Determinants of Nigerian Household Carbon Footprint

Mubaraq Dele Sulaimon
Winners Academy, off Iwo Road, Ibadan, Nigeria

Abstract
The statement that household carbon footprint accounts for a significant portion of a country's total carbon footprint is a truism. Hence, reducing this type of carbon footprint will play an important role in ameliorating global carbon footprint and climate change. The study aimed at examining the determinants of Nigerian household carbon footprint. To achieve this, data on household socio-economic and demographic characteristics were obtained from the National Bureau of Statistics 2015 General Household Survey, and household direct carbon footprint was estimated using the Linear Multiplier Factor Method. To analyse the data, a cross section log-linear regression model was built on the environmental Kuznets curve hypothesis and the parameters were estimated using the Ordinary Least Squares (OLS) estimation technique. The empirical results revealed that the effects of household income, household size, motorisation, literacy ratio and household head gender are positive and significant at 1% level. Although literacy ratio oppose a priori expectation. Male population, polygamy and age of household head are insignificant at 1%, 5% and 10% level respectively. Both age of household head and household income show significant non-linear relationship with household carbon footprint. The study concludes that household income, household size, motorisation and literacy ratio are the quantitative factors that influence the level of Nigerian household carbon footprint. Based on the findings, the researcher recommends policies that will help prevent Nigerian household carbon footprint level from going worse.
Keywords: Environmental Kuznets curve, Carbon footprint, Household, Nigerian

1. Introduction

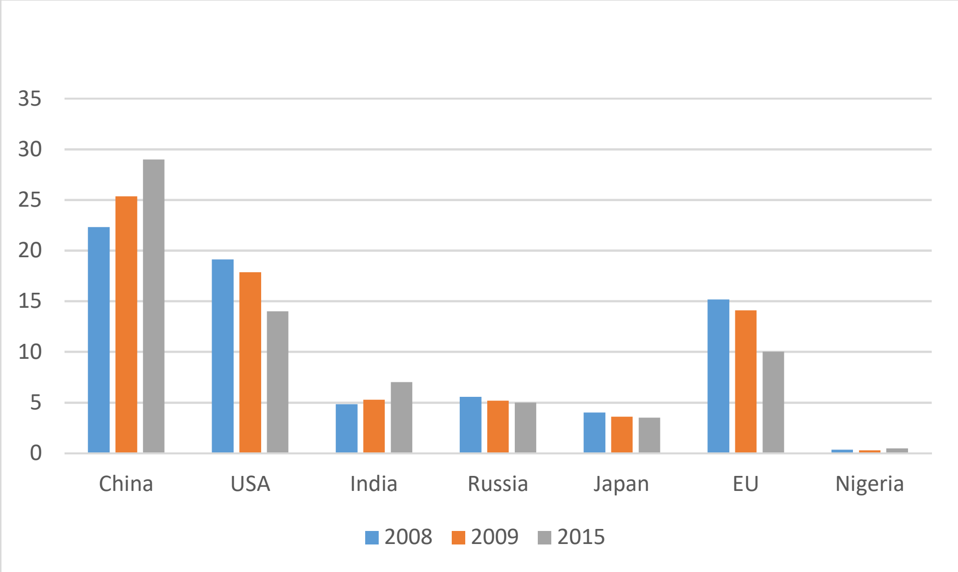
1.1 Background to the Study

Carbon footprint as it is widely known by many scientists is the aggregation of carbon dioxide (CO_2) released into the atmosphere from the activities of individual, household, firm or a country. In other words, it is the total greenhouse gas (GHG) emissions caused directly and indirectly by an individual, organisation, event or product. As viewed by Wright, Kemp and Williams (2011), carbon footprint is "a measure of the total amount of carbon dioxide (CO_2) and methane (CH_4) emissions of a defined population system or an activity, considering all relevant sources, sinks and storage within the spatial and temporal boundary of the population, system or activity of interest. Calculated as carbon dioxide equivalent (CO_2e) using the relevant 100-year global warming potential (GWP100)." According to the United States of America Environmental Protection Agency (2017), 76% of global greenhouse gases are accounted for by carbon dioxide emissions.

Being the largest economic agent in any society, the contribution of households to global and national carbon footprint via its consumption of goods and services cannot be underestimated. Empirical findings in both developed and developing countries have revealed the monumental contribution of households to total carbon footprint. In the United Kingdom, more than 70% of the total carbon emissions are accounted for by its households (Baiocchi, Mint and Hubacek, 2010), 75% by households in India (Pachauri and Spreng, 2002), more than 80% by households in the United States of America (Bin and Dowlatabadi, 2005) and 30% by households in China in 2004 (Wang and Shi, 2009).

In 1956, it became noticeable that countries around the world started releasing more CO_2 into the atmosphere than the recommended volume required for the stability of the climate (Minx, Scott, Peters and Barret, 2008). The carbon dioxide absorption capacity of the planet has been exceeded, hence, global warming has emerged. Nigeria is not a major emitter of carbon dioxide as evident by its contribution to global CO_2 emissions. Figure 1.0 below shows the contribution of the United States of America, Japan, Russia, China, India, European Union and Nigeria to global CO_2 emissions.

Figure 1.0: Selected Countries and their Shares of World CO_2 Emissions



Data Source: IES Monthly Update and Olivier (PBL) et al. (2016)
Chart Source: Author's Construction

The above bar graph reveals the five largest emitting countries, the European Union and Nigeria. In year 2015, China (29%), USA (14%), India (7%), Russia (5%), Japan (3.5%) and all countries of the European Union (10%) accounted for two-third of the total global emissions (Olivier, Janssens-Maehout, Muntean and Peters, 2016), while Nigeria accounted for 0.33% of the global CO_2 emissions. In Year 2008 and 2009, China accounted for 22.31% and 25.36%, USA accounted for 19.13% and 17.84%, India accounted for 4.83% and 5.27%, Russia accounted for 5.57% and 5.17%, Japan accounted for 4.0% and 3.61%, countries of the European Union accounted for 15.18% and 14.1%, Nigeria accounted for 0.26% and 0.48% of the global CO_2 emissions. Most developing countries of the world are not major emitters of carbon dioxide, except China and India as revealed by the statistics. The contribution of Nigeria to global CO_2 emissions is small relative to the contribution of other developing countries like China and India.

1.2 Statement of the Problem

The risk associated with the increasing level of carbon footprint has in no doubt tickled the consciousness of stakeholders at the national, regional and international levels. Ministries and agencies in different countries, as well as non-governmental organisations such as the United Nations, Union of Concerned Scientists, Greenpeace, World Meteorological Organisation, World Bank, et cetera have become key players in the crusade against increasing carbon footprint. In addition, countries within the planetary boundaries have entered into various environmental treaties to show their concern to ensuring a safe environment for all by pledging an emission reduction commitment that is to be achieved within a convenient time frame. One of the international environmental conventions entered into by countries is the Kyoto Protocol that was adopted in Kyoto, Japan, on the 11th of December, 1997. The Kyoto Protocol was based on the premise that global warming exists and that anthropogenic (human related) activities have caused it. Hence, its principal objective is to fight global warming by reducing the level of carbon footprint to a level that would prevent significant distortion of the climate system or cause climate instability.

The increasing level of carbon footprint is widely believed by most scientists to be the genesis of global warming and climate change. Results of various empirical investigations have identified anthropogenic activities as the culprit responsible for the high level of carbon footprint concentration in the atmosphere, thereby provoking global warming and climate change. According to the Intergovernmental Panel on Climate Change Fifth Assessment Report (2013), "It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century" (as cited in Wikipedia, 2017). The Intergovernmental Panel on Climate Change (2007a) asserts that recent scientific evidence reveals that the current level of carbon footprint is above the level of natural variability and is primarily driven by human behavior (as cited in Underwood, 2013). From this Premise, the Intergovernmental Panel on Climate Change (2007a) concluded with **very high confidence**[1] that the global average net effect of human activities on the climate since 1750 has been one of warming (as cited in Underwood, 2013).

[1] According to IPCC, very high confidence is a terminology that implies that the assertion is "at least 9 out of 10 chance of being correct"

"Continual emittance of greenhouse gases at current rates would likely cause further warming and induce additional changes in the climate that would very likely be of greater magnitude than those already observed. The risk to human civilization of this increased carbon footprint and warming are many and varied, but are certain to impose cost: psychological, social and economic" (Underwood, 2013). According to the Intergovernmental Panel on Climate Change (2007b), the most susceptible of industries and societies are "generally those in both coastal and river flood plains, those whose economies are linked with climate sensitive resources and those in areas prone to extreme weather events, especially where rapid urbanization is occurring" (as cited in Underwood, 2013). The limited adaptive capabilities and heavy reliance on resources that are very sensitive to changes in climate, such as food and water make poor communities the most vulnerable (Underwood, 2013). The likely adverse effect carbon footprint poses to the health status of millions of people all over the world, particularly countries with low adaptive capabilities, is one of the most serious costs of climate change (Underwood, 2013). As IPCC[1] (2007b) asserts, "increases in malnutrition and consequent disorders, with implications for child growth and development; increased deaths, disease and injury due to heat waves, floods, storms, fires and drought; the increased burden of diarrheal disease; the increased frequency of cardio-respiratory disease due to higher concentration of ground-level ozone related to climate change; and, the altered spatial distribution of some infectious disease vectors" are all possible implications of increased carbon footprint (as cited in Underwood, 2013). However, climate change may offer some benefits, but the negative health effects will far exceed any potential benefits (Underwood, 2013).

Household consumption pattern has been identified as one of the factors influencing the level of global carbon footprint (Serino and Klasen, 2015). Consumption at the household level is chiefly influenced by various socio-economic and demographic characteristics. These demographic and socio-economic characteristics range from household size, household income, dependency ratio, gender of the household head, et cetera. In 2012, the national average household size was estimated to be 5.5 persons. At the sectoral level, rural and urban averages were 5.9 and 4.9 persons respectively. At the regional level, the average household size in the south was 4.6 persons and 6.6 in the north. The Nigerian household dependency ratio was 1.2. At the sectoral level, dependency ratio for rural household was 1.3 and 1.1 for urban household (NBS, 2012). One way household population affects the environment is through the pressure they exert on natural resources. Household income is another factor that influence household choice of energy demand. In Nigeria, most households in rural areas are low income earners relative to households in urban areas. This fact speaks volume of urban and rural household energy choice. According to World Health Organisation (WHO) and the United Nations Framework Convention on Climate Change (UNFCC) (2015), in 2013, 95% of rural population, 49% of urban population and 75% of national population use solid fuels for cooking. This has implication on the quality of air members of household breathe in in rural and urban areas. As it has been established, air pollution in and around the home is largely a result of the burning of fossil fuels for cooking, et cetera. Therefore, has the demographic and socio-economic characteristics of Nigerian household changes, consumption pattern changes and the associated carbon footprint changes as well.

It is crystal clear that increasing carbon footprint from anthropogenic activities such as energy consumption for cooking, heating, transporting, et cetera could cause ecological disaster, thereby placing potential costs on Nigerians and the economy as a whole. One of the sectors that seems most vulnerable to climate change is the agricultural sector. Like in any other economy, the agricultural sector is a component of the Nigerian economy whose performance is not only determined by monetary and fiscal factors, but also by climatic factor. The sector is estimated to be the highest employer of labour and contribute the highest to the nation's Gross Domestic Product. In period 2010-2015, the sector contributed an average of 25.3% to the country's real Gross Domestic Product (CBN[2], 2015). According to Folawewo and Olakojo (2010), in the period 1996-2000 and 2001-2007, the average contribution of agricultural sector employment to total employment was 55.2% and 53% respectively. On the basis of sectoral contribution to employment and national output, the Nigerian economy can be said to be strongly tied to climate sensitive resources. In Nigeria, more than 50% of agricultural activities take place in the rural areas and this consequently make rural households the most vulnerable to climate change. By implication, if left uncontrolled, increasing carbon footprint could trigger a climate change and expose economic activities in the agricultural sector to the grave consequence of climatic instability.

The potential adverse health effect associated with increasing carbon footprint is another issue of serious concern. Climate change such as increased temperature, flooding, drought and displacement, et cetera negatively impacts agricultural production and cause breakdown in food system. These disproportionally affect those most vulnerable to hunger and can lead to food insecurity and nutritional crisis. The deterioration of air quality associated with increasing carbon footprint may provoke different types of respiratory diseases such as cystic

[1] The IPCC was established in 1988 jointly by the United Nations Environment Program (UNEP) and the World Meteorological Organisation (WMO) to provide an authoritative up-to-date interdisciplinary knowledge on climate change. Although it does not conduct its own research, but comprehensively evaluate the scientific, technical and socio-economic information on climate change that is available around in the peer-reviewed literature, journals, books and other sources.

[2] Central Bank of Nigeria

fibrosis, lung cancer, emphysema, asthma, bronchitis, pneumonia, influenza, et cetera and reduce labour productivity. According to World Health Organisation (2012), in Nigeria, "57% of an estimated 130,900 child deaths due to acute lower respiratory infections is attributable to household air pollution (as cited in WHO and UNFCCC[1], 2015). According to WHO (2012), "50% of total deaths from ischemic heart disease, stroke, lung cancer, chronic obstructive pulmonary disease (18-year+) and acute lower respiratory infections (under 5years) are attributed to household air pollution" (as cited in WHO & UNFCCC, 2015). The rising level of the Earth temperature is yet another outcome of rising carbon footprint. On the overall, carbon emissions has the potential to reduce the quality of life and life expectancy of Nigerians. Falling aggregate output as a result of declining labour productivity and ill health could rear its ugly head in the scheme of things in the face of uncontrolled or rising carbon footprint.

In conclusion, the thirst for sustainable development by countries of the world has triggered wider discussion and concentration on the concept of "environment" as well as its quality. As a matter of fact, the recently launched Sustainable Development Goals (SDGs), otherwise known as the Global Goals, directly and indirectly included environmental quality as one of the needed recipes for achieving sustainable development by any country within the planetary boundaries. On this premise, understanding the determinants of Nigerian household carbon footprint is a necessary condition in devising policies on alleviating climate change towards the achievement of sustainable development in Nigeria. This is the focal point of the research.

1.3 Objectives of the Study

The broad objective of this research is to employ econometric technique to uncover the socio-economic and demographic factors that influence the level of Nigerian household carbon footprint. In addition, based on the results of empirical findings, policies will be recommended to the government and policy makers.

1.4 Justification of the Study

Unlike advanced countries, there is dearth of empirical investigations on developing countries' household carbon footprint. As Serino and Klasen (2015) assert, the few conducted studies for developing countries are usually from the major emitters like China and India. Nigeria is not considered a major emitter of greenhouse gases as evident by its share of global carbon footprint. Despite this fact, it is relevant to investigate the determinants of its household carbon footprint before its carbon emission level become worse. Adeoti and Osho (2011) in their study estimated only the carbon dioxide emissions associated with household kerosene consumption for lighting without recourse to examining factors that influence household consumption patterns and its associated carbon emissions. Hence the research fill the identified gap by examining the determinants of Nigerian household carbon footprint.

1.5 Scope of the Study

The study focuses only on the carbon dioxide (CO_2) component of carbon footprint and disregard other greenhouse gases. More so, the study is limited to household direct energy consumption. Hence kerosene, petrol, liquefied petroleum gas, firewood, charcoal, electricity and diesel are the focused energies. In conclusion, the study examines the carbon footprint of a sample of four thousand five hundred and sixty households that domiciled within the borders of Nigeria.

2. LITERATURE REVIEW

2.1 *Review of Empirical Literature*

Wei, Liu, Fan and Wu (2007) found that approximately 26% of total energy consumption and 30% of CO_2 emissions are caused by residents' lifestyle in China. The study revealed that residents' lifestyle has significant impact on energy use and related CO_2 emissions.

Kerkhof, Benders and Moll (2009) found that average households in the Netherlands and United Kingdom emitted higher amounts of CO_2 relative to average households in Sweden and Norway. It is also revealed that the carbon emission intensities of households' consumption decreased with increasing income in both the Netherlands and the United Kingdom, whereas it increased in Norway and Sweden. Comparison of the national results revealed that country's characteristics like energy supply, population density and the availability of district heating influenced variations in household CO_2 emissions between and within countries.

Adeoti and Osho (2011) found that average CO_2 emissions from kerosene combustion for lighting in Nigeria is about 0.06 kg per hour per lamp. The researchers also found that $3\times10W_p$ solar pv is required to replace a kerosene lamp, while about 0.124 tons of CO_2 would be avoided per lamp per year. At the national level, under the kerosene lamp replacement projection assumptions made, between 0.4 and 1.0 million tons of CO_2 would be avoided per year. Findings also revealed that the household investment required to own a solar pv including the capital cost of switching from kerosene lamp is about US$ 356, while the national capital investment outlay is

[1] United Nations Framework Convention on Climate Change

between US$1,138.265 and US$2,848. They also found that assuming the CO_2 saved is to be traded, it will magnet a significant annual revenue on the order of 6.96 million to almost US$ 17.4 per annum.

Liu, Wu, wang and Wei (2011) found that population, per capita household consumption and urbanization level have significant positive impact on the growth of household CO_2 emissions. However, carbon emission intensity decline reduce the growth of household carbon emissions.

Wu, Liu and Tang (2012) in their study, found that family size, household income and educational level have statistically significant impact on household CO_2 emissions. However, in terms of direction of relationship, family size is positively related to household CO_2 emissions, while family income and educational level are found to be negatively related to household CO_2 emissions. The authors' argument for the negative nexus is that when household income increases, household tends to search for better energy sources as explained by the energy ladder hypothesis.

Jaiswal and Shah (2013) in their study, found that households do not differ significantly in their carbon footprints due to age, education and family income. However, the research also revealed that carbon footprints of the households vary significantly with their personal income, family size, employment status and type of family.

Wang and Yang (2014) found that for urban residents' indirect CO_2 emissions is on the rise. The estimated regression model revealed that urbanization level, per capita income and industrialisation level have positive effect on urban household CO_2 emissions, but negatively influenced by energy intensity and Engel coefficient. For the rural households, the indirect CO_2 emissions is on the decline. Empirical findings showed that Engel coefficient, energy intensity and industrialization level have positive impact on rural household CO_2 emissions, but negatively influenced by urbanization level and per capita income.

Lee and Lee (2014) in their study, found that population-weighted density, centrality, and transit subsidy have significant negative impact on household carbon emissions, while population size has an insignificant positive impact on household GHG emissions within the study period. Also, Polycentricity is found to have significant positive impact on household carbon emissions.

Han, Xu and Han (2014) found that employment has a significant negative impact on per capita HECEs (household embedded carbon emissions), unemployment has a significant negative effect on per capita HECEs, retired has a significant negative impact on per capita HECEs, beingeducated has a significant negative impact on per capita HECEs, preschool has an insignificant positive impact on per capita HECEs, marry has an insignificant negative impact on per capita HECEs, gender has an insignificant positive impact on per capita HECEs, education has a significant positive impact on per capita HECEs, net income has a significant positive impact on per capita HECEs, expected income has a significant positive impact on per capita HECEs, deposit has a significant positive impact on per capita HECEs, ownhouse has a significant negative impact on per capita HECEs and owncar has a significant positive impact on per capita HECEs.

Das and Paul (2014) found that activity coefficient, structure coefficient and population are the main cause of increased CO_2 emissions from household fuel consumption. It is also revealed that energy intensity has gone down by 60% within the period of study.

Sharaai, Mokhtar, Jin and Azali (2015) in their study, found that electricity consumption and transportation have significant positive impact on household CO_2 emissions, while income has an insignificant positive impact on carbon emissions. Household size has an insignificant negative impact on the dependent variable.

Ahmad, Baiocchi and Creutzig (2015) in their study, divided emissions in India according to their sources: electricity use, private transport and cooking. The results revealed that income is positively correlated with all types of emissions. Household size is negatively correlated with all types of emissions except private transport. Urban density is negatively correlated with emissions except for cooking fuels emissions.

Xu, Tan, Chen, Yang and Su (2015) in their study, found a significant negative correlation coefficients between household CO_2 emissions, age, age squared, male ratio and dependency ratio. While household size, employment ratio, living area, perceived measures, distance and household CO_2 emissions have significant positive correlation coefficients. The results of the conducted Analysis of Variance (ANOVA) test revealed that the mean household CO_2 emissions among different urban households vary significantly in terms of household head educational attainment, car-holdings, household income, energy saving, energy saving awareness, city location and household head occupation. The estimated model and statistical test revealed that age, male ratio, household size, dependency ratio, income, car-holdings, living area and city location have significant positive impact on household carbon emissions. On the other hand, age squared, energy saving and distance have significant negative impact on the variable of interest. All the categories of occupation except high-end occupation have insignificant negative impact on household carbon emissions. The advanced Diploma/university degrees category of education has insignificant positive impact, while junior to senior high school category has insignificant negative impact on the variable of interest.

Li, Zhao, Liu and Zhao (2015) in their study, found a unidirectional causal relationship between the independent variable and the dependent variables with causation running from urbanisation to direct and indirect household carbon dioxide emissions. As revealed by the estimated models and statistical test, urbanisation is found to have significant positive effect on direct and indirect household CO_2 emissions.

Qu, Maraseni, Liu, Zhang and Yusaf (2015) found that urban household emit CO_2 than rural household within the period of study. Statistically, in 1995, per capita household carbon emissions from direct sources for urban and rural households were 0.5 tCO_2 and 0.22 tCO_2 respectively. In 2011, these values had increased to 20% and 177.27% respectively. Similarly, in 1995, per capita household carbon emissions from indirect sources were 0.43 tCO_2 and 0.16 tCO_2 respectively. In 2011, these values had increased by 306% and 235% respectively. The result of the regression model showed that per capita income has positive impact on per capita urban household carbon emissions, while household size has negative impact on per capita urban household carbon emissions. On the rural side, per capita income has positive impact on per capita rural household CO_2 emissions, while household size has negative impact on per capita rural household CO_2 emissions. The negative impact of household size on both per capita urban and rural households' carbon emissions was suggested to be the implication of economies of scale of energy use within the household. The per capita income and household size are responsible for 99.7% variations in the per capita urban household carbon emissions, while per capita income and household size are responsible for 98.9% variations in the per capita rural household carbon emissions.

Serino and Klasen (2015) in their study, found that on the average, households emitted 1.46 tons of CO_2 in year 2000 and it increased to 1.86 tons in year 2006. The household emissions was further disaggregated into income quintiles. The Results showed that in year 2000, households in the poorest income quintile emitted an average of 0.10 tons of CO_2 per capita, while households in the richest income quintile emitted an average of 0.77 tons of CO_2 per capita. In year 2006, households in the poorest income quintile released 0.12 tons of CO_2 per capita, while households in the richest income quintile emitted an average of 1.02 tons of CO_2 per capita. The estimated cross section regression model showed that income has significant positive impact on household CO_2 emissions, although, its elasticity coefficient is less than one. Age, year 2006, household size, urban lifestyle, educational level of the household head, married household head, electricity access and floor area have significant positive impact on household CO_2 emissions, while male headed household, widowed household head, income squared and age squared have significant negative impact on household CO_2 emissions.

Li, Huang, Yang, Chuai, li and Qu (2016) from the estimate of the SLM model found that urbanization level, carbon intensity, age structure and per capita income have significant positive impact on per capita household CO_2 emissions. However, July average temperature, January average temperature and total household population have negative impact on per capita household CO_2 emissions. The S-GWR model estimate showed that urbanization level, age structure and per capita income have significant positive impact on per capita household CO_2 emissions, while January average temperature, July average temperature and total household population have negative impact. However, the July average temperature does not have significant impact on the dependent variable.

Wang and Yang (2016) estimated total emissions to be 10.5 Mtc in year 2000, 20.12 Mtc in year 2002, 25.84 Mtc in year 2007 and 21.35 Mtc in year 2010. It was found that emission coefficient effect, intermediate demand effect, the per capita GDP effect and the population size effect have positive effects on the growth of indirect household CO_2 emissions. It was also noted through the findings that per capita GDP has the highest effect, while intermediate demand effect has the lowest positive effect on indirect household CO_2 emissions. On the other hand, energy intensity effect; residential consumption rate effect; consumption structure effect and the rural and urban residential consumption rate effect have negative impacts on the growth of indirect CO_2 emissions. It was also noted that the energy intensity effect played the dominant role in indirect household CO_2 emissions reduction.

2.2 Review of Methodology

Wei et al. (2007) employed the consumer lifestyle approach (CLA) to analyse the impact of lifestyle of urban and rural residents on the energy use and the related CO_2 emission in China. The direct CO_2 emissions from household energy consumption was calculated using the linear multiplier factor method and the indirect CO_2 emissions was calculated by multiplying the carbon emission intensity of each sector by its corresponding consumption expenditure. The study also used descriptive statistics to present data on variables that are relevant to the study.
Kerkhof et al. (2009) adopted a hybrid approach of physical chemical process and economic input-output analysis to determine the country specific carbon emission intensity of each sector. The carbon emission intensity of each sector was then linked to the national data on consumption expenditures to estimate average household CO_2 emissions in each country. Descriptive statistics was also employed to present data on variables that are relevant to the study.

Adeoti and Osho (2011) obtained data on household kerosene lamp fuel consumption through questionnaire survey, direct measurement and method triangulation. An emission factor of 3.15 kg CO_2 per litre of kerosene was employed to estimate the average amount of CO_2 emissions. The cost of solar pv equipment was obtained from market source, while installation cost was estimated. The annual worth cost (awc) model was specified to estimate the profitability of the replacement strategy. The awc comprises the present worth cost, the minimum attractive rate of return, the economic life and the capital recovery factor obtained from the interest rate table. Descriptive statistics was also employed to present data on variables relevant to the study

Liu et al. (2011) employed the input-output method to estimate the indirect CO_2 emission from household consumption. The direct CO_2 emission from household consumption was calculated using the Intergovernmental Panel on Climate Change. The logarithmic mean divisia index (LMDI) method was employed to decompose the effects of changes in the identified independent variables on indirect CO_2 emissions from household consumption.

Jaiswal and Shah (2013) employed the service of an online standard carbon emission calculator to estimate or compute the carbon footprint of each household under study. Descriptive statistics was used to analyse the data.

Wu et al. (2012) conducted their study using the stratified random sampling technique with a semi structured questionnaire as the research instrument. To obtain the CO_2 emissions of each energy source, the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories standard emission factors were utilized. The Tukey's HSD (honest significance difference) test was used to compare the means of different parameters, and a multiple linear regression model was built to analyse the impact of identified factors on household CO_2 emission.

Wang and Yang (2014) calculated the indirect CO_2 emission from household energy consumption by aggregating the product of carbon emission intensity of each sector by its corresponding consumption expenditure. The industrialisation level was measured by the ratio of the share of secondary industry output to value of Gross Domestic Product. The STIRPAT (Stochastic Impacts by Regression on Population, Affluence and technology) was employed to analyse the impacts of the identified factors on indirect household CO_2 emissions. The model was estimated using partial least square estimation technique. Descriptive statistics was also utilised to analyse data on certain variables.

Lee and Lee (2014) adopted the multilevel structural equation model (SEM) to empirically analyse the effect of urban form on household greenhouse gas emissions in the United States of America. In addition to the econometric approach, the study employed descriptive statistics to present data on some variables.

Han et al. (2014) calculated the embedded carbon emissions using the input-output expenditure method. Both the ordinary least squares regression model and quantile regression were employed to ascertain the determinants of per capita household embedded carbon emissions (HECEs) within the study period.

Das and Paul (2014) in their study, employed the input-output approach to estimate both the direct and indirect CO_2 emissions from household energy consumption. The decomposition method proposed by Sun (1998) was utilised to evaluate the impact of each factor on household CO_2 emissions. The pollution coefficient was defined as the ratio of CO_2 emitted to the amount of energy consumed. Energy intensity coefficient was defined as the ratio of energy consumed to the household consumption expenditure. Activity coefficient was defined as the ratio of total household consumption expenditure to population. Structure coefficient was defined as the ratio of household consumption expenditure for a particular category to the total household consumption.

Sharaai et al. (2015) employed the structural equation modelling (SEM) to evaluate the impact of identified independent variables on household CO_2 emission in Penang, Malaysia.

Ahmad et al. (2015) employed a panel data model to evaluate the impacts of identified factors on household CO emissions among urban households within the period of study. The ordinary least squares estimation technique was used to estimate the parameters in the model. The decision of which model (fixed effects or random effects) to settle down with was influenced by the Hausman test conducted. Chow test was performed to evaluate whether city specific effects should be considered.

Li et al. (2015) in their study, estimated indirect household CO_2 emissions using input-output method and the direct household CO_2 emission using Linear Multiplier Factor Method. The research employed Augmented Dickey-Fuller test (ADF) to examine the stationarity status of the series in the model. Furthermore, to know the direction of causal relationship between the variable of interest and the explanatory variables, Granger causality test was employed. The optimal lag length for the ADF test was determined using Schwarz Information Criterion (SIC) and Akaike Information Criterion. The specified time series econometric model was estimated using Ordinary Least Squares (OLS) estimation technique. Descriptive statistics was also used to present data on variables that are relevant to the study.

Qu et al. (2015) in their study, decomposed household CO_2 emissions into direct and indirect CO_2 emission from household energy consumption. The direct CO_2 emission was estimated using the Intergovernmental Panel on Climate Change (IPCC's) reference approach, while the indirect CO_2 emission was estimated using the input-output analysis approach. A linear regression model was set up to analyse the impact of identified factors on urban and rural household per capita carbon emissions in China.

Xu et al. (2015) estimated household carbon emissions using the IPCC reference approach. Pearson correlation analysis was employed to evaluate the degree of relationship between household carbon emissions and various household characteristics. Analysis of Variance (ANOVA) test was conducted to ascertain the statistical significance of variations in average household carbon emissions. In addition, a cross section linear regression model was employed to analyse the survey data. The parameters of the model was estimated using Ordinary Least Squares (OLS) technique.

Serino and Klasen (2015) estimated carbon emissions from household consumption using input-output expenditure approach. To empirically evaluate the impacts of identified socio-economic and demographic factors on household CO_2 emissions, a cross section linear multiple regression model was specified. Ordinary Least Squares (OLS) estimation technique was used to estimate the parameters in the model. In addition to the econometric analysis, the study also employed the service of descriptive statistics to present data on variables that are relevant to the study.

Li et al. (2016) decomposed household CO_2 emission into direct and indirect carbon emissions. The direct CO_2 emission was calculated using the IPCC reference method. The indirect CO_2 emission was estimated using the input-output method and consumer lifestyle approach. The spatial econometric model was employed to analyse the influence of identified factors on per capita household CO_2 emission. The akaike information criterion was adopted for model selection. The variance inflation factor (VIF) and condition index were utilised to test for the existence of multicollinearity in the model.

Wang and Yang (2016) decomposed household CO_2 emissions into direct and indirect CO_2 emissions. The direct CO_2 emissions from household consumption was estimated by multiplying carbon emission factor of each energy source by its corresponding amount consumed. The indirect CO_2 emissions from household consumption was estimated using the input-output and consumer lifestyle approach. The logarithmic Mean Divisia Index (LMDI) was employed to analyse the impacts of identified factors on CO_2 emissions from household consumption within the period of study in Beijing. Descriptive statistics were also utilised in the study.

3. METHODOLOGY

3.1 Estimating Direct Carbon Footprint from Household Energy Consumption

Direct carbon footprint can be viewed as the carbon footprint from the direct consumption of energies in household activities such as household energy use for cooking, lighting, transportation et cetera. In general, the Linear Multiplier Factor Method is applied to estimate the direct carbon footprint from household energy consumption. First, each energy usage amount is multiplied by its corresponding carbon emission coefficient or factor, and then added to get the total direct carbon footprint for the i^{th} household. The estimation model of direct carbon footprint from household energy consumption is expressed as follows:

$$DC_i = \sum_{k}^{n} CF_k \cdot A_k$$

$Where:$

$CF_k = Carbon\ emission\ factor\ of\ k^{th} energy$

$A_k = Amount\ of\ the\ k^{th}\ energy\ consumed$

$DC_i = Direct\ carbon\ footprint\ of\ the\ i^{th}\ household$

$$\sum_{i}^{z} DC_i = Total\ households\ direct\ carbon\ footprint$$

3.2 Theoretical Framework

The theoretical environmental Kuznets curve model adopted was developed by Andreoni, J. and Levinson, A. in 2001. The AL model approaches the EKC from a consumer standpoint and assumes increasing returns to pollution abatement.

Consider a representative agent whose utility function depends on the consumption of one private good, C, and on a bad good called pollution, P. The preferences can be expressed as:

$U = U(C, P\ )$ ……………………………………………… 1

Where $\frac{\delta U}{\delta C} > 0$ and $\frac{\delta U}{\delta P} < 0$, and U(C, P) is quasiconcave in C and −P and both arguments (C, −P) are normal goods.

Suppose that the representative agent has a means by which he can alleviate pollution by spending resources either to clean it up or, equivalently, to prevent it from happening at all. Let environmental effort, E, be the resources available to do so. Pollution then becomes a positive function of consumption and a negative function of environmental effort.

$P = P(C, E)$ ……………………………………………….. 2

Where $\frac{\delta P}{\delta c} > 0$ and $\frac{\delta P}{\delta E} < 0$. Suppose the representative agent has an endowment, Y, of resources which can be spent on C and E. For simplicity, the relative costs of consumption and environmental effort are normalized to 1. The resource constraint becomes:

$Y = C + E$ ……………………………………………… 3

Suppose:

$U = C - zP$ ………………………………………………..4

$P = C - C^{\alpha}E^{\beta}$ ……………………………………………….5

Where U is the utility function and P is the pollution function. Eq. (4) is linear and additive in C and P, z > 0 is the constant marginal disutility of pollution. The first term of Eq. (5), C, is the gross pollution before abatement and is directly proportional to consumption. The second term of Eq. (5), $C^{\alpha}E^{\beta}$, represents abatement. Eq. (5) indicates that consumption causes pollution one-for-one, but resources spent on environmental effort abate pollution with a standard concave production function.

Suppose z = 1, substituting the pollution function into the utility function implies the individual is maximizing $C^{\alpha}E^{\beta}$ subject to Y = C + E, hence consumption and environmental effort have standard Cobb-Douglas solution:

$$Max.(C,E): U = C^{\alpha}E^{\beta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..6$$

$$Subject\ to: C + E = Y$$

$$Solution:$$

$$U = C^{\alpha}E^{\beta} - \pi(M - C - E) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.7$$

$$\frac{\delta U}{\delta C} = \alpha C^{\alpha-1}E^{\beta} + (-1)\pi = 0 \quad First\ Order\ Condition$$

$$\pi = \alpha C^{\alpha-1}E^{\beta}$$

$$\frac{\delta U}{\delta E} = \beta C^{\alpha}E^{\beta-1} + (-1)\pi = 0 \quad First\ Order\ Condition$$

$$\pi = \beta C^{\alpha}E^{\beta-1}$$

$$Setting\ \alpha C^{\alpha-1}E^{\beta} = \beta C^{\alpha}E^{\beta-1} gives\ C = \frac{\alpha E}{\beta}\ and\ E = \frac{C\beta}{\alpha}$$

$$Substituting\ \frac{\alpha E}{\beta}\ and\ \frac{C\beta}{\alpha}\ into\ Eq.3\ gives:$$

$$E^{*} = \frac{\beta}{\alpha + \beta}Y$$

$$C^{*} = \frac{\alpha}{\alpha + \beta}Y$$

C^{*} *and* E^{*} *are the optimal consumption and environmental effort that maxize utility*

Substituting C^{*} *and* E^{*} *into Eq.5 gives:*

$$P^{*}(Y) = \left(\frac{\alpha}{\alpha + \beta}\right)Y - \left(\frac{\alpha}{\alpha + \beta}\right)^{\alpha}\left(\frac{\beta}{\alpha + \beta}\right)^{\beta}Y^{\alpha+\beta}$$

The above expression gives the Environmental Kuznets Curve.

The derivative of $P^{*}(Y)$ represents the slope of the EKC curve:

$$\frac{\delta P^{*}}{\delta Y} = \frac{\alpha}{\alpha + \beta} - (\alpha + \beta)\left(\frac{\alpha}{\alpha + \beta}\right)^{\alpha}\left(\frac{\beta}{\alpha + \beta}\right)^{\beta}Y^{\alpha+\beta-1}$$

The sign of which depends on the parameters α and β.

If $\alpha + \beta = 1$*, effort spent abating pollution has constant returns to scale, and* $\frac{\delta P^{*}}{\delta Y}$ *is constant. Then* P^{*} *rises with Y without a downward sloping portion of the pollution income curve.*

If $\alpha + \beta < 1$*, effort spent abating pollution exhibits decreasing returns to scale such that* $P^{*}(Y)$ *convex.*

If $\alpha + \beta > 1$*, effort spent abating pollution exhibit increasing returns to scale such that* $P^{*}(Y)$ *is concave. This is the EKC curve.*

3.3 Model Specification

According to Boulding (1966), theories without facts may be barren, but facts without theories are meaningless. In reaction to this, the environmental Kuznets curve hypothesis is the theoretical foundation of the model specified below. The EKC identifies income as the principal determinant of indicators of environmental degradation. However, at the household level, other socio-economic and demographic factors may play an important role in explaining the dynamics of Nigerian household carbon footprint. The introduced explanatory variables are: household size; age of household head; motorization; household male population; literacy ratio; household head gender and polygamy status.

The model is specified explicitly as follows:

$$Ln(CF_i) = \beta_0 + \beta_1 HH\_Income_i + \beta_2 HH\_Income_i^2 + \beta_3 Age_i + \beta_4 Age_i^2 + \beta_5 Lit\_Ratio_i + \beta_6 Motorisation_i + \beta_7 Male\_Pop_i + \beta_8 HH\_Gender_i + \beta_9 HH\_Size_i + \beta_{10} Polygamy_i + U_i$$

Where:

$(CF_i) = Carbon\ footprint\ of\ the\ i^{th}\ household$

$HH\_Income_i = Income\ of\ the\ i^{th} household$

$HH\_Size_i = Number\ of\ individuals\ in\ the\ i^{th} household$

$Age_i = Age\ of\ the\ i^{th}\ household\ head$
$Male\_Pop_i = Male\ population\ of\ the\ i^{th}\ household$
$HH\_Gender_i = Gender\ of\ the\ i^{th}\ household\ head$
$Polygamy_i = Polygamous\ status\ of\ the\ i^{th}\ household$
$Lit\_Ratio_i = Literacy\ ratio\ of\ the\ i^{th}\ household$
$Motorisation = Number\ of\ vehicles\ owned\ by\ the\ i^{th}\ household$
$ln = Natural\ logarithm\ (log_e)$
$U_i = Error\ term\ of\ the\ i^{th}\ household$

3.4 Description of variables

Variables	Definitions
Household size	The number of individuals that make up the household
Household income	Household's total income in naira
Age	Age of household head
Male population	Total number of males in the household
Literacy ratio	The ratio of household members that can read and write in any language to total number of household members (0, 1)
Motorisation	Total number of vehicles owned by the household **Note:** A vehicle is a mobile machine that transports people or cargo. Pollution intensive vehicles used other than bicycle are the focus
Polygamy	The state of household head having more than one wife. Assign 1= if household head is polygamous and 0 = if otherwise
Household head gender	The sex of household head. Assign 1 = if household head is male and 0 = if otherwise

Note: (0, 1) implies that the value lies within 0 to 1

3.5 A priori Expectation

Sequel to the explicitly specified cross section regression model:

$$Ln(CF_i) = \beta_0 + \beta_1 HH\_Income_i + \beta_2 HH\_Income_i^2 + \beta_3 Age_i + \beta_4 Age_i^2 + \beta_5 Lit\_Ratio_i + \beta_6 Motorisation_i + \beta_7 Male\_Pop_i + \beta_8 HH\_Gender_i + \beta_9 HH\_Size_i + \beta_{10} Polygamy_i + U_i$$

The parameters in the model are expected to behave as follows:

$\beta_0 > 0$, $\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 > 0$, $\beta_4 < 0$, $\beta_5 < 0$, $\beta_6 > 0$, $\beta_7 > 0$, $\beta_8 > 0$, $\beta_9 > 0$ and $\beta_{10} > 0$

3.6 Data Requirements and Sources

For this research, data on household socio-economic and demographic characteristics were obtained from the 2015 National Bureau of Statistics General Household Survey and data utilised for the trend analysis were obtained from the 2017 International Energy Statistics (IES) monthly update and Olivier et al. (2016). For the estimation of household direct carbon footprint using the Linear Multiplier Factor Method, the required carbon emission factors were obtained from the United States of America Environmental Protection Agency (EPA) website as well as related journal articles. In conclusion, the kilogram price of firewood was obtained from the Cocoa Research Institute of Nigeria (CRIN[1]) website and that of charcoal through interview.

4. RESULTS AND DISCUSSION

The table below shows the determinants of Nigerian household carbon footprint. The explanatory variables examined are household income, household size, male population, literacy ratio, motorisation, age, polygamy status and gender of the household head

[1] CRIN Website: www.crin-ng.org/index.php/services

Table 1: OLS Regression Results

Variables	Coefficients
HH_Income	$8.84\times10^{-6***}$ (6.83×10^{-7})
HH_Income^2	$-1.37\times10^{-12***}$ (1.08×10^{-13})
HH_Size	0.0492^{***} (0.0107)
Age	0.0097 (0.0086)
Age^2	$-1.28\times10^{-4*}$ (7.75×10^{-5})
HH_Gender	0.2289^{***} (0.0536)
Polygamy	0.0202 (0.06)
Lit_Ratio	0.2133^{***} (0.0585)
Motorisation	0.0934^{***} (0.0272)
Male_Pop	0.001 (0.0167)
Constant	3.9992^{***} (0.2308)
Observations	4560
R-squared	0.0988
F_cal	49.85 [0.0000]
Note: Standard errors are presented in parentheses Probability values are in brackets $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$	

Source: Author's Computation using STATA 12

The results of the estimated cross section regression model presented in Table 1 above are analysed sequentially below:

- Household Carbon Footprint and Household Income

The regression results show that household income has statistically significant positive impact on household carbon footprint ($\beta = 8.84\times10^{-6}$, $p < 0.01$). The positive sign of the interaction term implies that household carbon footprint is an increasing function of household income. Holding other factors constant, a naira increase in household income will cause 8.84×10^{-4} percent increase in household carbon footprint. This result is reported in similar studies conducted by Serino and Klasen (2015), Xu et al. (2015), Sharaai et al. (2015), Han et al. (2014) and Li et al. (2016).

- Household Carbon Footprint and Household Size

The regression results show that household size has statistically significant positive impact on household carbon footprint ($\beta = 0.0492$, $p < 0.01$). The positive sign of the coefficient implies that household carbon footprint is an increasing function of household size. Assuming other factors remain unchanged, a one person increase in household size will cause 4.92 percent increase in household carbon footprint. This result is reported in similar studies conducted by Serino and Klasen (2015) and Xu et al. (2015), but in contrast to Sharaai et al. (2015) and Li et al. (2016).

- Household Carbon Footprint and Age of Household Head

The regression results reveal that age of the household head has statistically insignificant positive effect on household carbon footprint ($\beta = 0.0097$, $p > 0.1$). The positive sign of the interaction term implies that household carbon footprint level is an increasing function of household head age. Holding other factors constant, a one year increase in age of household head will cause 0.97 percent increase in household CO_2 emissions. Since the probability value is greater than the level of significance (10%), it is concluded that the effect of the increase on household carbon footprint is not statistically different from zero.

- Household Carbon Footprint and Household Head Gender

The regression results show that gender of household head has statistically significant positive impact on household carbon footprint ($\beta = 0.2289$, $p < 0.01$). The positive sign of the interaction term implies that the level of household carbon footprint is being raised by the gender of household head. Holding other factors constant, the movement of household head gender from 0 to 1 will cause 25.72 percent increase in household carbon footprint. This result is consistent with similar study conducted by Han et al. (2014) but in contrast to study conducted by Serino and Klasen (2015).

- Household Carbon Footprint and Polygamous Status

Surprisingly, the regression results show that polygamous status of household head has statistically insignificant positive impact on household carbon footprint ($\beta = 0.0202$, $p > 0.1$). The positive sign of the coefficient implies that household carbon emissions level is being raised by the polygamous status of household head. Holding other factors constant, the movement of household head polygamous status from 0 to 1 will cause household carbon footprint to increase by 2.04 percent. Since the probability value is greater than the level of significance (10%), it is concluded that the impact of the increase on household carbon footprint is not statistically different from zero.

- Household Carbon Footprint and Literacy Ratio

The regression results show that the literacy ratio of household has statistically significant positive impact on household carbon footprint ($\beta = 0.2133$, $p < 0.01$). Paradoxically, household carbon footprint is an increasing function of household literacy ratio. Holding other factors constant, a one unit increase in literacy ratio will cause 21.33 percent increase in household carbon footprint. This result is in contrast with similar study conducted by Han et al. (2014).

- Household Carbon Footprint and Motorisation

The regression results show that motorisation has statistically significant positive impact on household carbon footprint ($\beta = 0.0934$, $p < 0.01$). The positive sign of the interaction term implies that household carbon footprint is an increasing function of motorisation. Holding other factors constant, a one unit increase in household vehicle stock will cause house carbon footprint to increase by 9.34 percent. This result is consistent with similar study conducted by Han et al. (2014).

- Household Carbon Footprint and Male Population

The regression results show that male population has statistically insignificant positive impact on household carbon footprint ($\beta = 0.001$, $p > 0.1$). The positive sign of the interaction term implies that household carbon emissions level is an increasing function of household male population. Holding other factors constant, increase in household population by one male will cause 0.1 percent increase in household carbon footprint. Since the probability value is greater than the level of significance (10%), it is concluded that the effect of the increase on household carbon footprint is not statistically different from zero. This result is consistent with similar study conducted by Xu et al. (2015).

- Household Carbon Footprint and Household Income-squared

The regression results show that household income has statistically significant nonlinear effect on household carbon footprint ($\beta = -1.37\times10^{-12}$, $p < 0.01$). The negative sign of the coefficient implies inverted U-shaped relationship between household carbon footprint and household income. By implication, household carbon footprint will increase with household income to a maximum point (turning point), beyond which further increase in income will lead to significant decline in household carbon footprint. This result confirms the validity of environmental Kuznets curve (EKC) hypothesis at the household level. Be that as it may, this result is consistent with similar study conducted by Serino and Klasen (2015).

- Household Carbon Footprint and Age-squared

The regression results show that age of household head has statistically significant nonlinear effect on household carbon footprint ($\beta = -1.28\times10^{-4}$, $p < 0.01$). The negative sign of the interaction term implies inverted U-shaped relationship between household carbon footprint and age of household head. By implication, household carbon footprint level will increase with age of household head to a particular point (turning point), beyond which further increase in age will lead to significant decline in household carbon footprint. Preferences and consumption patterns of household members do not only change with income, but with age as well. This result is consistent with similar studies conducted by Serino and Klasen (2015) and Xu et al. (2015).

- Household Carbon Footprint and Intercept Coefficient

The results show that the intercept coefficient of the model is statistically significant and positive ($\beta = 3.9992$, $p < 0.01$). This implies that if all the explanatory factors are zero, household carbon footprint will be 54.55 kg CO_2. In conclusion, the predictors accounted for 9.88 percent variations in household carbon footprint ($R^2 = 0.0988$).

4.1 Demographic Characteristics of Nigerian Household

Table 2 below shows the demographic characteristics of Nigerian household. The demographic characteristics under assessment are household size, male population, female population and age of household head.

Table 2: Demographic Characteristics of Nigerian Household

Household Size		Male Population		Female Population		Age of H/Head	
Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
7.16	3.56	3.51	2.14	3.65	2.17	52.83	14.59

Source: Author's Computation from 2015 General Household Survey

The results presented in the above Table revealed that on the average, the population of Nigerian household is 7.16 persons. In terms of gender distribution of the household, the average size of male and female population are 3.51 and 3.65 persons respectively. The average age of household head in Nigeria is 52.83 years.

4.2 Summary Statistics of Nigerian Household Carbon Footprint

The table below presents information on the mean carbon footprint of Nigerian household.

Table 3: Average Nigerian Household Carbon Footprint

Household Carbon Footprint (kg CO_2)	
Mean	Std. Dev
304.72	514.49

Source: Author's Computation

4.3 Summary of Findings

The results of the estimated regression model x-rayed the socio-economic and demographic factors that influenced the behaviour of Nigerian household carbon footprint. As revealed by the findings, household income, household size, literacy ratio, motorisation and household head gender have statistically significant positive effects on household carbon footprint. Surprisingly, literacy ratio contradicts a priori expectation. In addition, male population, age and polygamous status of household head have statistically insignificant positive impacts on household carbon footprint. The coefficients of income-squared and age-squared are negative and significant at one percent level. These confirm non-linear relationship between household carbon footprint and household income as well as age of household head.

4.4 Conclusion

Based on the results of the empirical investigation, household income, literacy ratio, household size and motorisation are the quantitative factors that significantly and positively influence the behaviour of household carbon footprint in Nigeria. This implies that carbon footprint from household activities will continue to rise as household become more affluent, educated and large in size. If handled with kid gloves, the potential ecological and economic disaster associated with high carbon footprint may obstruct the sustainable development mission of the country. This, however, does not translate to preventing income, literacy ratio and household size from being on the rise. Alternative options that are capable of ameliorating household carbon footprint should be looked into.

4.5 Policy Recommendations

Considering the fact that Nigeria is a country with large reserve of people living below the poverty line, the huge cost associated with renewable energy use may hinder large scale movement of households away from the consumption of high carbon intensive fuels. However, the following policy options, if adhered to by the government and policymakers will prevent Nigerian household carbon footprint level from going worse.

- Government should ensure regular supply of electricity (an energy with relatively low carbon emission factor) in order to discourage low and medium income households from using energies with high carbon emission factors, e.g. firewood, kerosene, et cetera.
- Government should combine improvements in the public transportation system with regulations and incentives to encourage the use of less polluting or non-polluting transportation alternatives such as walking, cycling, et cetera.
- Government should embark on adequate sensitisation of the public on the need to be conscious of the environmental consequence of their transportation choices.
- Government should prioritize technical schools in Nigeria so that technical students can be equipped with the required knowledge to produce renewable energy gadgets for households and firms at relatively affordable prices.
- There is need for government to breathe life into its environmental regulatory agencies. If this is achieved, less environmental friendly lifestyle in the country can be reduced to the least level.

4.6 Limitations of the Study

It is desired by the researcher to look beyond the number of households, variables and energy options in this study, but the inability to do so is enrooted in the scope of the household survey data used.

References

Adeoti, O. & Osho, S. O. (2012). Opportunities to reduce greenhouse gas emissions from households in Nigeria. *Mitig Adapt Strateg Change*, 17, 133-152.

Ahmad, S., Baiocchi, G. & Creutzig, F. (2015). CO_2 emissions from direct energy use of urban households in India. *Environmental Science and Technology*, A-I. DOI: 10.1021/es505814g

Andreoni, J. & Levinson, A. (2001). The simple analytics of the environmental Kuznets curve. *Journal of Public Economics,* 80, 269-286.

Baiocchi, G., Minx j. & Hubacek, K. (2010). The impact of social factors and consumer behaviour on carbon dioxide emissions in the United Kingdom. *Journal of Industrial Ecology,* 14(1), 50-72.

Bin, S. & Dowlatabadi, H. (2005). Consumer lifestyle approach to US energy use and the related CO_2 emissions. *Energy Policy,* 33(2), 197-208.

Das, A. & Paul, S. K. (2014). CO_2 emissions from household consumption in India between 1993-94 and 2006-07. *Energy Economics*, 41, 90-105.

EPA. (2017). *Greenhouse gas emissions.* Retrieved from http://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

Folawewo, A. & Olakojo, S. (2010). Determinants of agricultural exports in oil exporting economy: Empirical evidence from Nigeria. *Journal of Economic Theory,* 4(4), 84-92.

Han, L., Xu, X. & Han, L. (2014). Applying quantile regression and Shapley decomposition to analyzing the determinants of household embedded carbon emissions: Evidence from urban China. *Journal of Cleaner Production*, xxx, 1-12.

Jaiswal, N. & Shah, K. (2013). Assessment of carbon footprints of rural households of Vodora district, Gujarat, India. *Indian journal of Applied Research*, 3(11), 243-245.

Kerkhof, A. C., Benders, R. M. J. & Moll, H. (2009). Determinants of variations in household CO emissions between and within countries. *Energy Policy*, 37, 1509-1517.

Lee, S. & Lee, B. (2014). The influence of urban form on GHG emissions in the U.S. household sector. *Energy Policy*, 68, 534-549.

Li, J., Huang, X., Yang, H., Chuai, X., Li, Y. & Qu, J. (2016). Situation and determinants of household carbon emissions in Northwest China. *Habitat International,* 51(1), 178-187.

Li, Y., Zhao, R., Liu, T. & Zhao, J. (2015). Does urbanisation lead to more direct and indirect household carbon dioxide emissions? Evidence from China during 1996-2012. *Journal of Cleaner Production*, 102, 103-114.

Liu, L., Wu, G., Wang, J. & Wei, Y. (2011). China's carbon emissions from urban and rural households during 1992-2007. *Journal of Cleaner Production*, xxx, 1-9.

NBS. (2012). *LMS-integrated surveys on agriculture.*

Olivier J.G.J., Janssens-Maenhout G., Muntean M. & Peters J.A.H.W. (2016). *Trends in global CO_2 emissions*. The Hague: PBL Netherlands Environmental Assessment Agency; Ispra: European Commission, Joint Research Centre.

Qu, J., Maraseni, T., Liu, L., Zhang, Z. & Yusaf, T. (2015). A comparison of household carbon emission patterns of urban and rural china over the 17-year period (1995-2011). *Energies*, 8, 10537-10557.

Ramseur, J. L. (2014). *U.S. greenhouse gas emissions: Recent trends and factors*. New York, USA: Congressional Research Service.

Serino, M. N. & Klasen, S. (2015). Estimation and determinants of the Philippines' household carbon footprint. *The Developing Economies,* 53(1), 44-62.

Sharaai, A. H., Mokhtar, A. M., Jin, N. W. & Azali, N. A. (2015). Determining the primary factor contributed to household carbon emission by using structural equation modelling (SEM). *Procedia Environmental Sciences*, 30(1), 344-348.

Underwood, A. J. (2013). *Household carbon dioxide emissions in the United States: The role of demographic change* (Unpublished doctoral dissertation). Colorado State University, Fort Collins, Colorado, USA.

Wang, Y. & Shi, M. (2009). CO_2 emissions induced by urban household consumption in China. *Chinese Journal of Population and Resources and environment,* 7(3), 11-19.

Wang, Z. & Yang, L. (2014). Indirect carbon emissions in household consumption: Evidence from the urban and rural area in China. *Journal of Cleaner Production*, xxx, 1-10.

Wang, Z. & Yang, Y. (2016). Features and influencing factors of carbon emissions indicators in the perspective of residential consumption: Evidence from Beijing, China. *Ecological Indicators*, 61, 634-645.

Wei, Y., Liu, L., Fan, Y. & Wu, G. (2007). The impact of lifestyle on energy use and CO_2 emission: An empirical analysis of China's residents. *Energy Policy*, 35, 247-257.

WHO & UNFCCC. (2015). *Climate and health country Profile – Nigeria*.

Wikipedia. (2017). *Global warming*. Retrieved from http://www.wikipedia.org/wiki/Global_ warming

Wright, L. A., Kemp, S. & Williams, L. (2011). Carbon footprinting: Towards a universally accepted definition. *Carbon Management*, 2(1), 61-72.

Wu, G., Liu, T. & Tang, M. (2012). Analysis of household energy consumption and related CO emissions in the disregarded villages of Lijiang City, China. *International Journal of Sustainable Development and World Ecology*, 19(6), 500-505.

Xu, X., Tan, Y., Chen, S., Yang, G. & Su, W. (2015). Urban household carbon emission and contributing factors in the Yangtze River Delta, China. *Plos One*, 10(4), 1-21.