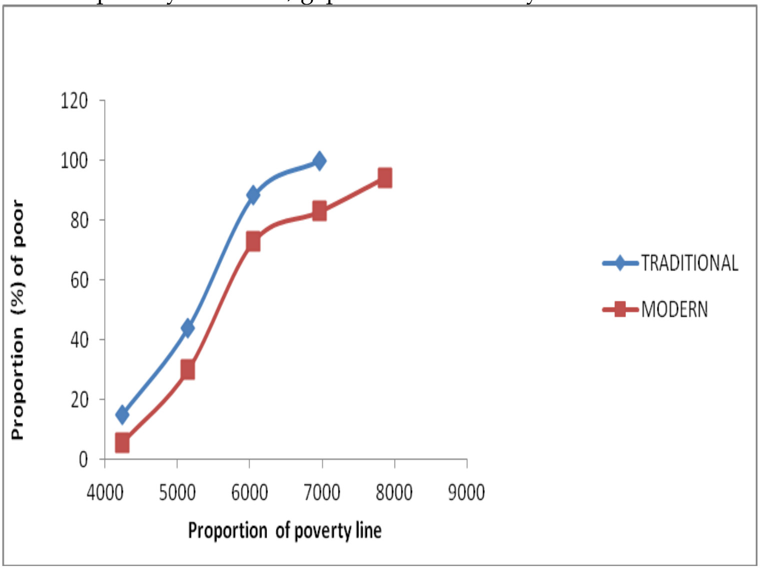

Figure 3: Distribution of dominance analysis by types of Energy source

Table 6: Test of significant of pair of energy variables

Variables	P_0	P_1	P_2
Source of Energy (lighting)			
local vs kerosene	-3.001 ***	1.432	-1.240
local vs electricity	-16.201 ***	-4.900 ***	3.721***
electricity vs kerosene	-2.392 **	-1.549	1.032
Source of Energy (cooking)			
biomass (fuel wood) vs kerosene (fossil)	7.111 ***	-1.678 *	0.985

Field survey, 2014; ***; **; * significant at 1%; 5% & 10% vs=versus

CONCLUSION AND RECOMMENDATIONS

The research focused on energy poverty estimation among rural households in North Central Nigeria. An attempt was made to decompose the source of energy by lighting and cooking, and modern or traditional method, in order to be able to identify the contribution to overall energy expenditure inequality in the study area. It is very clear from the result of the analysis of energy source that the bulk of rural households lack access to modern energy. They depend largely on traditional biomass for cooking and local or improvised lighting source. Therefore, improving the local biomass supplied and used for cooking and lighting such as designing more economical, efficient and less pollutants cooking stoves and lighting equipments that uses local bio-fuels (renewable) such as Shea butter oil, palm kernel oil residue and ethanol in the study area is recommended; Harnessing and installation of modern energy source (renewable and non-) in the rural areas to supplement the use of biomass for rural farming households' (viz. Fossil fuels, Electricity, biogas, coal, wind and solar) will reduce energy poverty level: ultimately, this will make substantial progress on the global targets, the first Millennium Development Goals (MDG) of halve the percentage of people in extreme poverty and hunger, the third goal of promoting gender equality and empower women, the sixth goal of combating diseases and the seventh goal of ensuring environmental sustainable policy of global objective.

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