Analysis of Households' Charcoal Consumption and Alternative Energy Source Usage in Jere Local Government Area of Borno State, Nigeria

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Abstract

This study analysed households' charcoal consumption and alternative energy source usage in Jere Local Government Area of Borno State. A multistage sampling technique was employed to collect data from six different wards in Jere. Three hundred and eighty-five returned questionnaires were analysed using both descriptive (such as frequency, mean, percentages, and bar charts) and inferential statistics (multiple regression model). The findings revealed that the majority of the household's heads are male, married, and farmers by profession. Also, the respondents are in their active age to support their household. Although most of the respondents have no formal education with a family size between 6-10, earning a low income of less than ₦30,000. The consumption of charcoal is mostly done by low-income households. With regards to the socio-economic determinants, charcoal consumption is positively influenced by household size, sex, and age, while negatively related to income and educational level. The study concluded that most households are multiple energy source users, affirming that the energy ladder model does not hold for the households in Jere LGA. Therefore, the study recommends that there is the need for the government to create awareness as well as capacity development among the households on how to produce and use briquette since the raw materials used for such are the available household waste that attracts no less cost, the government also needs to improve the economic status of the people via job creation opportunities as well as the needs to continue on her effort and restore electricity supply in the study area so as to encourage its usage in cooking, water heating, and ironing.

Keywords: *Households, Charcoal, Consumption, Energy, Jere*

Introduction

The types of fuels used by households for everyday activities, such as cooking, lighting, and heating have an important bearing on various factors influencing their well-being. These factors range from health consequences and financial risks to aspects of individual and collective time use. In addition, the societal relations which dictate who is exposed to the adverse effects associated with the use of traditional, 'dirty' fuels, such as charcoal and firewood, intimately link fuel use to the risks faced and the work carried out by women and children (Amghizar, Vandewalle, Van-geem and Marin, 2017). Hence, energy is vital to human activities and it is critical to social and economic development. Energy refers to the utilization of chemical resources, which is aimed at providing a source of power or light for cooking, space heating, cooling, ironing, heating of local scent sticks, and other purposes (Maina, Kaura & Kyari, 2017).

Domestic energy is the energy used in homes mostly for cooking, heating, and cooling processes. However, people make different choices as to the types of energy they use at home for different purposes in different circumstances. Even though Nigeria is endowed with abundant natural energy resources like biomass, hydropower, wind, natural gas, solar, etc., the opportunities for making these energy resources into usage, cleaner and more environmentally friendly are inaccessible due to technological gaps. Nigerians rely heavily on traditional energy sources like charcoal, firewood, biogases, and crop residues for their daily energy needs at home (Muazu & Ogujiuba, 2020).

Traditional fuels, such as firewood, charcoal, and coconut husks, are still inherently more popular than the modern, 'cleaner' and more expensive alternatives; like Liquefied Petroleum Gas (LPG) in most countries of West Africa (Asante, Afari-Asiedu, Abdulai, Dalaba, Carrion, Dickinson and Jack, 2018). It is also widely assumed that as households acquire wealth, they would 'naturally' switch to cleaner and more modern fuels for their cooking and other household needs. Some households however even when the opportunity to shift to cleaner fuel presents itself, continue to use biomass for particular cooking purposes. Thus, households often rely on a range of fuels for different reasons including resource reliability and cost-effectiveness (Pillarisetti, Mehta, and Smith, 2016) and this over-dependence on biomass has broader effects on the environment in form of forest degradation and pollution (Vicente, Quiring, Pena-Gallardo, Yuan, and Dominguez-Castro, 2020).

The role of energy in meeting household's needs cannot be overemphasized in Jere Local Government Area. Whether it is the traditional biomass energy source such as charcoal, animal dung, crop residues, fuel wood, or the alternative modern energy source which include electricity, Liquefied Petroleum Gas, kerosene, etc., at least one particular source of energy is required by any particular household to cook, boil, fry and preserve food items at home. The heterogeneous population of Jere LGA with different levels of income pave way to the use of different energy types at various households.

Although, there are a lot of studies conducted in Nigeria on households charcoal demand to mention but a few is a study by Babalola and Opii (2012), Ogwumike, Ozughalu, and Abiona (2014), Sakanko and Obilikwu (2018) , Umar, Baba, Ibrahim and Unegbu (2018) which focused on determinants of charcoal consumption among households in Maiduguri Metropolis Area of Borno State, Nigeria. However, little or none of these studies in northeast Nigeria focus on a micro level, nor explore the alternative energy use by the households as well as examines the households' conformity to energy demand theories. This study filled the knowledge gap by analyzing households charcoal consumption and alternative energy source usage in Jere Local Government Area of Borno State, Nigeria. Therefore, the study is hinged on the following objectives:

i. examine the socio-economic characteristics of the households in the study area;
ii. identify households charcoal consumption pattern in the study area;
iii. assess the socio-economic factors determining the households charcoal consumption in the study area;
iv. investigate alternative energy sources consumed by households in the study area.

Literature Review

Conceptual Issues: In this subsection, the concepts of households' energy use, energy consumption pattern, energy and socioeconomics, clean energy and dirty energy were reviewed.

***Households Energy Use*:** According to National Population Commission, (2006), a household consists of a person or group of persons living together usually under the same building or compound, who share the same source of food and recognize themselves as a social unit with a head of household. In addition, a household is a group of people living together and maintaining unique eating arrangement (National Bureau of Statistics, 2010). Hu and Peng (2015) stated that household comprises those who dwell under the same roof and composed a family. According to Rakodi (2014), a household is based in the arrangement made by person, individually or in group, for producing the self with food or other essentials for living. Household energy demand means the total amount of energy purchased and used by households for various purposes such as cooking, space heating and cooling, lighting, ironing, for use in electrical appliances and so on (Maina *et al.,* 2017). Thus, energy demand is essential for household welfare, public investment and environmental considerations. Household energy services are required for a variety of purposes. It is required for lighting, heating, cooking and for use in electrical appliances. This usage is commonly referred to as household energy consumption and is defined as the energy consumed in homes to meet the needs of households (Kadiri and Alabi, 2014). To conceptualize the definition of Household energy demand, the study adopted the definition presented by Maina, *et al (*2017).

Energy Consumption Pattern: Energy consumption pattern in Nigeria can be broadly grouped into domestic, commercial and industrial spheres. The consumption of energy in Nigeria is centred on cooking, lighting, cooling, space heating, running of electrical appliances and so on. (Maina, *et al*, 2017; Danlami 2017 & Bisu, Kuhe & Iortyer 2016). Maina, *et al* (2017) revealed that household energy demand is affected by factors such as income, energy price, household size, age, etc. This is in line with Emagbetere, *et al* (2016) that household energy preferences and consumption pattern are due to some factors such as energy price, income, employment, education, household size, etc. Similarly, Sa'ad and Bugaje (2016) mentioned that the main drivers of traditional fuels consumption in Nigeria include poverty, availability, cost and cultural factors.

More so, Bisu, *et al* (2016) affirmed that household size, dwelling ownership status, change of season, income, level of education, dwelling location, availability and affordability are the factors that were found to influence household cooking energy choice. Furthermore, there are also wide variations in the level of consumption and the patterns of cooking energy use by households based on their levels of urbanization and income. These categorizations, in general, include rural and urban households, and low income and high-income households (Malla & Timisina, 2014). For the purpose of this study, energy consumption pattern can be deduced to refer to as the way and total use of non-renewable energy (i.e., charcoal) by households within a particular locality

Theoretical Framework

This sub-section reviewed two (2) energy demand theories, viz; energy ladder model and energy stack model.

Energy Ladder Model: The energy ladder Model is used to describe the way in which households will move to more sophisticated fuels as their economic status (incomes) improves. This is because it is assumed that as income increases, the energy types used by households would be cleaner and more efficient, but more expensive as they move from traditional biomasses to electricity. A synopsis of the energy ladder indicates that there is a positive relationship between socio-economic level and modern fuel uptake, that fuel preferences are ordered by physical characteristics and fuel costs and that there is an assumption of complete substitution of one fuel for another (Reddy, Annecke, Blok, Bloom, Boardman, Eberhard and Ramakrishna, 2000). . The energy ladder model is, however, based on certain assumptions as outlined below:

i. Economic factors determine energy consumption;
ii. Unidirectional movement in energy consumption;
iii. Linear progression of energy consumption;
iv. Movement due to improvement in the economic situation;
v. Energy consumption depends on fuel preferences.

Household energy consumption is often analyzed and understood through the energy ladder model (Van Kroon, Brouwer, & Van Beukering, 2013). Baiyehun and Hassan (2014) ascertained that in rural Nigeria, the transition from fuelwood to kerosene, natural gas and electricity occurs along to rising income. Similarly, in the same country as above, Abd'razack, Medayese, Matins, Idowu, Adelaye, and Bello (2012) found a significant relationship between choice of energy and income in support of the energy ladder model.

***Energy Stack Model*:** Energy stack model is the ability of households to combine both traditional and modern fuels to meet their domestic energy needs. This model rejects the linear simplification of the energy ladder, suggesting that households do not wholly abandon inefficient fuels in favor of efficient ones. Rather, modern fuels are integrated slowly into energy use patterns, resulting in the contemporaneous use of different cooking fuels (Masera, *et al.,* 2000). The Energy Stack Model is based on certain assumptions as outlined below:

i. All households use a combination of different fuels/energy use equipment over a period of time.
ii. Energy is a compound commodity and comprises the different sources of energy such as kerosene, liquefied petroleum gas, electricity, charcoal and firewood etc.;
iii. Households also allocate part of their income or expenditure to energy and further decide on how much of this expenditure will be put towards the different sources of energy.

***Relevance of the Model*:** The study adopted the energy stack model theory which is considered cogent because it aligns to the fact that most households seem not to switch fuels entirely, but more generally uses multiple fuels. Most households combine traditional and modern fuels to meet their domestic energy needs. The result revealed that there is evidence of fuel stacking as majority (60% and 16% totaling 76%) use multiple fuel sources (2 and 3 fuels respectively). The proof of fuel stacking within the study area as a position debunks the energy ladder model in that economic growth alone cannot be considered as the only driver for household energy use behavior. Thus, households in the study area used a different combination of energy mix menu for their energy needs. They also allocate part of their

income or expenditure to energy and further decide on how much of this expenditure will be put towards the different sources of energy.

Empirical Review

Socio-economic Characteristics of Households and Energy Consumption Pattern:

Mafimisebi, Bobola & Mafimisebi, (2013) stress that the marital status of a person is expected to determine the extent of responsibility of that person in the family and the manner in which he or she will allocate scarce resources at his or her disposal. The marital status indicates the weight of responsibility, the extent of commitment to his or her job as well as the quantity of energy he or she is likely to use at a point in time. Single households are more likely to demand less of the energy due to the small size of their dwelling compared to those who are married with many people under them to take off. In addition, Umar *et al* (2018) revealed that the coefficient of marital status was positive and significant, implying that an increase in the number of married people would result to a significant increase in the quantity of charcoal consumption. A plausible explanation is that unmarried ones will tend to opt for kerosene and gas cooker because they are faster and cleaner sources of cooking fuels. According to Emagbetere, *et al* (2016) stated that the type of employment of people affect the choice of energy. Majority of people who were gainfully employed used LPG while low income earners used kerosene despite their preference for gas. Similarly, Eakins (2013) proved that those in white collar jobs (executives, big entrepreneurs) adopt clean energy, while those in blue-collar jobs (such as farming, trading) tend to adopt firewood and other biomass fuels.

Socio-economic factors determining Households Charcoal Consumption. Food Agricultural Organization (2015) showed that the direct determinants of household energy consumption are found precisely at the level of household's size. Household size has been observed to be sometimes a more important determinant of household energy consumption than income. Maina, *et al* (2020) stated that the higher the family size, the higher the CO_2 emission because the more family size without a corresponding increase in income, the more they resort to the use of alternative but dirty fuels.

Similarly, Olasunkami and Ogunjobi (2015) ascertained that households with large family size were found to be more likely to consume charcoal and wood and less likely to use kerosene while households with small family size consumed more kerosene whereas electricity consumption did not depend on family size. The number of a household's members (i.e. household size) affects the household's energy consumption decision; the larger the size of a household, the lesser the adoption of cleaned energy (Danlami 2017 and Ozcan 2013). Increase in family size due to visitations or marrying more wives and the attendant increase in the number of children makes cooking with more expensive higher fuels uneconomical and may necessitates switching to cheaper fuels such as wood, charcoal, thereby increasing their consumption (Bisu, *et al,* 2016).. Hence, larger households prefer other faster means of cooking (Umar, *et al* 2018).

Eakins, (2013) and Laureti, *et al,* (2012) reveals that education plays a vital role in the utilization of resources by households. Education is regarded as the acquisition of knowledge by an individual aimed at improving his skills and abilities. A household's level of education appears to have an impact on energy conservation beliefs and behaviors. The level of

education of the household head has a positive relationship with cleaned energy adoption. Therefore, a household with well-educated head, spouse and other members tend to have the ability to afford more amount of energy and have higher tendency to choose cleaner energy because it is more convenient, time saving and have health benefits (Ahmed and Darazo; 2016 and Rahut, Das, Groote, and Behera, 2014).

Also, Danlami (2018) established that there is a strong relationship between the household energy use and the level of education of the household head. Furthermore, Emagbetere, *et al* (2016) stated that education has a positive relationship with energy choice as people with tertiary education prefer LPG due to their level of education and exposure while people with secondary education have preference for LPG but used kerosene due to lack of awareness of potential benefit that would compensate for cost implication involve in it. More so, Maina, *et al* (2020) in a study on analysis of household energy use and carbon dioxide emission using environmental kuznets curve in Nigeria discovered that increase in the educational level of household head would make him decrease his carbon dioxide emission through the use of less polluting energy.

Rahut, *et al,* (2014) argued the age of household head could determine the choice of energy used by the household as older household heads may be used to the traditional sources while the household heads that are relatively younger use modern energy sources due to their social exposure. The age of the household head was found to have a negative relationship with the adoption of cleaned energy (Mensah, 2015). Maina, *et al* (2020) found that younger households' heads would use more clean energy sources such as electricity for lighting homes and LPG for cooking because they are more comfortable with these energy sources due to conveniences, low risks, and fewer health implications than fuelwood known for causing indoor pollution. This is in line with Olasunkami and Ogunjobi (2015)

Emagbetere, *et al* (2016) ascertained that there is a significant relationship between the income of households and the type of energy used for cooking as high income earners use clean fuels as LPG, electricity while low income earners used kerosene due to its low cost and availability; however, they prefer gas and electricity. In addition, there is a positive relationship between the households' income and the adoption of cleaned energy (Ozcan, *et al* 2013 & Couture *et al,* 2012). Similarly, Bisu, *et al* (2016) showed the relationship between cooking energy choices and the annual income of households; the use of wood dropped gradually with increase in income.

Also, on energy price, there exist as a negative relationship with energy consumption. When the price of an energy source is high, households switch to other alternatives fuels available (Umar, *et al* 2018; Nilom & Karimov 2014). Furthermore, Olasukanmi and Ogunjobi (2015) ascertained that it is difficult to estimate the effect of energy prices on residential energy consumption in developing countries. This is because most of the energy consumed is via traditional fuels gathered informally without any modern monetary expenditure.

While on the sex of the household, it is stressed that a woman has more time to cook most of her meals than the male counterparts whose tendency is more of to eat in a nearby restaurant or eatery (Rahut, *et al*, 2014). In the same vein, Mensah (2015) revealed that households tend to adopt cleaner energy when the head of the household is female. Similarly, Bisu, *et al* (2016). In other words, gender does not really have significant influence on cooking energy choice of households in the study area. Similarly, Maina, *et al* (2020) stated that sex of

households' heads is an insignificant determinant for both rural and urban household's energy demand.

Households' Alternative Energy Sources: Mohammed *et al* (2018) stated that there is loss utilization of biomass in Maiduguri due to factors such as reduced fuelwood business in the city due to the prevailing security situation in the state and the northeast zone Nigeria in general. Bisu, *et al* (2016) mentioned that wood consumption has however been shown to decrease with change of season, increase in income and level of education of respondents. According to Madukwe (2014) rural households rely more on biomass fuels than those in urban areas to meet their energy need for cooking. Maina, *et al* (2020) revealed that fuelwood was the fourth most demanded energy source amongst petrol, LPG, Diesel, Kerosene, charcoal, firewood, electricity in Northeast zone of Nigeria. This could be because most fuelwood is fetched from nearby bushes; hence, a lot is consumed instead of demanded (effective). Mohammed, *et al* (2018) stated that the use of solid biomass for cooking, commercial business and industry is associated with indoor pollution and damage to health through the practice of open-free three stone stoves has localized the environmental effects and health implications, particularly for regular users (women, children, bakers and roasters, etc.) who are often closely by during the combustion process. Reliance on biomass resources in Nigeria cannot be regarded as sustainable due to high rates of deforestation and negative environmental impacts (Ibrahim & Muhammad, 2015). The consumption of traditional biomass is responsible for indoor air pollution, forest depletion and Green House Gas (GHG) emissions (Toole, 2015; Muller & Yan, 2016).

Subsequently, dry animal drug is more commonly used than moist dung, because it burns more easily. Dry manure is typically defined as having moisture content less than 30 percent (McCarthy, Duffney, Wyatt, Thatcher, Philipps, Sime, 2017; Chiumenti, Borso and Limina, 2018). According to Bedoić, Cosic, and Duic (2019), agricultural waste is the by-product generated by the rearing of animals and the production of harvest of crops or trees.. It has been estimated that globally, 2.4 billion people use wood, charcoal, other plant materials (biomass) and coal as their primary source of cooking fuel. In developing countries, the use of biomass accounts for up to 80% of all household fuel use (Rohra & Taneja, 2016).

Wakili, Abdullahi, Gani, and Bello (2012) ascertained that charcoal is not only the major sources of household energy for rural and urban dwellers; it also contributes to national energy balance. Several advantages makes charcoal attractive for cooking and heating especially among the urban poor compared to firewood, charcoal has higher energy content is less bulky easier to transport and more accessible and burn more clearly with less smoke Although, the expenditure elasticity of charcoal is a bit higher, thus this might be because the commodity is commonly used in Northeast zone of Nigeria in homes to heat pieces of local scent sticks used as room air freshener. Other reasons are cooking, space heating during harmattan season and ironing clothes due to ineffective electricity supply. Charcoal is among the top dirty fuels used by households in Nigeria due to the fact that it is a pure carbon. It emitted more CO2 of 2,735 kg instead of the 745 kg used (Maina, *et al* 2017 & Ojo & Chuffor, 2013). Contrary, the degree of the deleterious fumes emitted is often less than wood due to the stoves sometimes use in conjunction with charcoal (Toole, 2015).

Lam, Smith, Gauthier and Bates (2012) defined kerosene as the proportion of crude oil that boils when heated between $145^0$and 300^0C. It is a volatile liquid widely used by many

households as the main source of energy for cooking, lighting lamps, burning bushes, fuels for automobiles. It is also used as insect's repellent because of its odour. Compared to its immediate predecessor and biomass, kerosene burns more cleanly and more efficiently, an advantage in terms of both health and the environment. (Sa'ad & Bugaje, 2016). Kerosene is seen as a necessary good with expenditure elasticity of less than one as it produces fewer fumes compared to firewood. It is safe to keep for a long time without escaping into the air like LPG and it also provide a source of lighting when used in bush lamps. In addition, it is used as a backup fuel by most household that use LPG in case their gas unexpectedly finishes and in lighting fuel wood (Maina, *et al,* 2017). Furthermore, kerosene requires substantial expenditures at the first instance of purchase because combusting the fuel requires additional equipment. These fixed costs may deter use, particularly if the households face liquidity or credit constraints (Van der Kroon, *et al,* 2013). Bisu, *et al* (2016) revealed that kerosene is not affected by moisture and since it is more available, households that cannot afford higher fuels fall back to it.

Toole, (2015). LPG has increased efficiency and cleanliness of combustion and allows for quicker heating of food or water with fewer emissions Bisu, *et al* (2016) stated that an increased in household size translates into the demand for a larger quantity of food to be cooked at a time. This makes the use of gas unattractive because the gas stove available in the market is too small to accommodate very large pots. Insisting on using gas for such large pots may require industrial burners which will consume more gas. While Maina, *et al* (2020) showed that the lowest demanded energy was electricity. It is used for lighting homes, just lie petrol in generators.

However, it is often used for cooking and ironing clothes. Still, due to the epileptic nature of power supply in Nigeria, many households have resorted to alternative energy sources (Arshad & Ali, 2017). Electricity is mainly dedicated to lighting, locomotive and communication devices in addition to occasional uses for cloth pressing and water boiling, while cooking which is a frequent and energy intensive area is mainly done with solid biomass and kerosene (Mohammed *et al* 2018). Therefore, most of the studies that have been carried out used different methodologies and estimation techniques. This study contributes to existing literature on households' charcoal consumption and alternative energy source usage in Jere Local Government Area of Borno State, Nigeria.

Methodology

Descriptive survey research design was employed for the study which was hinged on the use of primary data. Although, secondary data was employed to complement the existing data. The population for this study consists of the entire households in Jere Local Government Area, with population of 209,107 (NPC, 2006), while the population in 2020 is approximately 307,301. In order to select an appropriate sample size, Yamane (1967) provides a simplified formula to calculate sample sizes. This formula was used to calculate the sample sizes in various research works. The formula is given as follows:

$$n = \frac{N}{1 + N(e)^2}$$

Where n= the sample size, N= Population size, e = level of precision (0.05), Substituting the figures as; n = 307,301 e = 0.05 n =399.6112 n ≈ 400

Multi stage sampling technique was used in this study; this is for is convenience of finding the survey sample. The first stage involved purposive selection of six (6) wards out of the total number of twelve (12) wards in Jere. The choice for these wards is because they are easily accessible and relatively secured as the State is faced with the insurgency. The second stage involve random selection of households in the six (6) wards selected. A total of 75 households were proportionately selected from the six wards for the purpose of a more robust analysis and to broaden the perspective on the issue of charcoal consumption in Jere LGA.

In addition, both descriptive and inferential statistics were used to analyze this study. Descriptive statistics such as frequencies, mean, percentages and bar chart were used to achieve objectives one, two and four: While, Ordinary Least Square (OLS) technique was used to achieve objective three Consequently, the regression model (specifically multiple) was adopted to analyze socio-economic factors determining households charcoal consumption in the study area as used by Umar, *et al.,* (2018).
The explicit form of the model is specified below;

$EC_i = \beta_0+\beta_1HHI+\beta_2HHA+\beta_3HHS+\beta_4HEL+\beta_5SHH+\mu$……3.1

Or

$EC_i = \beta_0+\beta_1X_{1i}+\beta_2X_{2i}$ …… ……3.2

Where EC_i = Dependent Variable

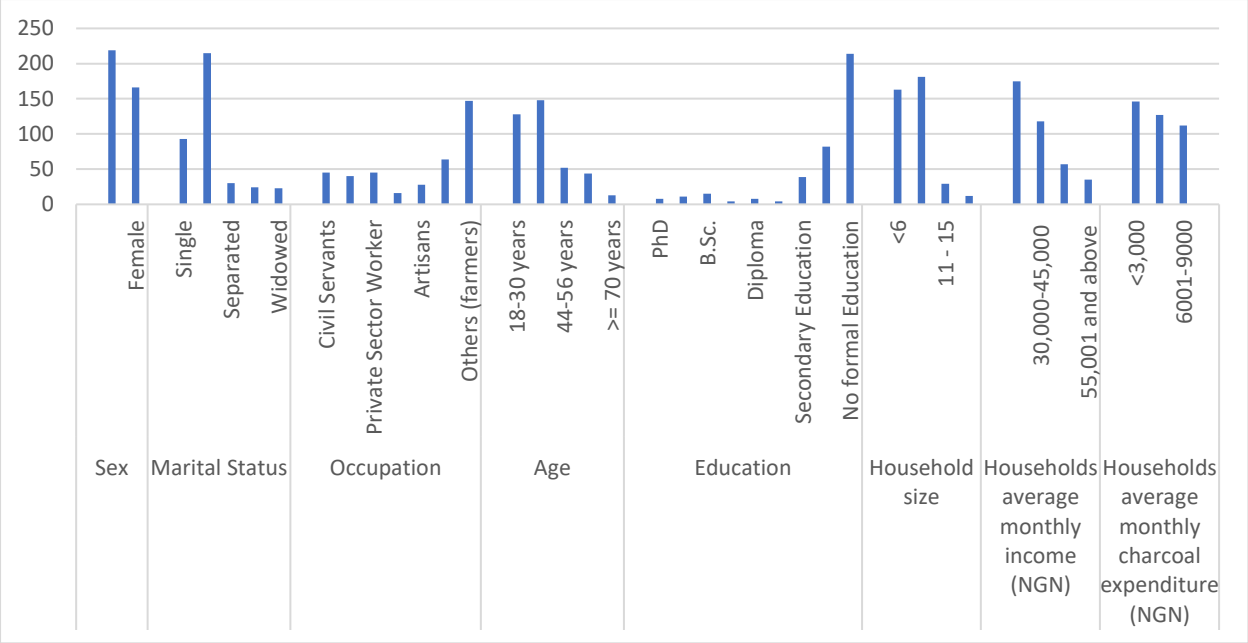
β_0 = Intercept,
X_{1i} = Independent variables, HHI = Household income measured in naira (₦), HHA = Household head age measured in years, HHS = Household size measured by the number of persons living under the same roof whom shared the same source of food and recognize themselves as a social unit., HEL = Household head educational level measured by the number of years spent in formal school , SHH = Sex of household head which is categorical and its coded as "1"for male while "0" is meant for female.
β = Slope,
i = the ith individual or unit in the population,
U = Error term,

Results and Discussion

This sub-section presents the descriptive and inferential results of the specific objectives of this study. Four hundred and fifty (450) questionnaires were administered but only three hundred and eighty-five (385) were returned, making a response rate of 86%.

Socio-economic Characteristics of the Respondents

Figure 1.1: Socio-economic Characteristics of the Respondents
Figure 1.1 below shows the socio-economic profile of the respondents ranging from sex, age, marital status, occupation, educational level, household size as well as household average income and expenditure in naira.



Source: Field Survey, (2021).

Sex: Figure 1.1 indicated a dominance of male (57%) against female (43%). This indicates that most of the household heads in the study area are males as it portrays the reality of family setting in most homes in Northern Nigeria. This is in line with the findings of Danlami and Islam (2020); Maina, *et al* (2019); Bisu, *et al* (2016) whom reported that according to norm, tradition and culture of the Northeastern region of Nigeria, the male gender is generally considered as the household head. Thus, he is saddled with the responsibilities of household financial decisions.

Age: Figure 1.1 indicated that 33% of the respondents were between the ages of 18-30 years; 38% were 31-43 years; 14% were between the ages of 44-56 years; 12% were between the ages of 57-69 years, 3% were between the ages of > =70. This implies that greater percentage of the respondents were within their economically active age group and as such support their households financially. This corresponds with the findings of Maina, *et al* (2021) in a study on the effect of fuelwood use on health of household infants in Nigeria that the mean age of households head was 43 years which shows that the respondents were in their productive age. This also falls within the productive age bracket given by the Organization for Economic Cooperation and Development (OECD) in its OECD Labor Force Statistics (2020), implying that such age bracket of the household head can influence energy decision of his or her household.

Marital Status: Figure 1.1 revealed that 24% of the respondents were single, 56% were married, 8% were separated, 6% were divorced and 6% were widowed. The predominance of married households in the study area is a possible indicator of high consumption of traditional fuels as married people are more responsible for overseeing the family affairs making them to have lower budget on traditional energy source to cater for other family responsibilities compared to the non-married individuals. This agrees with the findings of Isaac *et al* (2020) in a study on socio-economic determinants of wood fuel energy consumption in Minna that majority of the respondents were married. This also upholds the findings of Adepoju, Oyekale and Ademoralan (2012) whom opined that most of the households interviewed

during the survey on household energy demand in Odede Local Government of Ogun State were married.

Occupation: From Figure 1.1 about 12% of the respondents were civil servants, 10% were self-employed, 12% were private sector workers, 4% were retirees, 7% were artisans, and 17% were trading/hawking and others (farmers) 38%. This implies that majority of the respondents are blue collar workers. This is in agreement with the findings of Maina, *et al.,(*2019) who revealed that majority of the household heads interviewed during a survey on the impact of fuel use on the environment in Borno State are those employed in the blue collar with a fraction working in the white collar sector.

Household Head Educational Qualification: Figure 1.1 indicated that most of the respondents (56%) have not acquired formal education while 44% have acquired formal education. Among those that have acquired formal education, 2% acquired PhD, 3% have acquired M.Sc., 4% have acquired B.Sc., 1% have acquired HND, 2% have acquired Diploma, 1% have acquired NCE, 10% have acquired secondary education and 21% have primary education. Majority of the respondents have no formal education. Thus, the lower the level of households' education, the lower the income earned from non-skill jobs and the higher the possibility of consuming dirty fuels. This is in line with the results of Uma*r, et al* (2018) who revealed that there is a negative but significant relationship between education and charcoal consumption. This is because higher level of education implies higher income, highly educated people in the society are expected to earn higher level of income. Hence, they prefer the better, healthier, faster and cleaner source of fuels like gas cooker and kerosene for their cooking. More so, Maina, *et al* (2020) in a study on analysis of household energy use and carbon dioxide emission using environmental kuznets curve in Nigeria discovered that increase in the educational level of household head would make him decrease his carbon dioxide emission through the use of less polluting energy. Thus, it could be that an educated household's head is well informed on the importance of using less polluting energy sources. Also, his lifestyle such as interactions with his colleagues, TV, radio, social media platforms etc. could be the most influencing factor on his energy choices.

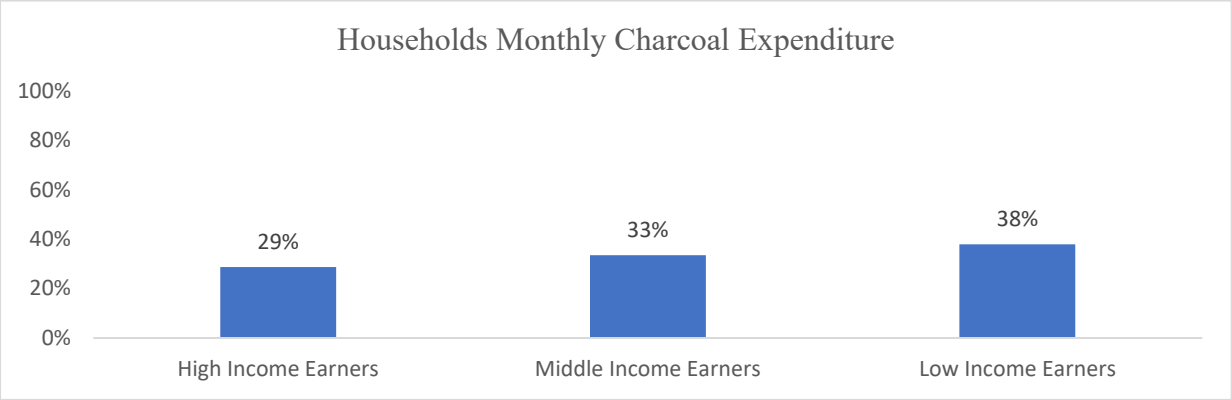
Household Size: Figure 1.1 shows that 42% of the sampled households had <6 family members, 47% of the sampled households had 6-10 family members, 8% had 11-15 family members and 3% had 16 and above family members. Most of the respondents have 6-10 household members. This corresponds with the findings of Maina, *et al* (2021) in a study on the effects of fuelwood use on health of households infants in Nigeria that majority of the households in most zones of Nigeria are polygamous; this shows the likelihood of having more infants in a household where there are more than one wives. Similarly, Bisu, *et al* (2016) in a study on urban household cooking energy choice in Bauchi Metropolis stated that many number of people in the household is a reflection of religious belief in the study area, where a man can marries more than one wife and as such have many children. Thus, the more the number of children/family members, the less the chance of using clean fuels cause its uneconomical for larger families making dirty fuels consumption such as charcoal, firewood to be high.

Household Average Monthly Income: Figure 1.1 shown that on average, most of the respondents were earning less than 30,000 monthly income, thus, the lower the level of household income, the higher the possibility of utilizing traditional energy sources and vice

versa. This agrees with the findings of Isaac *et al* (2020) in a study on socio-economic determinants of wood fuel energy consumption in Minna that majority of the households interviewed earned less below ₦30,000 which is less than the thirty-thousand-naira minimum wage in Nigeria.

Households Charcoal Energy Consumption Pattern

From figure 1.2, high income earners (29%) consumed less of charcoal because they have the means to channel their preferences to alternative cleaner fuels, while low income earners (38%) consumed more charcoal due to the fact that the lower the level of household income, the higher the possibility of utilizing traditional energy sources available. See figure 1.2



Source: Field Survey, (2021).

Figure 1.2: Households Monthly Charcoal Expenditure

Table 1.1: Factors influencing Charcoal Consumption Pattern

Variable	Frequency	Percentage
Nearness to source of charcoal		
Yes	287	75%
No	98	25%
Usage		
Cooking	344	45%
Ironing	219	29%
Room heating	99	13%
Heating local scent	105	14%
What factors influence your choice for charcoal consumption?		
Availability	239	39%
Convenience	135	22%
Cost	183	30%
Efficiency	52	9%

Source: Field Survey, (2021).

The findings from Table 1.1 revealed that majority of the respondents 75% purchased charcoal close to their houses as the commodity is readily available in the study area. Thus, this implies that households that are near to source of charcoal demand more of it. This is in line with the findings of Umar, *et al* (2018) and Babalola (2012) that proximity to charcoal

source make households to demand more of the commodity. Charcoal is a commodity that has multiple uses among the respondents as 45% of the respondents used it for cooking, 29% of the respondents used it for ironing, 13% of the respondents used charcoal for room heating and 14% of the respondents used charcoal for heating local scent. This corresponds to the findings of Maina, *et al* (2020) that charcoal has multiple uses as it is commonly use in Northeastern Nigeria in home to heat piece of local scent sticks used as room air freshener, cooking, space heating, ironing clothes etc. In the same vein, Babalola (2012) affirmed that in Benue charcoal is majorly used for cooking, ironing clothes etc.

Table 1.1 revealed that the factors that influenced respondents choice for charcoal includes; availability (39%), cost; relatively cheap, (30%); convenience; charcoal is desired for the flavor which it imparts to grilled food; (22%) and efficiency; it burns easily for a long time and can be easily extinguished and reheated, can be stored without fear of insect problems, (9%). This corresponds to the findings of Babalola (2012) that the factors influencing charcoal in Benue state includes, cheapness of the commodity, readily available, prolong heat, not turn black etc.

Socio-economic Determinants of Households Charcoal Consumption

The third research objective of this study was to assess the socio-economic factors determining households charcoal consumption and the results are presented in Table 1.2

Table 1.2 Socio-economic Determinants of Households Charcoal Consumption

Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*
Intercept	13.86006	3.120113	4.442167	0.0000**
HHA	0.284272	0.092139	3.085240	0.0021**
HEL	-0.011895	0.004628	-2.570016	0.0106**
HHI	-1.699912	0.164954	-10.30539	0.0000**
HHS	1.765866	0.043546	40.55199	0.0000**
SHH	2.305882	0.223277	10.327460	0.0000**
R^2	0.886416			

Note *Significant at 1%

Source: Field Survey, (2021).

From table 1.2, the R^2 value was 0.886, implying that about 88.6% of the variation in charcoal consumption in the study area was explained by the variables used in the model.

Household Head Age: The result reveals that the coefficient of age of household head was positive, implying that the older the household head the more the charcoal consumption. One-year increase in the age of household head would result in about 0.28 increase in household charcoal expenditure. This might be because old people prefer food cook on traditional fuels because of its special taste than younger people. This agrees with the results of Maina, *et al* (2020); Mensah (2015); Olasunkami and Ogunjobi (2015) and Rahut, *et al* (2014) that households adopt less cleaner energy sources when the head is older.

Household Head Educational Level: The coefficient of educational level of household head was found to be negative (-0.011) but significant at 1%. This implies that the more educated a

household head is the lesser the use of charcoal. One-year increase in the years of studies of the household heads would reduce charcoal consumption by 0.011. This is plausible because the higher the level of education, the higher the possibility of earning higher income and the higher the preferences of households to adopt cleaner fuels. This agrees with the studies of Umar, *et al* (2018); Danlami, *et al* (2018); Buba, *et al* (2017); Bisu, *et al* (2016); Emagbetere, *et al* (2016); Ahmed, *et al* (2016); Rahut, *et al* (2014); Eakins (2013); Laureti, *et al* (2012); all in their respective studies found that educated people prefer cleaner fuels because they earn higher income from skill jobs and they are more aware of the dangers of using traditional fuels than people whom have not received formal education.

Household Income: The coefficient of households' heads average monthly income was found to be negative (-1.699) and statistically significant because it has a p-value of less than 5 per cent. This implies that one naira increases in the household's head's monthly income would reduce charcoal expenditure by 1.699 naira. This is in conformity to energy ladder theory that households tend to use modern fuels as their income increases. More so, this is in line with the findings of Emagbetere, *et al* (2016) that there is a significant relationship between the income of households and the type of energy used for cooking as high income earners use clean fuels as LPG, electricity, while low income earners used kerosene due to its low cost and availability; however, they prefer gas and electricity. There is a positive relationship between the households' income and the adoption of cleaned energy (Ozcan, *et al* 2013 & Couture, *et al,* 2012). Similarly, Bisu, *et al* (2016) showed the relationship between cooking energy choices and the annual income of households; the use of wood dropped gradually with increase in income. Charcoal and kerosene utilization rose gradually and then about the middle-income level, begin to decline. LPG, electricity and solar energy utilization increased gradually with increase in income, though with some fluctuations.

Household Size: The coefficient of household size was positive (1.765) and significant at 1%. This implies that an addition of one member to family size will leads to about 1.765 increase in the households' charcoal expenditure in the study area. This depicted the polygamous nature of family setting in the study area. Thus, in the study area a man can marry more than one wife and as such have many children. Thus, the more the number of children/family members, the less the chance of using clean fuels cause its uneconomical for larger families, making dirty fuels consumption such as charcoal, firewood to be high. This agrees with the results of Maina, *et al* (2020), Olasunkami and Ogunjobi (2015), Buba, *et al* (2017), Danlami (2017), Bisu, *et al* (2016) Ozcan (2013) all in their respective studies that the larger the family size, the lesser the adoption of clean fuels.

Sex of Household Head: The coefficient of household head sex was positive (2.305) and significant at 1%. The male headed households are estimated to spend 2.305 naira on charcoal expenditure more than the female headed households. This is because the belief is that, men are more financially buoyant than women in the study area and are expected by the culture to take the financial responsibility of their families, while women are saddled with the responsibility of cooking. Male might not have the knowledge of the dangers of using traditional fuels such as charcoal, firewood, etc. because they are usually outdoors working so as to meet up with the family's financial needs while females do and would prefer a cleaner fuels (Maina, *et al.,* 2021).

Alternative Energy Sources Consumed by Households

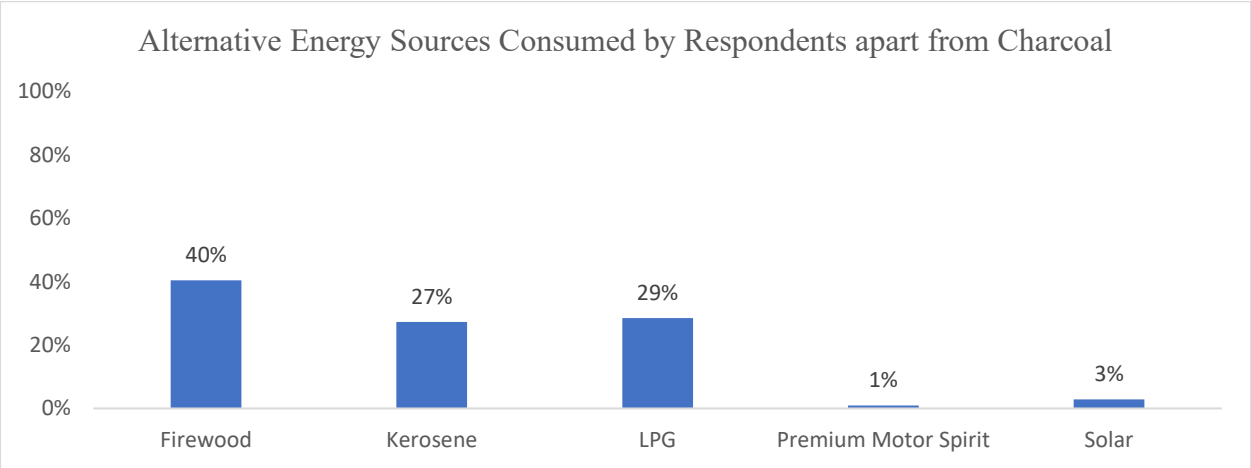
The fourth research objective of this study was to investigate alternative energy sources consumed by households and the result is presented in Table 1.3

Table 1.3 Usage Pattern of Fuel

User Categories	Frequency	Percentage
Single Fuel Users		
Fuel wood	51	13
Kerosene	13	3
LPG		7
Premium Motor Spirit	4	1
Total		**24**
Multiple Fuel Users (2 fuels)		
Firewood and Premium Motor Spirit	53	14
Firewood and Kerosene	86	23
Firewood and LPG	16	4
Firewood and Solar	4	1
LPG and PMS	51	13
Kerosene and LPG	20	5
Total		**60**
Multiple Fuel Users (3 fuels)		
Firewood, Kerosene and LPG	17	4
Firewood, Solar and LPG	19	5
Firewood, LPG and PMS	25	7
Total		**16**

Source: Field Survey, (2021).

The result from Table 1.3 revealed that there is evidence of fuel stacking as majority (60% and 16% totalling 76%) use multiple fuel sources (2 and 3 fuels respectively). The proof of fuel stacking within the study area as a position debunks the energy ladder model in that economic growth alone cannot be considered as the only driver for household energy use behavior. The bar chart below portrayed that majority of the sampled respondents (40%) used firewood as alternative energy source, while premium motor spirit energy sources accounts for least percentage (1%). This is since most of the sampled respondents prefer to use firewood due to its **availability** and relative **cheapness** compare to other modern forms of energy, which are usually expensive and relatively scarce.



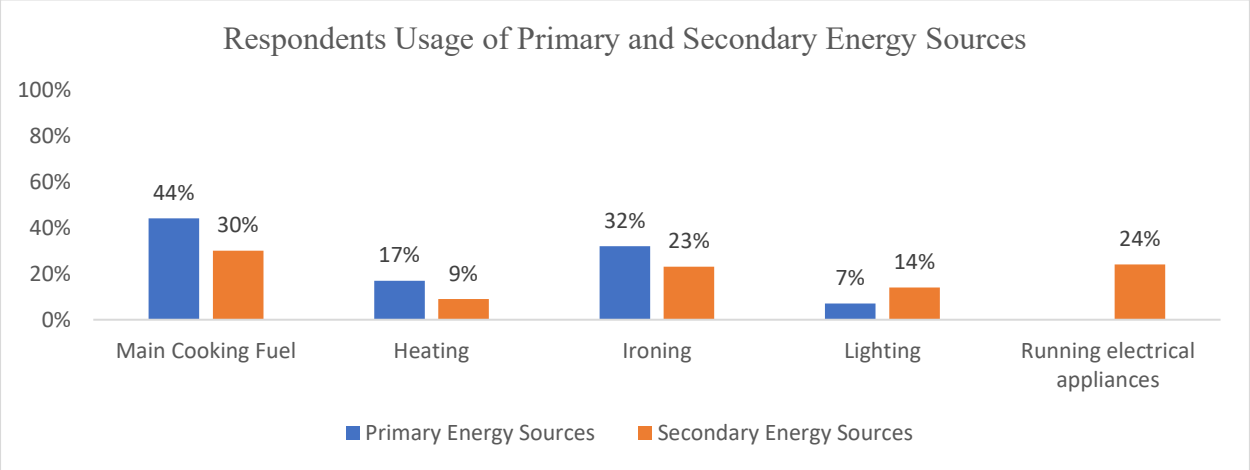
Source: Field Survey, (2021).

Figure 1.3 Alternative Energy Sources Consumed by Respondents

Respondents Usage of Primary and Secondary Energy Sources

Primary energy sources in this study referred to energy sources from agricultural waste, firewood, charcoal, while secondary energy sources referred to energy sources from kerosene, LPG, electricity, generators, solar, etc. Figure 1.3 revealed respondents primary and secondary energy usage.

Based on the responses from the selected samples, majority of the respondents, 44% used primary energy sources as their main cooking fuels; 17% respondents used it for heating, 32% respondents used it for ironing and 7% respondents used it for lighting. More so, 30% of the respondents used secondary energy sources as their main cooking fuels, 9% respondents used it for heating, 23% respondents used it for ironing, 14% respondents used it for lighting as well as 24% respondents used it for running electrical appliances.

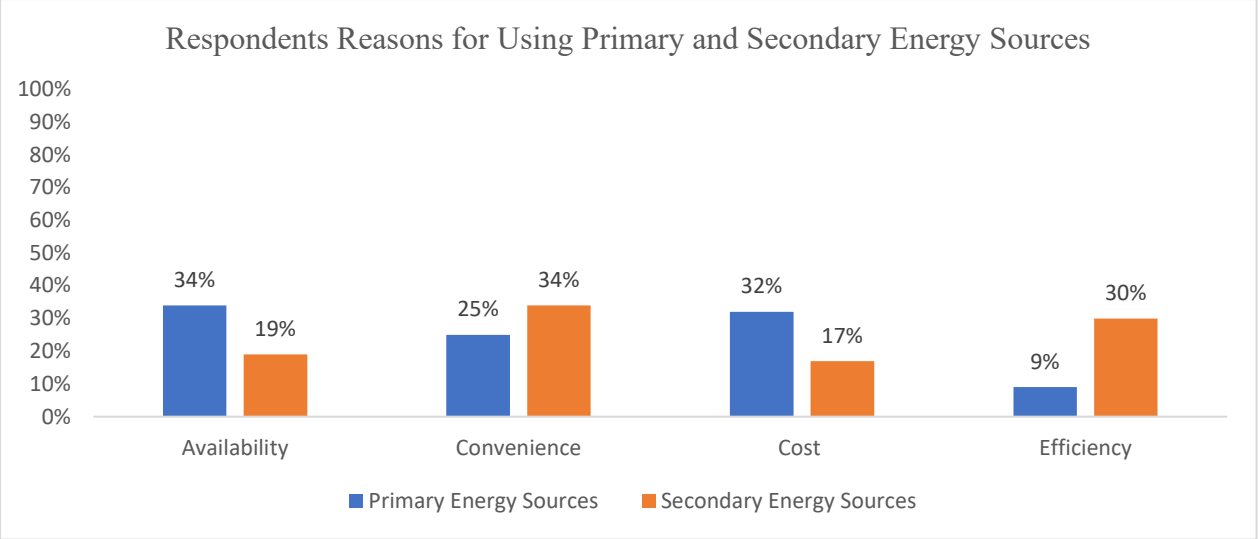


Source: Field Survey, (2021).

Figure 1.3: Respondents Usage of Primary and Secondary Energy Sources

Respondents Reasons for using Primary and Secondary Energy Sources

From figure 1.4, primary energy source is the energy source that is the most preferred by households because of its availability with 34%, cost 32%, convenience 25% and efficiency 9%. This is because firewood, which is the most preferred alternative energy source by the sampled respondents is readily available and cheap making respondents to utilize it more than the other energy sources. Furthermore, from figure 4.4, secondary energy sources are also preferred by some of the sampled respondents because of convenience with 34% respondents, efficiency 30% respondents, availability 19% respondents while cost has the least percentage 17% respondents. This is because secondary energy sources are usually expensive and relatively scarce compared to their primary energy counterparts.



Source: Field Survey (2021).
Figure 1.4: Respondents Reasons for using Primary and Secondary Energy Sources

Conclusion and Recommendations

The study concluded that majority of the households' heads who are in their active age, mostly on a blue-collar job earning less income rely heavily on charcoal consumption. Having a rise in income results in a decrease in charcoal consumption. Furthermore, most households are multiple fuel users, affirming that energy ladder model does not hold for the households in Jere LGA. Hence, usage is largely determined by age, income, family size, educational level and the male head of a household.

Recommendations

Based on the findings of the study, the following recommendations were made:

i. Most of the respondents are blue collar workers. This makes the consumption of charcoal higher among the low-income households. Hence, there is the need for the government to create awareness as well as capacity development among the households on how to produce and use briquettes since the raw materials used for such are the available household waste that attract nothing less cost, thereby improving the environment and saving cost on the part of the households.
ii. Income and price have influence over charcoal consumption as a rise in both is associated with decrease in charcoal consumption and a switch to other clean alternative sources. Hence, there is the need for government to improve the economic status of the people by creating more job opportunities.
iii. Most respondents prefer the use of firewood and other energy sources as their alternative sources. This could be because clean energy sources such as LPG is expensive and electricity supply has been out for almost a year now. The government needs to continue her effort and restore electricity supply in the study area so as to encourage its usage in cooking, water heating and ironing.

References

Abd'Razaq, N. T. A., Medayese, S. O., Matins, V. J., Idowu, O. O., Adelaye, B. M., & Bello,L. O. (2012). An appraisal of household domestic energy consumption in Minna, Nigeria. *Journal of Environment Sciences, Toxicology and Food Technology*, 2(3):16-24.

Amghizar, I., Vandewalle, L. A., Van Geem, K.M., & Marin, G.B. (2017). New trends in olefin production. *Engineering*, 3(2): 171-178

Babalola, F. D., & Opii, E. E. (2012). Factors influencing consumption of charcoal as household energy in Benue State, Nigeria. *International Journal of Organic Agriculture Research and Development*, 6: 68-81.

Bisu, D. Y., Kuhe, A., & Iortyer, H. A. (2016). Urban household cooking energy choice: an example of Bauchi metropolis, Nigeria. Energy, *Sustainability and Society*, 6(1): 1-12.

Buba, A., Abdu, M., Adamu, I., & Usman, Y. I. (2017). Socio-economic determinants of households fuel consumption in Nigeria. *International Journal of Research Granthaalayah*, 5(10): 348-360.

Chiumenti, A., da Borso, F., & Limina, S. (2018). Dry anaerobic digestion of cow manure and agricultural products in a full-scale plant: Efficiency and comparison with wet fermentation. *Waste Management, 71*: 704-710.

Chambwera, M., (2004) Economic analysis of urban fuel wood demand: the case of Harare in Zimbabwe. *Ph.D. Thesis,* Wageningen University, The Netherlands.

Couture, S., Garcia, S., & Reynaud, A. (2012). Household energy choices and fuelwood consumption: An econometric approach using French data. *Energy Economics*, 34(6): 1972-1981.

Danlami, A. H., & Islam, R. U. (2020). Explorative Analysis of Household Energy Consumption in Bauchi State, Nigeria. *Energy Efficiency and Sustainable Lighting*, 79.

Danlami, A. H. (2017). Determinants of household electricity consumption in Bauchi State, Nigeria. *Hyperion Economic Journal*, 5(1): 16-28.

Danlami, A. H., Applanaidu, S. D., & Islam, R. (2018). An analysis of household cooking fuel choice: A case of Bauchi State, Nigeria. *International Journal of Energy Sector Management.*

Eakins, J. (2013). An analysis of the determinants of household energy expenditures: empirical evidence from the Irish household budget survey (*Doctoral dissertation*, University of Surrey).

Emagbetere, E., Odia, J., & Oreko, B. U. (2016). Assessment of household energy utilized for cooking in Ikeja, Lagos State, Nigeria. *Nigerian Journal of Technology*, 35(4), 796-804.

FAO (2015) Global Forest resource assessment: How are the world forest resources changing? Second edition. Pp 97-102

Hu, Z., & Peng, X. (2015). Household changes in contemporary China: an analysis based on the four recent censuses. *The Journal of Chinese Sociology, 2*(1): 1-20.

Kadiri, E. K., & Alabi, O. A. (2014). Household energy consumption pattern in Offa City, Kwara State Nigeria. *Journal of Scientific Research and Reports*: 499-1506.

Kayode, R., Farshchi, M. A., & Ford, A. (2015). Analysis of household energy consumption in Nigeria. Going north for sustainability: Leveraging knowledge and innovation for sustainable construction and development: 23-25.

Lam, N. L., Smith, K. R., Gauthier, A., & Bates, M. N. (2012). Kerosene: a review of household uses and their hazards in low-and middle-income countries. *Journal of Toxicology and Environmental Health*, Part B, 15(6): 396-432.

Laureti, T., & Secondi, L. (2012). Determinants of Households'space Heating Type And Expenditures In Italy.

Madukwe, C. E. (2014). Domestic Energy Usage Pattern of Households in Selected Urban and Rural Communities of Enugu State. *An unpublished M. Sc. dissertation* in the Institute of Development Studies at the University of Nigeria, Nsukka.

Mafimisebi, T. E., Bobola, O. M., & Mafimisebi, O. E. (2013). Fundamentals of cattle marketing in Southwest, Nigeria: analyzing market intermediaries, price formation and yield performance (No. 309-2016-5133).

Maina, Y. B., Murtala, M. K., & Kyari, B (2017). An Empirical Analysis of Household Energy Demand in the North East Region of Nigeria. *The International Journal Research Publication's*, *Research Journal of Economics and Business Studies* 6(11): 10-16.

Maina, Y., Kyari B., & Jimme M.A. (2019). Households' Clean Energy Demand in Nigeria and Its Implication on the Environment. *Journal of Agricultural Economics, Environmental and Social Sciences*, 5(1 and 2): 35-55

Maina, Y., Yakubu, A., & Kyari, B. (2019).The Impact of Fuel use on the Environment: A Case Study of the Households in Borno State.

Maina Y. B., Egbedimame A. B. & Kyari B. G., (2020). Analysis of Household Energy Use and CO_2 Emission using Environmental Kuznets Curve. *Nigerian Journal of Environmental Sciences and Technology*, 4(2): 341 350. https://doi.org/10.36263/nijest.2020.02.0223

Maina, Y. B., Kyari, B., & Jimme, M. A. (2020). Impact of household fuel expenditure on the environment: the quest for sustainable energy in Nigeria. *Central Asian Journal of Environmental Science and Technology Innovation*, 1(2): 109-118.

Maina, Y. B., Kyari, B., & Jimme, M. A. (2021). Effects of Fuelwood use on health: The Case Study of household infants in Nigeria. *FUW Trends in Science & Technology Journal,* www.ftstjournal.com 6(1): 301-304.

Malla, S., & Timilsina, G. R. (2014). Household cooking fuel choice and adoption of improved cookstoves in developing countries: a review.

Mensah, J. T., & Adu, G. (2015). An empirical analysis of household energy choice in Ghana. *Renewable and Sustainable Energy Reviews*, 51: 1402-1411.

Mohammed, H., Dayyabu, H. A., & Muhammed, U. (2018). Assessment of Consumption

Rate of Solid Biomass Fuels and the Consequent Environmental Impact in Maiduguri Metropolis. *Open Journal of Air Pollution*, 7(01): 34.

Muazu, N. B., & Ogujiuba, K. O. (2020). Analysis of dynamics of domestic fuelwood energy consumption in Nigeria: Is fuel stacking theory apt? *ATBU Journal of Science, Technology and Education, 7*(4): 255-267.

National Population Commission (2006). Population May First.Org. (2006). Nigerian Census Figure 2006, Nigeria. Retrieved from http://www.citypopulation.de/php/nigeriaadmin.php.

NBS (2010) General Household SurveyPanel Wave 2. (2009/2010). Retrieved from www.nigeriastat.gov.ng>STATAuploads.

Ogwumike, F. O., Ozughalu, U. M., & Abiona, G. A. (2014). Household energy use and determinants: Evidence from Nigeria. *International Journal of Energy Economics and Policy*, 4(2): 248.

Ojo, C. O., & Chuffor, L. (2013). Accessibility to domestic energy among rural households: a case study of Damboa Local Government Area of Borno State, Nigeria. *Greener Journal of Social Sciences*, 3: 166-170.

Olasunkami, M. & Ogunjobi, J.O., (2015) Determinant of household energy consumption in Ogun State, Nigeria. *International journal of Social Science and Management*, 4(12): 35-41

Pillarisetti, A., Mehta, S., & Smith, K. R. (2016). HAPIT, the household air pollution intervention tool, to evaluate the health benefits and cost-effectiveness of clean cooking interventions *Broken pumps and promises* (pp. 147-169): Springer.

Rahut, D. B., Das, S., Groote, H. D. & Behera, B. (2016). Determinants of household energy use in Bhuyyan. *Energy*, 60: 661-672.

Rakodi, C. (2014). A livelihoods approach–conceptual issues and definitions *Urban livelihoods* (pp. 26-45): Routledge.

Reddy, A. K., Annecke, W., Blok, K., Bloom, D., Boardman, B., Eberhard, A., & Ramakrishna, J. (2000). Energy and Social Issues. *World Energy Assessment*: 39-60.

Rohra, H., & Taneja, A. (2016). Indoor air quality scenario in India—an outline of household fuel combustion. *Atmospheric Environment, 129*: 243-255.

Sa'ad, S., & Bugaje, I. M. (2016). Biomass consumption in Nigeria: Trends and policy issues. *Journal of Agriculture and Sustainability*, 9(2).

Sakanko, M. A., & Obilikwu, J. (2018). An Empirical Analysis of the Determinants of Charcoal demand in Niger State, Nigeria.

Toole, R. (2015). The Energy Ladder: A Valid Model for Household Fuel Transitions in Sub-Saharan Africa.(August): 1–104.

Umar, A.S. S, Baba, A.S,Ibrahim, A. & Unegbu, A.Y.(2018). Determinants of Charcoal Consumption among households in Maiduguri Metropolitan Area of Borno State, Nigeria. *Journal for Science Environment*, 3(1): 10-13.

Wakili, A., Abdullahi, M. B., Gani, A. M., & Bello, A. A. (2012). Combustion rate of ten wood fuel tree species in Bauchi State. *IJABR*, 4(1&2): 171-177.

Yamane, T., 1967. Statistics, An Introductory Analysis, 2nd Ed., New York: Harper and Row.