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An Empirical Study of Household Energy Use and the Negative Externality of Co_2 Emission in the North-East Region of Nigeria

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Abstract
This study empirically analyzed the link between household energy use and the negative externality of CO_2 emission in the North-East Zone of Nigeria. Secondary data was used for the study, obtained from NBS on general household survey (2013). The study employed CLA and OLS model. The results revealed that petrol was the major CO_2 emitter with the total amount of 5139.367kg but charcoal was the dirties energy source because it emitted four times more CO_2 than its actual kg that was used. Also, household monthly income, age, family size and rural-urban dichotomy were found to influence negative externalities (CO_2) positively at 1% level of significance each. The policy implication of this study implies that electricity and LPG are the cleanest fuel. The study therefore, recommended policies to improve electricity and LPG production and supply at subsidized rate and to tax any energy source that is environment unfriendly.
Keywords: Household, Energy, Negative Externalities, CO_2, Emission

1 INTRODUCTION

Energy is an essential component for survival of every society. It has been recognized as one of the most important strategic commodities considered to be the lifeline of an economy. It is indeed an important factor of production in all economies. Thus, domestic energy is a necessity; it is very important for household welfare, public investments and environmental considerations. Moreover, efficient exploitation and development of a nation's energy resources is truly of great importance to the progress and wellbeing of the people (Ogunleye & Ayeni, 2012). However, despite the importance of energy, it has become a cause for concern globally because of its link with negative externalities such as the emission of CO_2, which is the major cause of climate change (Muñoz & Sommer, 2011).

According to Murthy, Panda and Parikh (1997), there is apparent link between population of a country and its contribution to negative externality of CO_2 emission. The population of Nigeria as at the end of 2016 stood at 186,987,563 and is projected to rise to 191,835,936 by the end of 2017 (National Population, Commission, 2017). Given this projection, it's obvious that the country has a very high potential of contributing substantially to the world's CO_2 emission (Onyenechere, 2010).

In 2003, the Federal Ministry of Environment Nigeria estimated negative externalities from the combined livestock population of over 44 million to be well above 1115 Gg of methane (CH_4). The report further disclosed that rice production led to the externality of CO_2 of 1090 Gg of CH_4, savannah burning generated 109 Gg of CH_4, 3.4 Gg of N_20, 2890 Gg of CO and 120Gg of Nox. On the incidence of gas flaring, World Bank (2004) reported Nigeria to have contributed more GHG than all other sources in the sub-Saharan Africa combined.

Moreover, the Nigerian household sector also contributes greatly to negative emissions of CO_2 due to their unsustainable use of energy. This has negative impacts on the environment and human health (Haines, Kovats, Corvalan, & Campbell, 2006). This is because apart from lack of electricity supply households have little access to the conventional energy sources such as LPG partly due to the absence of good road networks (Olaleye & Akinbode, 2012). In addition, Mohammed (2015) reported that due to high rate of firewood consumption, desertification and deforestation have become serious cause of concern to the population of the northern part of the country which is manifested through food insecurity.

Similarly, in the north-east region of Nigeria there is high rate of fuelwood use (Bello, 2011). Furthermore, as reported in Ojo and Chuffor (2013), Borno State has a very high rate of charcoal use. This may be explained by the fact that apart from its use in cooking, space heating and ironing clothes, it is also widely used in homes to heat pieces of local scent sticks used as room air freshener. Moreover, the household which were hitherto using fossil fuels now had to rely more on wood because of availability and affordability.

Hence, the widespread use of inefficient energy sources for cooking and lighting are hazardous to human health and contribute to externalities through Indoor Air Pollution (IAP). This adds to the total emission to the atmosphere, thus influencing the environment locally and climate globally (World Health `Organization, [WHO], 2015). These forms of negative externalities have far reaching consequences to the society and most of the impacts resulting from pollution are already evident in different ecological zones in the country, amounting to huge economic losses (Ogunniyi, Adepoju, & Olapade-Ogunwole, 2012).

There are a lot of studies on energy use, demand or consumption in the study area such as Bello (2011), Ojo and Chuffor, (2013) and Ogunleye and Ayeni (2012) amongst others which used different data sets from Nigeria. However, each study is beset by a number of short-comings for example Bello (2011) gave consideration to determinants of household cooking fuels consumption. Ojo and Chuffor (2013) dwelled on rural household wood fuel consumption while Ogunleye and Ayeni (2012) focused on a disaggregated energy demand at macro level. These necessitated for further empirical investigation of the problem. Therefore, against this background, this study seeks to empirically explore the link between household energy use and Co externality in the north-east region of Nigeria. Specifically, the study determines the amount of CO_2 emission by households through their energy use and explores the household socioeconomic factors that influence negative externality of CO_2 emission. To achieve the set objectives, this paper is structured into five sections. Section two presents the theoretical framework and literature review, section three contains the methodology adopted and section four presents the empirical results and discussion of findings. Finally, section five gives the conclusion and policy recommendations.

2 THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 The Consumer Lifestyle Approach (CLA) Model

The CLA is a popular theoretical framework used in the study of household consumption and CO_2 emission (Gupta, 2011). Consumer refers to an individual who purchases and uses products and services for the satisfaction of household's needs. Thus, a lifestyle is a reflection of an individual's manner towards the consumption of the products and services bought (Feng, Zou & Wei*,* 2010). The consumer lifestyle approach takes into account both direct and indirect CO_2 emissions by households. Energy can be broadly categorized into two: direct and indirect energy. Direct energy is the type of energy that is used by a consumer directly and finally. On the contrast, indirect energy is used in the course of producing goods and services for consumption. Hence, the energy calculation is done based on how much CO_2 is emitted through the direct energy use by each of the energy typesby households. The indirect approach on the other hand incorporates consumers' diverse needs and wants such as clothing, food etc. In this approach, the energy used in the production and processing of these products are calculated as the indirect energy sources (Wei *et al.,* 2007).

The CLA method breaks down all the total energy consumption of a household based on its lifestyle. Bin and Dowlatabadi, (2005) opined that CLA comprises of the following factors: Environmental factors, such as culture, consumption attitudes etc. that moulds a consumer's decision process. Household socio-economic characteristics, such as family size, income and location that influence consumer‘s decisions. Consumer demand factors, such as services and equipment and consumer's behavioral change. The direct CO_2 emission is calculated using the following equation:

CO_2 direct = F_ m x CO_2 coefficient…………… (1) Where:

F_ m is a matrix of energy consumption. Thus, F_ m is 1×n (vector-matrix), CO_2 coefficients for fuels equal 1 x n matrix of CO_2 coefficients for fuels, n = total number of energy types considered.

The Indirect approach on the other hand is calculated using this method below. The intensity for energy consumption and CO_2 emissions for each consumer spending category as:

E indirect urban EI X P urban…………… (2)

E indirect rural EI X P rural…………….. (3)

CO indirect urban CI X P urban………… (4)

CO indirect rural CI X P rural …………… (5)

where; E indirect urban = Indirect energy consumption by urban households in tons of the energy type in question or equivalent (tce), E indirect rural = Indirect energy consumption by rural households in tons of the energy type in question or equivalent (tce), CO_2 Indirect Urban = Indirect CO_2 emission by urban households in tons of the energy type in question or equivalent (tce), CO_2 Indirect rural = Indirect CO_2 emission by rural households in tons of the energy type in question or equivalent (tce), EI = 1 x n matrix energy intensity expressed in tce/10^4

n = total number of consumer expenditure, CI= 1x n matrix CO_2 intensity expressed in tce/10^4

X = n x 1 matrix of consumer expenditure per person, P urban = number of urban residence,

P rural = number of rural residence

Therefore, this study adopts CLA as its theoretical framework because of the following justifications. One, it considers socio-economic, and demand factors as considered by this paper. Two, the CLA derives CO_2 emissions from both direct and indirect sources. Hence, the direct approach would be the best framework for organizing this research work.

2.2 Literature Review

Murthy, Panda and Parikh (1997) study CO_2 emission from energy consumption in India using input-output (I-O) model in 1990 for the various sectors of the Indian economy. Panel data for the period of 1989-90 was estimated to determine the CO_2 contributions of each sector for 1990 and the observed growth between 1989 and 1990 and for 1992-1993 GDP is used to project the final demand for 2005. The study reveals that there is disparity of CO_2 emission by households just like their consumption pattern differs. The per capita expenditure of rural poor and rural high income amount to 1764 rupees and 6688 rupees respectively and their total emission stand at 0.0545 and 0.210 respectively. In general, the CO_2 emission by urban households is 2.2 times than that of the rural households. The study concludes that Urbanization, change in population rural-urban migration influence CO_2 emission. Thus, oil conservation policy through the promotion of energy efficiency is recommended to reduce CO_2 emission. The study fails to take into consideration the major determining factors of energy demand that contribute to CO_2 emission, thus a study that incorporates it needs to be conducted.

In the same vein Kumar and Viswanathan (2007) studied households and cooking fuels in India, with the aim of identifying the relationship between indoor pollution and income levels of households based on EKC hypothesis. Household level data collected by National Sample Survey Organization (NSSO) of India is utilized for the periods 1993-1994 and 1999-2000 in order to determine whether household income level contributes to pollution. The dependent variables are categorized according to clean and dirty fuels to allow for substitution to take place between groups and among fuels. Probit model is used to examine the influence of income on the quantity of chosen aggregate fuel group. The results reveal that as income increases demand for dirty fuels tends to decline while that of clean fuel increases.

With regards to the determinants of CO_2 emission, the results show that the larger the family size the less dirty fuel is used. Moreover, the more the household members are educated the less use of dirty fuel. The study however fails to look at the rationales related to the issues in the context of bio fuel adoption. It would have been great because efficient fuel energy utilization results to less CO_2 emission.

Feng, *et al.* (2010) analyze the impact of household energy consumption on CO_2 emission. They used CLA and the data obtained from China Energy Statistical Yearbooks for 2004–2008 for direct energy consumption by households and final energy consumption by different sectors. While the CO_2 coefficients for coal, oil and natural gas were taken from Zhang. CO_2 coefficients for electricity and heat are based on calculations according to China Energy Statistical Yearbooks for [17–19]. The urban household energy consumption pattern is found to be diverse. While that of rural households appeared to be a single energy structure (biomass). Moreover, the results show that the direct energy consumption and CO_2 emission are rising faster in the urban households than in the rural households. They conclude that the higher the income, the more energy consumption and CO_2 emission structure vary. They further recommend that government should promote the consumption of energy efficient appliances and to provide the rural areas with enough varieties of efficient energy uses.

Hargreaves, Preston, Vicki, and Joshua (2013) examine the distribution of household CO_2 emissions in Great Britain. They also analyze how the various socio-demographic factors of the households' influence CO_2 emission. They gave special emphasis to income as a correlating factor to CO_2 emission. Data for the study were gotten from The Expenditure and Food Survey (EFS). In addition, a one-way analysis of variance (ANOVA) was used to analyze if there were any significant differences between groups as defined by the various socio-demographic factors considered in the study. The results reveal that *CO_2* emission varies significantly across many socio-demographic factors and correlates strongly with income. Also, it shows that richest households in Great Britain emit three times higher than the poorest households. Home-owners (with mortgages) emit two to three times more than those renting. Household with employed head emit two-three times more than unemployed households. In general, apart from the strong relationship with disposable income, total CO_2 emissions are higher for those with larger households and also middle-age group (35-60), those that are economically active and of a higher occupational and socio-economic class and those in more rural locations. The study concludes that the lower income the lower their CO_2 emissions. Therefore, policies which place a cost on carbon itself should be considered because they could be more likely to be progressive. The work did not analyze variation within-group.

Hewen *et.al* (2014) studied rural household energy consumption in terms of energy sources and energy end uses in China. Primary data drawn through interview method were used. The energy sources considered are straw, firewood, dung and coal. Emission factors of SO_2, NO_x and total suspended particulates (TSP) for the same fuels have also being considered in this study. The study uses simple arithmetic and descriptive statistics to analyze the results. The study shows that energy from biomass represents the largest share of total energy supply. 41.15% of the total energy consumed and is for home heating and cooking. While the annual total GHG and AP emissions contributed by each household are 3234.35 and 21.65 kg, respectively. Emissions of CO_2 made up most of the total household GHG emission (99.82%), with 40.49% of CO_2 emitted from coal consumption, followed by 25.36% from dung, 24.85% from straw. Thus, the study recommends the development and promotion of biogas and solar energy that emit less GHG. The work however, dwelt on rural household only. Therefore, there is the need to examine the benefits and potentials of renewable energy in urban areas as well.

3 METHODOLOGY

3.1 Study Area

The study was conducted in the North-East Zone of Nigeria. The region lies between latitudes $6^{o}25^{'}$ -$13^{o}43^{'}$ north of the equator and longitudes 8°35'- 14°39' east of the Greenwich meridian. It has a total land area of 923,773 sq kilometers. The zone is made up of Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe States.The combined population was 18, 832, 995 as at the end of 2006 (NPC, 2006), which was projected to rise to 22, 847, 445 by the end of 2017.

3.2 Data Type and Variables

Secondary data was used for the study. The data was obtained from the database of the National Bureau of Statistics (NBS) General Household Survey, Panel 2012-2013. A total of 709 households were interviewed from the north-east region. The relevant information collected in the survey include household socio-economic characteristics, information on farm, non-farm enterprise, income generating activities, food consumption expenditure, and other non-food expenditure.

This paper considered five independent variables. Table 3.1, presents how each of the variables is measured.

Table 3.2 presents the various conversion factors of the energy sources. In calculating the negative externalities, the household monthly expenditure on the various energy sources were divided by their respective prices and were further converted into quantities. Then the estimated quantities were converted into different types of equivalent unit litre or kg of direct CO_2 emissions based on table 3.2.

Table 3.1
Variables measurement

Variables	**Measurement**
CO_2 emission	Is measured by the amount of CO_2 emitted by a particular energy type in kg
Household monthly income	Household Monthly income is proxied by total household monthly expenditure.
Household size	The variable is measured as the total number of individuals dwelling in the same house and sharing meals together.
Age	This variable is measured in years as the total number of years since the person was born.
Sex	Sex of respondent is a binary variable representing a value of 1 for male and 0 for female.
Rural-Urban dichotomy	This is also a dummy variable representing 1 for urban and 2 for rural.

The conversion factors given by the US Environmental Protection agency (clean energy, 2013) were used in order to convert the energy types into equivalent liter or kg.

Table 3.2
Energy Conversion Factor for the Various Fuels

Fuel type	Unit	CO_2 emission per unit
Petrol	1 liter	2.4kg
LPG	1 liter	0.16 kg
Diesel	1 liter	2.7 kg
Kerosene	1 liter	2.6kg
Charcoal	1kg	3.67Kg
Firewood	1kg	1.73kg
Electricity	1kwh	0.10lbs (2.204lbs = 1kg)

Source: (U.S.A EPA (2013; & Malgwi, 2001) Note 1kg is equivalent to 1 litre.

3.2 Model Specification and Method of Estimation

In estimating the amount of CO_2 emission by various energy sources across the sampled households, the Consumer Lifestyle approach (CLA) as adopted by Kumar & Viswanthem, (2011) was used to estimate the direct negative externality. However, there are some modifications made. The authors assumed their biomass energy estimation a 10 percent non-renewability factor in case of biomass based fuels and hence accounts for net positive CO_2 emission from such fuels. While this study used, the estimate given by the U.S.A, EPA (2013). The CLA is given as:

CO_2_ direct = F_ m x CO_2_ coefficient…………………….. (1),

Where;

F_m = matrix of energy consumption (Firewood, Charcoal, kerosene, petroleum, diesel and LPG). Thus, F_m is a 1×7 vector-matrix. CO_2 coefficient is a 1×7 matrix of CO_2 coefficients for fuels.

To determine the socio-economic factors affecting CO_2, the study utilized Ordinary Least Squares (OLS) regression model to estimate the relationship specified in equation (2). Kavi and Brinda, (2007) estimated similar model using data on selected Indian households.

$Y = f(X_1, X_2, X_3, X_4, X_5, U)$ …………………. (2),

Where;

Y = Is the amount of CO_2 emitted by a particular energy type in kg

X_i = Household income(₦)

X_2 = Age of household head

X_3 = Sex of respondent

X_4 = Area of residence

X_5 = Household size

e = Error term

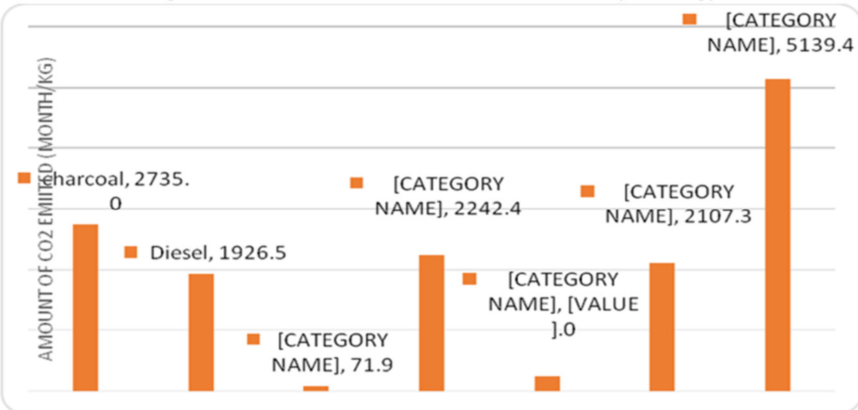
A priori expectation

The coefficients of household monthly Income and household head female would have positive effect on electricity (clean energy) use while household size, Age and Rural-Urban dichotomy (area of residence urban) would have a positive effect on the use of dirty fuels i.e. charcoal, kerosene, diesel and petrol and fuelwood.

4 Results and Analysis

In order to determine the link between household energy demand and CO_2 emission, the quantities of the various energy types were multiplied by the conversion factors given in table 3.2. Figure 4.1 presents the distribution of the negative externalities by energy type.

Figure 4.1 Distribution of CO_2 Emission by Energy



Source: Generated by Stata 13 from the author's data

As can be seen from figure 4.1, petrol emited more CO_2 than all the other energy sources with the total amount of 5139.367kg followed by charcoal with 2735kg of CO_2. Firewood was found to be the third with 2242.36kg, followed by kerosene, diesel, gas and electricity with 2107.3, 1929.5, 248 and 71.87 kgs respectively. This study shows that there is disparity between the households' energy use and their resulting CO_2 emission (Murthy, *et al,* 1997). However, there is an intersting discvorey between the household's energy used and their CO_2 emissions. For better explaination, table 4.1 presents it.

Table 4.1

Distribution of Household's energy Use and CO_2 Emission by Energy Types

Energy Type	Qty of energy use /month in kg	CO_2 emitted/month
Charcoal	745.2	2735.0
Diesel	713.5	1926.5
Electricity	158.4	71.9
Firewood	1296.2	2242.4
Gas	1550.0	248.0
Kerosene	810.5	2107.3
Petrol	2141.4	5139.4

Source: Generated by Stata 13 from the author's data

Table 4.1 presents the energy used by households and the amount of CO_2 each energy type emited. It can be observed that petrol was the most demanded energy type in the study area with 2141.4kg, ultimately it emitted more CO_2 of 5139.367 kg. However, the fact that it had the highest demand and therefore more CO_2 emission, it does not mean it is the dirtiest fuel. This is because when the quantity of charcoal is considered only 745.2kg was used in the study area but it emitted the total mount of 2735kg of CO_2 which is almost four times of its quantity used. While petrol emitted just twice its quantity. Hence, charcoal is the dirtiest fuel because it emitted more CO_2 than all the energy sources considered, this correspondes with the result of Hewen *et.al* (2014) which revealed that energy from biomass represents the largest share of total energy used and also it contributes more to CO_2.

Another, interesting discovery is the fact that LPG demand was the second with the total kg of 1550.0kg but it had the second lowest CO_2 emission of only 248kg. This implies that the fact an energy has high demand, it doesn't mean it would emit more CO_2 because it all depends on the conversion factor. Furthermore, firewood was the fourth, most demanded energy type with 1296.5kg while Kerosene, diesel and electricity demand stood at the fifth , six and seventh both in terms of demand and CO_2 emission.

Effects of Socio-economic factors that influence negative externalities (CO_2 emission)

Multiple regression technique was used to determine whether there is the link between socio-economic factors and the negative externalities of CO_2 emission. The coefficients and the significant levels are presented in the table below.

Table 4.2

Socio-economic factors that influence negative externalities (CO_2 emission)

Variable	Coefficient	Standard err	T value	p>[t]	R^2
Charcoal					**0.92**
Constant	4.250792	.8562185	4.96	0.000*	
Monthly Income	1.107035	.0743028	14.90	0.000*	
Age	.4355669	.0704499	6.18	0.000*	
Sex	.0530366	.0121831	5.31	0.014*	
Household size	1.801018	.538549	3.34	0.004*	
Rural-urban dichotomy	.0377813	.013276	2.85	0.005*	
Diesel					**0.69**
Constant	1.553762	.4760976	3.25	0.000*	
Monthly Income	.9100195	.3160995	2.88	0.004*	
Age	1.786917	.1843697	9.69	0.000*	
Sex	.0127597	.0399684	0.32	0.750^{NS}	
Household size	2.958016	1.346693	2.20	0.059 ^{NS}	
Rural-urban dichotomy	.4355669	.0704499	6.18	0.000*	
Electricity					**0.99**
Constant	7.646961	.0726339	105.28	0.000*	
Monthly Income	.2269484	.0110189	20.60	0.000*	
Age	.0455873	.0210951	2.16	0.033*	
Sex	.0294993	.0472055	0.62	0.534^{NS}	
Household size	.8677438	.0414064	20.96	0.000*	
Rural-urban dichotomy	.1511343	.0659189	2.29	0.023*	
Fuelwood			2.16		**0.97**
Constant	6.744734	.8052918	8.38	0.000*	
Monthly Income	.9161177	.0751183	12.20	0.000*	
Age	.161013	.0312935	5.15	0.000*	
Sex	.0425976	.0534744	0.80	0.426^{NS}	
Household size	.5372095	.1999778	2.69	0.008*	
Rural-urban dichotomy	.063845	.0130459	4.89	0.000*	
Kerosene					**0.98**
Constant	1.80132	.0758824	23.74	0.000*	
Monthly Income	.0230662	.0068461	3.37	0.001*	
Age	2.469558	.0183469	13.46	0.000*	
Sex	.0122166	.033736	0.36	0.717^{NS}	
Household size	.0198339	.0088908	2.23	0.026*	
Rural-urban dichotomy	.440398	.0503822	8.74	0.000*	
Petroleum					**0.73**
Constant	13.41857	.5354274	25.06	0.000*	
Monthly Income	.1494609	.0524089	2.85	0.005*	
Age	.0986448	.0155522	6.34	0.000*	
Sex	.3375984	.30131	1.12	0.264^{NS}	
Household size	.2197145	.0840911	2.61	0.010*	
Rural-urban dichotomy	.028705	.0116193	2.47	0.014*	

Source: Generated by Stata 13 from the author's data

Analyses of the results show that the coefficients of household monthly income (X_1) were positive for all the energy sources. This shows that the higher the income level the more the CO_2 emission, this agrees with the finding of (Kumar & Viswanathan, 2007). However, the rise in CO_2 due to rise in income depends on the type of energy with the highest magnitude of the t-value. Moreover, the coefficient of electricity was found to be positive which is consonance with the *a priori* expectation which assumed that the coefficient of Income would be positive for clean energy (electricity) this corresponds with the result of (Kumar & Viswanthem, 2011). They asserted that increase in income increases electricity use and consequently less negative externality from table 4.1 it can be seen that electricity used emitted the lowest CO_2 (negative externality) compared to other energy sources. Moreover, the coefficients of income for the various energy sources vary according to the energy types, with electricity, firewood and Charcoal having the highest. This indicates that the higher the income levels the higher the budget share allocation for these energy sources. The explanation for this is that the more electricity supply improves the more people will use it and the lesser its emission of CO_2. Firewood on the other hand, its positive relationship with income could be because of the habit and taste developed by household heads over their years of using it. In addition, the higher income coefficient for Charcoal could be because of its availability and affordability. However, the coefficient of electricity is the highest this means that whenever electricity supply improves in the country, whereby it consumers improve their electricity use and develop more confidence in its stability they will use it more thereby reducing the use of the other environment unfriendly energy sources. This would also lead to less use of the other energy sources that were allocated less budget shares.

The coefficients for variable (X_2) age of household heads were all significant at 1% level for all the energy sources. This means that the older the household head the more the negative externality of CO_2 emission, this corresponds with the result of Hargreaves *et al.* (2013) which shows that the total CO_2 emissions are higher for middle-aged group. The positive relationship is consistent with the *a priori* expectation that assumed that older headed households would emit more CO_2. This could be due to the test they have developed over their years of using the inefficient energy sources. Another reason for using more of this energy source could be because the issue of climate change started not long ago, so it could be possible they are less informed about the link between their energy use habit and climate change. However, the coefficient of age for electricity was the lowest this could be indicating that most older headed households don’t rely on the its use. This could be because for so many years now electricity supply has been epileptic in Nigeria. Moreover, its low use in the north-east zone could be attributed to the power failure associated with Boko Haram insurgents, who most times destroy the electricity connection lines. This could have discouraged the people in the area from using it whether as energy for lighting or cooking. The coefficient of age for kerosene has the highest coefficient which means that most older headed households in the study area use it and from table 4.1 it can be seen that kerosene emits about 2107.3kg of CO_2, although the amount of kg used was just 810.5 kg. This means that if the supply for the most efficient energy sources are not improved, the older the household heads the more the use of kerosene for cooking and the more the negative externality.

The results show that the coefficients of variable (X_3) were not good determinant of CO_2 emission for all the energy sources except for charcoal. The result shows that the male headed households have positive relationship meaning the more charcoal is used the more CO_2 is emitted This is contrary to the *a priori* expectation that assumed that female household heads will opt for cleaner fuel. The positive relationship with charcoal could be because it emitted more CO_2. Another reason could be because charcoal is found to be available, affordable and efficient in terms of buying it in small quantities. Hence, it was used more and emitted more negative externality. The reason for the coefficient of male gender been positively related to charcoal use and negative externality lies with the fact the study area is located in the northern part of the country where it is viewed as conservative society, with family structure largely patrilineal. In addition, the males dominate marketing due to the cultural factors that encourages them to go out to purchase material needs of the family.

The findings reveal that the coefficients of variable (X_4) Family size was a good determinant for all the energy sources at 1% level of significance except for diesel. This shows that the higher the family size the higher the CO_2 emission, this agrees with the finding of (Hargreaves *et al.,* 2013). The authors reveal that the total CO_2 emissions are higher for those with larger households. The positive relationship with dirty fuels that emit more CO_2 is in line with the *a priori* expectation, which assumed that the coefficient of family size would have positive relationship with dirty fuels. While the positive relationship with clean fuel is contrary to the *a priori* expectation, which also assumed to have negative effect on cleaner energy sources. On the other hand, the magnitude of the coefficients for all the energy sources that are significant except for electricity were low which means an increase in family size would not be accompanied by a proportionate increase in the use of these energy sources. While the magnitude of the coefficient for electricity was high, meaning the higher the family size the higher the use of electricity in more than proportionate way and the less negative externality. This could be justified by the fact that the more the family size increases the more the use of electricity for ironing, lighting, and space cooling and lesser the negative externality.

Analysis of the results show that the coefficients of rural-urban dichotomy (X_5) is a good determinant of

CO_2 for all the energy sources at 1% level of significance, this corresponds with the finding of (Feng *et.al.,* 2010 and Murthy, *et al.*, 1997) which shows that CO_2 emission are rising faster in the urban households. The positive relationship implies that area of residence urban has a positive relationship with CO_2 emission. This is in consonant with the *a priori* expectation which assumed that area of residence urban would have positive relationship withCO_2 emission. This could be justified by the fact that the households in the urban areas have more alternative to energy sources to substitute for and their unsustainable habit and taste for the various available energy sources could be the reasons for the positive relationship. On the other hand, the magnitude of the coefficients of Kerosene, firewood and Diesel were large indicating that the more there is urbanization the more these energy sources will be used and the more the negative externality. This could be justified by table 4.1 where diesel was the second lowest in terms of kg used but the fifth major emitter of CO_2. Similarly, fuelwood and kerosene are also dirty fuels hence; their use will result to negative externalities. On the contrary, the magnitude of the coefficient for electricity was the lowest; this is not surprising because already it has been expected. Due to availability for substitute energy for instance energy for lightening petroleum, diesel and solar and energy for cooking such as kerosene, charcoal and firewood these are enough reason why electricity is the lowest. The implication for this is that there is the need for electricity supply to be stable in order to improve its use and consequently reduce CO_2.

6 CONCLUSION, POLICY IMPLICATION AND RECOMMENDATIONS

In this study, we have found some notable results on the number of negative externalities (CO_2) emission by households through their energy use. The followings are the major findings of the study:

Firstly, we have found that although petrol is the major CO_2 emiter with the total amount of 5139.367kg, charcoal is the dirties fuel because is emitted four times more CO_2 when compared with its quantity used in the study area.

Secodly we have also found that electricity and LPG emit the least CO_2 out of all the energy sources studied. Hence, they are considered to be the two clean energy sources while all the other energy sources are environment unfriendly/inefficient energy sources.

Thirdly, on the socio-economic factors that influence (CO_2) emission from household energy use, we identified household monthly income, age, family size and rural-urban dichotomy as the major determinants of CO_2 emission. One, there exist a positive and significant relationship between income and CO_2 emission. Two, age of household head was also an important factor and positively related to CO_2 emission. Three, household size and four area of residence urban all are positive and have significant relationship with CO_2 emission. Finally, contrary to our expectation, sex of household head (male) was found to be an insignificant determinant of CO_2 emission for all the energy sources considered in this study except for charcoal.

The findings of this study have a policy implication and relevance. The findings suggested that most of the fossil fuels are environment/ climate unfriendly except for LPG. While electricity on the other hand is the cleanest of all energy types. However, these two energy sources were used less in terms of quantity. Therefore, this study proffers the following recommendations:

Firstly, the government should try and complete the ongoing hydroelectric dams in Nigeria and should show serious commitment and investiment into construction of (3000 MW) Mambila hydro dam beyond lip-service in order to achieve effective and efficient power supply.

Secondly, the government should invest on solar as a source of enery especially in the northern states, where there is an abundant solar radiation. It should also encourage the exploitation of other environment friendly energy sources (renewable energy sources) that are constantly replenished and will never run out. This can be done by giving some incentives to all those who are interested in its production or by making it tax free in the cause of the importation of the appliances that work with such energy types. This will boost competition among the power generating companies and in turn would benefit the consumers in terms of efficient pricing and also will reduce negative externality of CO_2.

Thirdly, the government/policy makers should encourage the use of LPG in order to help improve the air quality/environment. This can be done by improving the production and the supply of LPG and by also giving it at an affordable rate to households.

Finally, subsidy as a policy on fossil fuel especialy Petreoleum in Nigeria is wrong for an energy that is environment unfriendly, because instead of discouraging it use it encourages it. Therefore a better way of correcting this externality should be adopted. Where a particular energy source is a benefit to the environment some incentives should be provided to encourage it use and tax on the other hand be imposed on those energy sources that are cost to the environment. In addition, an alternative energy sources should be made available for the dirty ones to be substituted.

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