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ORIGINAL RESEARCH ARTICLE

Analysis of Household Fuelwood Consumption as Domestic Cooking Energy Source and the Implications on the Environment: A Case of Vandeikya Local Government Area of Benue State, Nigeria

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ABSTRACT

This study analysed households fuelwood consumption as domestic cooking energy source and the implications on the environment in Vandeikya Local Government Area of Benue State, Nigeria. A total of two hundred and forty (240) respondents were selected using multistage sampling procedure to elicit information for the study. Primary data for the study was garnered with the use of structured questionnaires and interview schedule and was analysed using descriptive and inferential statistics. Findings from the study revealed that the majority (81%) of the household heads were males with a mean age of 40 years. 83% of the respondents were married and had at least one form of education with secondary education having the highest share of 49%. The average household size of the respondents was 7 persons with majority (52%) of them taken to farming as their main occupation The mean monthly income of the respondents was *N43,150*. Majority (79%) of the respondents use firewood as their main fuel source for cooking which they obtained mostly at no cost from the forests (44%) and their farmlands (37%). The average cost price of a bundle of firewood stood at N200 in the study area while that of kerosene is N750/litre in the study area. Charcoal is sold at N2500/50kg bag (N50/kg), electricity, N61.5/kwh and gas, N780/kg. The average consumption level of fuelwood by respondents was estimated at 3 bundles daily. The result reveals that lack of cheaper energy alternatives (88%), large family sizes (84%), easy availability (77%) were the main reasons given by the respondents for fuelwood consumption over other sources. The perceived environmental effects of fuelwood utilization were; deforestation (75%), global warming (57%), Indoor and outdoor pollution (53%), violent windstorm (46%) among others. Marital status, educational status, household size, monthly income and cost of Gas significantly influenced the consumption of fuelwood by households. The study recommends use of alternative and clean energy sources should be encouraged and the corresponding alternative energy technologies made available and affordable to residents to reduce overreliance of households on the use of traditional energy carriers such as firewood and charcoal thereby reducing their negative impact on health and environmental degradation. Tree planting campaign should be embarked upon by both residents and relevant authorities to replenish the depleted forest resources and for its sustainability.

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INTRODUCTION

Fuelwood constitutes a very important source of energy for both the rural and urban dwellers in developing countries. Due to the fact that it accounts for most of domestic energy consumption, and it is produced within the systems itself, it occupies a unique position in rural energy systems (Isma'il *et al.,* 2014). Any type of energy source derived from woody biomass is referred to as fuel wood. This includes a variety of fuels like biogas, cellulosic ethanol, industrial fuelwood, wood pellets, fuel wood, charcoal, and other sophisticated bioenergy

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sources (UCS, 2011). Over half of the world's population still uses fuel wood, which is energy produced by burning wood biomass such as logs and twigs, as their main fuel source (Sogbon *et al.,* 2017). It is any tree or wood material which is combustible and can be used as fuel. It is often interchangeably used as firewood. In developing countries, fuelwood or firewood comes from dead woody material and small trees (Ewah, 2014). According to the International Energy Agency (IEA, 2010), worldwide, 1.4 billion people have limited access to electricity and 2.7 billion people rely on biomass fuel, mostly in rural areas. Tropical Africa depends on fuelwood for about 90% of its energy supply because it is still far cheaper than most alternative available forms of fuel (Uhunamure *et al.*, 2017). According to World Bank (2003) assessment, 73% of households in both rural and urban regions in sub-Saharan Africa, particularly Nigeria, rely on fuelwood as their primary source of energy for cooking. Concern has been expressed about the percentage of people in developing nations that rely on biomass to meet their energy demands for cooking, such as fuel wood, charcoal, agricultural waste, and animal dung (OECD/IEA, 2002). In Nigeria, fuelwood is largely obtained from the natural communal forest, forest reserves or some private forests free or at the payment of small fees to the landowners. Ebe (2014) reported that fuelwood accounts for about 95% of total wood consumed in Nigeria.

The role fuel wood energy plays in Nigeria can only be replaced by expensive electric power and other energy sources which most users of fuel wood cannot afford. In rural areas, it serves as the main source of energy for home purposes as well as for small-scale traditional industries and commercial organizations. Low-income households in metropolitan areas utilize it as their primary source of energy for heating and cooking. The middle-class owners utilize it as an alternative to or extra fuel for residential heating and cooking. The scarcity of conventional energy sources in Nigeria and the hike in the prices of these fuels had also prompted the continued dependence on fuel wood by many households in relation to other commercial fuels even among urban households (Ebe, 2014). To meet their residential energy needs, households prefer to spend their limited financial resources on fuelwood rather than electricity. This preference is related to a number of socioeconomic variables, including the exorbitant costs of monthly power rates in comparison to household incomes and the high expenses of purchasing electrical goods that must be maintained effectively (Uhunamure *et al.,* 2017). One main barrier keeping these homes from using electricity entirely is the cost of electricity in comparison to the household income. According to International Fund for Agricultural Development (IFAD, 2016) and Aide (2012), the share of various energy sources in the total primary energy supply in Nigeria is made up of oil, 10.4%; gas, 6%; hydro, 0.6%; and commercial renewable energy, 83%. The over-dependence on fuel-wood for energy is chiefly because of its relatively low prices and easy accessibility (Adedayo *et al.,* 2008). Other factors include shortages of conventional fuels and an expanding population, a major portion of whom still does not have earnings sufficient to cover the price of traditional fuels (Aide, 2012). The majority of people who live in rural areas depend on fuelwood in one form or another for their daily survival. There are many different ways and levels at which it is consumed. However, due to the vast amount of wood needed, supplying rural home fuelwood energy needs throughout the country has turned into a herculean effort. In Nigeria, the daily consumption of firewood by rural people is estimated to be 27.5 million kilograms (Aide, 2012).

Concern has been expressed about the percentage of people in developing nations that rely on biomass to meet their energy demands for cooking, such as fuel wood, charcoal, agricultural waste, and animal dung (International Energy Agency (IEA), 2002). In Nigeria, the daily consumption of firewood by rural people is estimated to be 27.5 million kilograms (Aide, 2012). Concerns about the consequences of climate change and global warming are sparked by this. Most lands have been stripped naked of vegetative cover in the effort to meet fuelwood requirements. The scramble for fuelwood has resulted in massive destruction of many wood resources leading to deforestation and increasing desertification in sub-Saharan Africa and many parts of Nigeria (Adedayo, *et. al.*, 2005). Popoola (2000) observed that the country's forest reserve which was estimated to be at 10% of the total land area in 1970 has been reduced to just 5% in 1999, which is alarming. According to Bailis *et al.*, (2015) and Sassen *et al.*, (2015), the heavy dependence of local communities in Africa on fuelwood as a source of household energy has led to altering of the structure of the forest. Fuelwood usage by the urban and rural household has adverse effect on the environment and human health in the long run. Problems such as environmental degradation, deforestation, erosion and subsequent influence on the ozone layer that alters the climatic condition are associated with the demand for fuelwood. In many developing nations, the use of biomass as fuel has been identified as one of the major factors contributing to the decrease of forests (Bhatt and Sachan, 2004). According to the World Health Organization (WHO), indoor air pollution caused by the use of solid fuels directly contributes to 1.6 million premature deaths per year (Bagnara *et al.*, 2018). Environmental damage from fuelwood harvesting can be significant if too many people depend on too few forested areas (Ullah & Masakazu, 2017). The consumption of fuelwood generates carbon dioxide into the atmosphere that brings about climate change, climate change in turns destroy plants and threatens human wellbeing (Muller & Yan, 2018). According to assessments of the World's forest resources, natural forest areas are diminishing, especially in Africa (Sloan and Sayer, 2015). Forest degradation is a significant issue

in the post-industrial world because of climate change. Due to the low human population in the past, the exploitation of the fuel wood source had little effect on the ecosystem. But as the human population grew, man's reliance on wood as a source of fuel and energy began to show signs of weakness. The disturbing impact of deforestation on the ecosystem as a result of human endeavors to have a constant supply of fuel wood for both home and small-scale industrial usage is obvious at this level (Umar *et al.*, 2016). The rate of forest destruction is now so rapid that we risk a total breakdown of the planet's support systems in the next 30 to 50 years. Nearly all of the tropical rainforests were still thriving and intact a little over 50 years ago. At the turn of this century, we have destroyed half of those forests and the pace of destruction is accelerating (Vihi *et al.*, 2020).

The increasing current demand for fuelwood without concomitant replenishment is an indication that the forest area will disappear fast, which makes the environment situation more precarious if no measures are put in place to check these threats (Sogbon *et al.*, 2017). Trees being cut down for fuelwood without being replaced has become a serious issue that contributes to serious deforestation. After a few years, the environment could not be able to support life, especially in the savanna biological zone, which is more vulnerable than the rainforest. Nigeria, whose forest lands have been disappearing at an alarming rate over the past few decades, is one of the nations' most vulnerable to climate change. According to reports, farm trees, whose density is declining, are the main source of firewood in the northern Nigerian state of Katsina (Aide, 2012). According to the same report, only 2% of land area in Benue State is covered by forest reserves. This falls far short of the 20% standard of the total land area set by the federal government for each state as minimum target for self-sufficiency in forest goods and services. The predicted wood deficit in Benue state is estimated at roughly three million cubic meters by the year 2010, notwithstanding the state's minimal (2%) percentage of conserved forests. Consequently, in order to maintain environmental quality and energy supply, all parties involved in fuelwood exploitation will need to identify substitute fuel sources (Dogo *et al,* 2019). Affordable, clean, eco-friendly, and effective energy is necessary for every nation that aspires to reduce poverty and promote long-term growth and development. This is due to the fact that having access to efficient energy sources lowers pollution caused by energy use, results in fewer infections, and reduces child mortality (Alem *et al.*, 2016; Adeyemi & Adereleye, 2016). Although the exploitation of fuel wood is unavoidable since it provides domestic fuel for both rural and urban homes, the principle of forest sustainability must be kept if our current population is to be supported by the vegetation we already have (Ikurekong *et al.*, 2009). However, small-scale disturbance, such as fuelwood harvesting is comparatively ignored and there is a lack of knowledge regarding its impact on environment and forest structure (Ullah and Masakazu, 2017).

In Vandeikya Local Government Area of Benue State, fuel wood accounts for major part of the energy sources for domestic needs. More people depend on the use of fuel wood as source of energy and more trees are felled for such usage. The rate of fuel wood exploitation is enormous as the area is almost stripped bare of its vegetation coverage. Fuel wood is still being harvested indiscriminately, and those who do so don't appear to care about how their actions affect the ecosystem. Fuel wood exploitation has gone beyond mere gathering of dead wood to a deliberate and wanton cutting of trees with power saws at a large scale on daily basis. Due to poverty, lack of awareness and no alternatives for fuel, people solely depend on trees and forests for fuelwood. The use of traditional energy sources by the poor who lack access to modern energy sources such as liquefied petroleum gas and electricity, has the unintended consequence of accelerating environmental deterioration processes like desertification and soil erosion. A holistic understanding of the economic problems that perpetuate consumption of fuelwood is necessary in addressing efficient energy use and abatement of deforestation. This is because despite the numerous problems associated with fuelwood consumption, many households in developing countries still rely on fuelwood as a source of cooking energy. This lack of consensus over household fuelwood preferences has been linked to a number of issues by various authors. For instance, Abebaw (2007) noted that even in places like Wolong, China, where there is access to electricity, households still rely on fuelwood. Meanwhile, several researches claimed that households would switch to modern fuels whenever the level of income increases. In Nigeria, fuelwood is commonly utilized among rural and urban households, however, the forces that influence the pattern and magnitude of fuelwood usage are not fully known. Researches that focus specifically on the socio-economic driving forces influencing fuelwood consumption are scarce in Nigeria especially in the study area.

To this end, this study set to analyze households' fuelwood consumption as domestic as domestic cooking energy source and its implications on the environment in Vandeikya Local Government Area of Benue State, Nigeria. Specifically, the study seeks to described the socio-economic characteristics of household heads in the study area, estimate the quantity of fuelwood consumed by households in the study area, identify the reasons for fuelwood preference over other energy sources in the study area, examine the perceived effects of fuelwood consumption on the environment in the study area and determine the factors influencing fuelwood consumption as domestic energy source by households in the study area.

MATERIALS AND METHODS

Vandeikya LGA was created out of Gboko Local Government Council in 1976. It is located between longitude 8°30' to 9° 00' East and latitude 6°30' - 7°00' North of Greenwich.

The Local Government has a population of 234,567 based on the 2006 census (NPC, 2006). The projected population by 2021 stands at 338,700 people going by a population growth rate of 2.25% per annum. It has a landmass of 183,939 square metres. The local government is made up of twelve administrative wards namely Mbaityough, Mbakaange, Mbayongo, Ningev, Nyumangbagh and Township (making up Tiev constituency). Other wards include: Mbadede, Mbagbam, Mbagbera, Mbajor, Mbakyaha, and Tsambe (making up Kyan constituency). The Local Government has two distinct seasons, the dry and wet season. The dry season is witnessed between the months of November and March while the wet season is witnessed between April and October. The vegetation of the area is that of Guinea Savanna, vegetation is made of varieties of trees species together with giant grasses. The climate is the tropical humid type with very high temperatures between March and April. The cool, dry harmattan weather is witnessed between December and February. The terrain is undulating, low-lying and is drained mainly by Rivers Aya, Sambe , Be, and Uaghshu. Vandeikya is in the South-Eastern part of Benue State and shares boundaries with Obudu and Bekwara in Cross River State to the East, Ushongo to the North and Konshisha LGA to the West. The Vandeikya people are hospitable and are predominantly Christians with a few traditionalists. Vandeikya Local Government area is dominated by undulating terrain with much of the area being below 183 m (600 ft) above the sea level. The mainstay of the population is agriculture, which includes arable land for the rearing of sheep, goats, and cattle. Almost all important food crops are directly farmed by over 80% of the population, with a focus on yams, rice, sweet potatoes, cassava, sorghum, citrus, spices, pepper, groundnuts, and bambara nuts (Vandeikya Local Government Information Office, 2018).

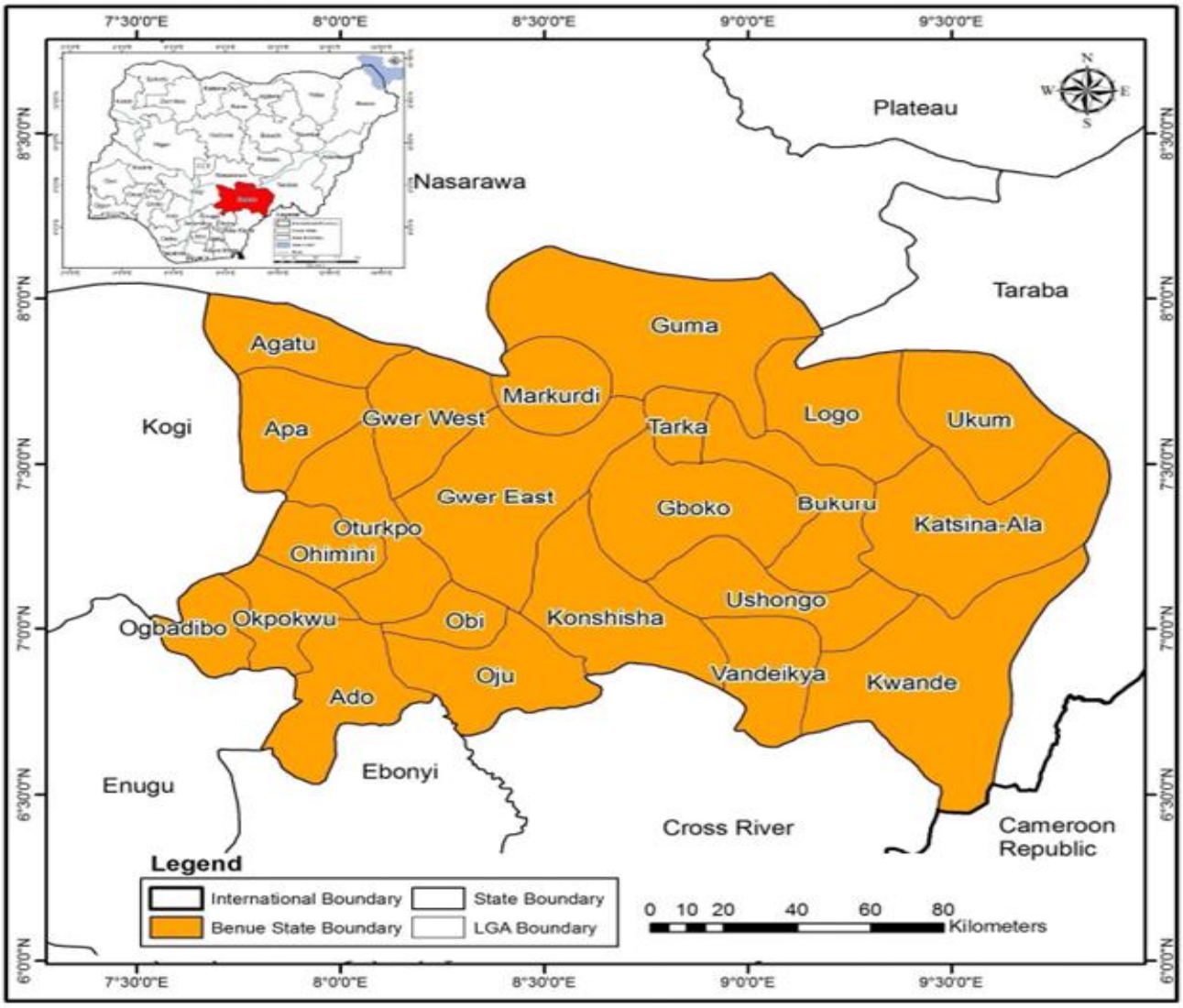

Figure 1: Map of Benue States showing all the twenty three (23) Local Government areas including Vandeikya LGA.

Sources of Data
The data for this was obtained from primary source. Interviews with household members and a standardized questionnaire were used to collect the main data. Due to the fact that they are in charge of making decisions regarding cooking energy, questionnaires were given to either household heads or their spouses. The questionnaire was given to a female household member who was up to 15 years old and typically participated in decisions regarding cooking energy if these two participants weren't accessible. The method of administering the questionnaire in person was used.

Sampling Technique
The study's respondents were chosen using a multi-stage sampling process. The first stage involved the stratification of Vandeikya Local Government Area in two development areas or constituencies namely; the Tiev and the Kyan constituencies each. The Tiev constituency is made up of six districts namely; Mbaityough, Mbakaange, Mbayongo, Ningev, Nyumangbagh and Township districts while the Kyan constituency comprises of Mbadede, Mbagbam, Mbagbera, Mbajor, Mbakyaha, and Tsambe districts. The second stage involved a purposive selection of three districts from each of the two constituencies for the study. This selection was purposively done to ensure that households from the rural, semi-urban and urban communities are all represented in the sampling. Thus Township, Ningev and Mbaityough in Tiev constituency were selected while Mbadede, Mbajor and Tsambe were selected in Kyan constituency. In the third stage, two communities were randomly selected from each district making up twelve (12) communities for the study. Finally, a systematic random technique was used to select twenty (20) households from each selected community bringing the total sample size to two hundred and forty (240) respondents. Questionnaires were administered systematically to every fifth household in the twelve (12) communities for the study. This procedure was maintained until the sample size for the community was obtained. The main targets were the household heads.

Method of Data Analysis
Data collected were analyzed using descriptive statistics (frequency counts, percentages, mean) and multiple regression analysis.

Multiple regression
Multiple regression analysis using SPSS Statistics was employed to determine the variables affecting the consumption of fuelwood in the research area. The explicit form of the model is presented as: $Y = \alpha 0 + \beta_1X_1 + \beta_2X_2 + \ldots\ldots + \beta_9X_9 + ei$

Where;

Y = Quantity of fuelwood consumed per month (Number of bundles)

X_1 = Age (years)
X_2 = Gender (male =1 and female = 2)
X_3 = Marital status (Dummy, where 1=married and 0 = otherwise)
X_4 = Education level (measured by years of formal schooling)
X_5 = Household size (measured by number of people in a household)
X_6 = Main occupation (Dummy, where 1= farming and 0 = otherwise)
X_7 = Monthly income (₦)
X_8 = Cost of fuelwood (₦ /Kg)
X_9 = Cost of liquefied gas
$\alpha 0$, β_1 - β_8 were parameters estimated
e_i = Error term

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Respondents
Result on the socio-economic characteristics of the respondents' is presented in Table 1. The age distribution of the respondents shows that, 42% of the respondents were within the ages of 31-40 years, 34% fell between age ranges of 41-50, 13% of the respondents were between the ages of 21-30 while 11% fell within the ages of 51-60. The responders were 40 years old on average. This finding reveals that age has a significant role in household energy preference because adults are more prone to experience energy problems than persons who are dependent on others. This agrees with the opinion of Buba *et al.* (2017) who in their study on socio - economic determinants of households fuel consumption in Nigeria stated that there is a particular age bracket that when reached household heads are more conscious about the disastrous effects associated with incessant consumption of fuel wood. Hence, he/she will use his/her life time savings (or retirement benefits) for consumption of the modern energy sources.

The result in Table 1 further shows that majority (81%) of the household heads were males while the females constituted 19% of the household heads. This male dominance is in line with the religious and cultural ethics in the study area where males function as household's head except in some cases where females function as household's head either as widows or divorcees. Fuel selection can be substantially influenced by gender. The male household leader may downplay the importance of the costs and benefits of using clean cooking fuels in a home where he is the only provider and the main decision-maker (Schlag & Zuzarte, 2008). According to the World Health Organization (WHO, 2016), men control the household budget in many nations and have more influence over energy choices. This means that even if women needed to switch to cleaner fuels, they would likely be unable to do so because of men's concerns about costs. However, Puzzolo *et al.* (2014) suggested that women who earn a salary will, in general, utilize clean fuels.

The marital status of respondents shows that 83% 0f the respondents were married while 17 % of the respondents were single. This result agrees with findings of Tsue *et al.* (2016) who stated that the demand for cooking energy among married people is higher as a result of their large household sizes.

Table 1. Distribution of Respondents According to socio-economic characteristics (n=240)

Variable	Frequency	Percentage	Mean
Age			
20-30	31	13.0	
31-40	102	42.0	
41-50	81	34.0	
>60	26	11.0	40
Gender			
Male	194	81.0	
Female	46	19.0	
Marital status			
Married	200	83.0	
Single	40	17.0	
Household size			
1-5	58	32.0	
6-10	168	62.0	
>10	14	6.0	7
Educational level			
Non formal			
Primary	43	18.0	
Secondary	118	49.0	
Tertiary	67	28.0	
Major occupation			
Farming	124	52.0	
Civil servant	86	36.0	
Business	30	12.0	
Monthly income			
10,000-20,000	8	3.0	
21,000-30,000	24	10.0	
31,000-40,000	72	30.0	
41,000-50,000	74	31.0	
51,000-60,000	36	15.0	
>60,000	26	11.0	**43,150**

Source: Field survey, 2022

Educational level of respondents revealed that 49% of the sampled household heads had secondary education, 28% had tertiary education, 18% had primary education and 5% had non- formal education. This result shows that majority of the respondents had at least one form of education with secondary education having the highest share. The relationship between education level and energy utilisation appears uncertain within literature. For example, Buba *et al.* (2017) opined that educated household heads are less likely to engage in consuming fuelwood, hence, reduces the tendencies of environmental degradation through deforestation in search for energy. Musango (2014) also opined that educational level will affect households' disposition to adopt modern fuels. On the contrary, Gatersleben *et al.* (2002) suggested that education is not associated with energy utilisation.

The result from Table 1 also showed that the majority (62%) of the households had 6-10 persons, 32% of the households in the study area had 1-5 persons, while 6% of the households had more than 10 persons. The average household size of the respondents was 7 persons which could be considered large. This suggests that given the relatively big size of the family couple's household and their poor income, there is a likelihood of increased strain on fuel wood. Maina et al. (2019) also reported a similar range. If everything else is equal, this could imply that the larger the household, the greater the use of fuelwood, as a household head will likely choose less expensive or no fuel at all, which has a more detrimental effect on the environment.

The result on the main occupation of respondents revealed that 52% of the respondents were farmers, 32% were traders/ business people while 12% were civil servants. The high percentage of farmers was expected because the study area is mostly rural and the major occupation is farming which justify their dependence on fuelwood exploitation as it brings shift in their income and expenditure level. A household's occupation dictates its degree of income, which in turn affects the type of energy utilized for domestic tasks. The monthly income distribution of the respondents shows that 61% of the respondents earn a monthly income of between N21000-50000, 15% earn between N51000-60000, while 11% earn above 61,000. The mean monthly income of the respondents was N43, 150. This result indicates that most of the households in the study area are low income earners as the majority of them are farmers who derive their income from farm produce which in most instances are seasonal.

The monthly income of the head of the household determines the economic status of the household. The higher the income of household heads, the greater the flexibility to shift to the desired household fuels. Fuelwood is mostly patronized by those who fall below the socio-economic status threshold. Thus, this high proportion of low income among respondents implies that the use of fuelwood through fetching could be high to save cost. The dependence of low income households on fuelwood as a source of energy due to lack of purchasing power has a negative effect on the environment as it causes the depletion of forest cover.

Main Source of Cooking Energy

Result in Table 2 reveals that the majority of the respondents (70%) indicated that their main fuel source for cooking is firewood. This is not surprising as the study area is predominantly rural. This result reflects a clear picture of the situation in the rural areas whereby the majority of households adopt firewood as the main source of cooking fuel. 3% of the respondents claim to be using charcoal as their main source of cooking fuel. The remaining 3% of the respondents claim to be using kerosene as their main source of cooking fuel, mainly in the semi-urban areas of the study area. None of the respondents used liquefied petroleum gas (LPG) and electricity as the major source of fuel for cooking. The adoption pattern for primary cooking fuel is mostly influenced by culture, accessibility, and affordability.

Table 2: Distribution of Respondents based on Main Source of Cooking Energy

Source	Frequency	Percentage
Firewood	189	79.0
Charcoal	31	13.0
Kerosene	20	8.0
Liquefied petroleum gas (LPG)	-	-
Electricity	-	-
Total	**240**	**100.0**

Source: Field survey, 2022

Source of Fuelwood in the Study Area

Table 3 revealed that about 44% and 37% of the respondents in the study area obtains their fuelwood at no cost from the forests and their farmlands respectively while 19% relied completely on purchased firewood from firewood vendors. This means the greater proportion of fuelwood consumed in the area comes from reserved natural forests and free access farmlands. For households that collect firewood; stockpiling is common amongst these households, as they collect more than twice per week, even when they have enough to sustain them for a month. This may consequently lead to over-harvesting of firewood resources in the community, which may significantly reduce forest size, thereby making the availability and accessibility of firewood resources a future struggle. The semi-urban communities of the study area are characterized by very limited vegetable cover. Consequently, there is extended pressure on the surrounding natural forests and farmlands in the rural communities which also have little tree density for fuelwood supply. This has further aggravated the disappearance of forest cover in the study area. Among the myriad causes of depletion of forests, increasing fuelwood usage has been identified as one of the biggest threats to forest covers (Agarwala *et al.,* 2016). Over 80% of rural and urban inhabitants in southern Africa, for instance, use fuelwood as a primary or secondary energy source (Baiyegunhi and Hassan, 2014).

Table 3: Distribution of Respondents based on Source of Fuelwood

Source	Frequency	Percentage
Fetched from forests	106	44.0
Fetched from farmland	89	37.0
Purchased from vendors	45	19.0
Total	**240**	**100.0**

Source: Field survey, 2022

Multiple Fuel Use by Respondents in the Study Area

In rural households, the use of different fuels is not completely swapped, but rather stacked, so that even the most conventional cooking methods are not completely replaced or abandoned (Hoffman *et al*., 2015). The result in Table 4 shows that 34% of the respondents use only fuelwood as cooking energy, 43% of the respondents use fuelwood and charcoal, 13% use fuelwood and kerosene, 7% use fuelwood and gas while 3% use fuelwood and electricity as source of cooking energy.

Table 4: Distribution of Respondents based on Energy Mix

Sources of energy	Frequency	Percentage (%)
Fuelwood only	82	34.0
Fuelwood + Charcoal	104	43.0
Fuelwood + Kerosene	31	13.0
Fuelwood + Gas	17	7.0
Fuelwood + Electricity	6	3.0
Total	**240**	**100.0**

Source: Field survey, 2022

It can be seen from the result that though fuelwood is the major source of cooking energy among the respondents, only 34% of the respondents use it exclusively without combining it with other sources of energy. The remaining 66% which represents more than half of the study population do not rely entirely on firewood alone as cooking energy but rather a combination of at least two energy sources. The major justification why households use multiple fuels is partly related to the fact that some fuels are only convenient for undertaking specific cooking activities. When there is an increase in the level of income and households move up the ladder, lower-level fuels are still kept and used simultaneously, forming part of the energy mix. Recent empirical studies on household energy consumption have been critical to the energy ladder model. Such studies claim that fuel switching is not a linear process where households directly switch the energy ladder as their socio-economic status improves. Rather, households always use traditional fuels even after they have started using modern cooking fuels (Kowsari and Zerriffi, 2011). One of the reasons stated by Kowsari and Zerriffi, (2011) is that household energy sources are imperfect

substitutes among each other for the fact that most of the time, specific fuels are preferred for specific cooking tasks. Therefore, instead of simply switching between different cooking fuels, most of the time, households choose to use one or more combination of fuels and depending on different circumstances.

Cost price of Energy Sources in the Study Area

The prices of cooking energy were determined for the various cooking energy types used in the study area. Findings revealed that there is variation in the cost price of solid fuels like fuelwood and charcoal in the study area. This is usually due to distance covered to collect the fuelwood and charcoal. The prices are higher in locations where it must be transported from far distances to the point of sales. Result in Table 5 reveals that the overall average cost price of a bundle of firewood stood at N200 in the study area. The average cost price of kerosene in the study area is N750/litre, charcoal, N2500/50kg bag (N50/kg), electricity, N61.5/kwh and gas, N780/kg. There are no incentives for using any of the energy kinds, and none of them are subsidized. From this result, it can be seen that the cost price of all the alternative energy sources is exorbitantly high beyond the purchasing power of most of the respondents considering their low level of income and large family sizes. This justifies the almost total dependence of the households on fuelwood which is relatively cheaper and available at little or no cost.

Table 5: Average Cost price of Energy sources in the study area (n=240)

Energy type	Unit price (N)
Fuelwood	200/bundle
Kerosene	750 /Litre
Charcoal	2500/ 50kg
Electricity	61.5/ kwh
Gas	780/ kg

Source: Field survey, 2022

Households' Fuelwood Consumption in the Study Area

In the study area, firewood is a significant source of cooking fuel for the homes. The average amount of fuelwood used by homes each day can often be determined by household size. Ican be seen from Table 6 that majority (75%) of the respondents in the study area consumes about 1–2 bundles daily, about 18% of the respondents use 3-4 bundles of fuelwood daily while the remaining 7% consumes more than 4 bundles daily. The average consumption level stands at 3 bundles daily. Further investigations revealed that *consumption of* fuelwood in the study area is generally high but higher amongst rural communities where family sizes are higher and the fuelwood sources are easily obtainable. According to Arabatzis *et al*., (2012), more than 2 billion people use wood, charcoal, dung or agricultural residues as the primary fuel for their cooking and heating needs, leading to significant health, economic and environmental consequences. Ibrahim *et al.* (2021) stated that biomass accounts for 73% of total domestic energy consumption and about 87% of households use firewood or charcoal with 2 kg of charcoal or 4.6 kg of firewood per day. Combustible trash and renewable resources, primarily in the form of biomass, provide more than half of the domestic energy needs. It should be emphasized that energy consumption is influenced by both their accessibility and availability and the cost of energy. Because of the poverty in developing nations and the rising cost of petroleum goods, firewood continues to be the most popular fuel in rural regions, while charcoal is primarily utilized in big cities (Zulu and Richardson, 2013). The unsustainable level of consumption of fuelwood in Nigeria is likely to continue for some time as long as the energy crisis facing the country remains unresolved. The country still witnesses an erratic supply of petroleum products (Kerosene and Gas), and when available the prices are beyond the reach of ordinary people. Since more people will turn to fuelwood, which is already in low supply, the implication is not unreasonable. FAO 2003, Experience of National Forestry Programmes in Nigeria (FAO, 2003).

Table 6: Distribution of Respondents based on Quantity of Fuelwood Consumed Daily in the Study Area

Quantity	Frequency	Percentage	Mean
1-2 bundles	144	60.0	
3-4 bundles	62	26.0	
4-5 bundles	21	9.0	
>5 bundles	13	5.0	**2.5**
Total	**240**	**100.0**	

Source: Field survey, 2022

Reasons for Households' Fuelwood Consumption as Main Energy Source

The reasons for choice of fuelwood as household cooking energy presented in Table 7. The result reveals that lack of cheaper energy alternatives ranked first with 88%. This was followed by large family size (84%), easy availability (77%), cooks faster (45%), uneasy or no access to clean fuels like electricity and gas (40%), suitability for specific dishes (15%) and better food taste (9%). The over dependence on fuelwood by the respondents is not surprising as the study area is predominantly rural. The majority of the respondents especially in the rural areas claimed they could not do without fuelwood because the available renewable energy sources like electricity and gas are not well developed and very expensive. Respondents with large family sizes would naturally tend to use of fuelwood as cooking energy source. A respondent said 'my family is relatively large and with the prevailing economic situation, it is far cheaper for me to use firewood instead of electricity for my domestic energy needs.

Table 7: Reasons for Household Fuelwood Consumption as Cooking Energy.

Reasons	Frequency	Percentage	Rank
Easily available	185	77.0	3rd
Easily available	185	77.0	3rd
No cheaper alternatives	211	88.0	1st
Food taste better with fuelwood	21	9.0	7th
Only suitable for specific dishes	37	15.0	6th
Large family size	201	84.0	2nd
Uneasy/no access to cleaner fuels (Electricity & Gas)	96	40.0	5th

Multiple Responses

Environmental Effects of Continuous Consumption of Fuelwood

Results from field survey suggest that the respondents have some knowledge of environmental implications of fuelwood consumption as they expressed varying views on the impact of cutting down trees for fuelwood. Result in Table 8 revealed that 75% of the respondents see deforestation as one of the environmental effects of fuelwood utilization, 57% indicated global warming, 53% were of the view that continuous use of fuelwood causes indoor and outdoor pollution causing respiratory diseases, 46% mentioned violent windstorm, 40% identified erosion, 28% indicated biodiversity loss while 13% linked desertification respectively to fuelwood consumption in the study area. It is known that deforestation contributes to global warming. Reduced carbon sequestration can be held responsible for this. Because of tree cutting and loss of forest cover, the heat traps that trees provide are no longer available. Given the imbalance caused by the loss of forest cover, this exposes plants and animals to increasingly unstable climatic conditions. It also poses the threat of global warming and endangers the populace (Worldwide Fund, 2013). Unrestrained and uncontrolled logging, according to Putz *et al.* (2001), can have a terrible effect on the ecosystem and significantly contribute to the global warming that is currently endangering the world. Burning agricultural waste or wood releases smoke that contains a range of irritating chemicals, some of which are proven carcinogens. Neina *et al.* (2020) stated that acute respiratory illnesses brought on by breathing in smoke from indoor cooking fires result in more than 1.5 million deaths annually. Children incur the greatest health risks since they are typically exposed to the highest quantities of contaminants. Infections of the respiratory system are the main cause of infant mortality globally. Cutting down trees for fuelwood leaves the lands bare leading to massive soil erosion owing to the fact that the soil would not have tree roots to hold it together. The respondents attested to having had incidences of soil being washed downhill owing to impaired holding by the roots from the cut-down trees. They were of the view that the prevailing situation heavily impaired and compromised the capacity of available farmlands to be productive owing to the event of having the rich top soils eroded. This heavily reduced the productivity of the farms occasioning the community diminished returns from their production. Tee *et al*, (2009) stated that the excessive fuel wood harvesting has led to massive soil erosion, decreased water quality and Dam siltation in Nigeria. When trees are cut, the forests no longer support the same wildlife as effectively as it did before and this may place its inhabitants at risk. Diaz (2006) discovered that logging led to the destruction of vital microbial ecosystems as well as the natural habitats of wild animals, vegetation species, fruit trees, and trees of medicinal relevance. Trees act as very good safeguards against strong wind. Cutting down of trees for fuelwood consumption predisposes the land to very strong windstorms leading to losses in lives and properties. The respondents were of the view that the felling down of trees exposed the local community to the pain of aggravated losses occasioned by strong winds undeterred by lack of windbreaks. The responses were reflective of the ability of the respondents to identify trees as important and effective in assuring them their economic and environmental needs. This equally brings to the fore the capacity of the respondents to attach a high premium to trees in their daily livelihoods. It was thus proof of having them informed on the importance of trees in terms of making the world a better living place.

Table 8: Perceived Environmental Effects of Household Fuelwood Consumption

Environmental effect	Frequency	Percentage
Deforestation	179	75.0
Global warming	136	57.0
Indoor and outdoor pollution	127	53.0
Violent windstorms	111	46.0
Soil erosion	97	40.0
Loss of biodiversity	66	28.0
Desertification	31	13.0

Multiple Responses

Factors Influencing Utilization of Fuelwood by Households

In order to analyze the determinants of fuelwood consumption in the area, a multiple regression was carried out and subjected to four functional forms (linear, semi log, double log and exponential forms). The linear form was chosen as the lead function because it has the R^2 value of 0.783 and the highest number of significant variables (Five variables). The coefficient of multiple determination of 0.783 indicates that about 78.3% of the variation in fuelwood consumption in the

study area has been captured by the model. The implication of this outcome is that 78.3% of fuelwood consumption is induced by the explanatory variables. The result in Table 9 shows that five of the nine explanatory variables used in the model significantly influenced the consumption of fuelwood by households. These variables are; marital status (X_3), educational status (X_4), household size (X_5), monthly income (X_8) and cost of Gas (X_8). Marital status, household size, cost of gas are the variables that positively influence the consumption of fuelwood by households. On the other hand, educational status and monthly income had negative influence on fuelwood consumption.

Marital status (X_3): The positive coefficient of marital status and its statistical significance at 5% implies that the more the number of married people in a population the higher the consumption of fuelwood and vice versa. The number of individuals living in families is typically higher among married people than among single persons, which raises the expense of living. The inference is that using fuelwood is a way to manage expenses in light of current economic conditions, freeing up scarce resources for other essential family requirements. This conforms with the expectation that larger households will prefer to use firewood since it is comparatively cheaper when compared to sources such as electricity which at many times is not available in the study area. This finding agrees with Obayelu *et al.,* (2017) that larger households may have extra and free labour for firewood collection.

Educational status (X_4): Educational status of respondents had a negative coefficient and was statistically significant at 1% level of probability. This means as the educational level of respondents increase, their probability to use firewood as their energy source relative to other energy sources decreases. This indicates that, with everything else held constant, the respondents having more education are more likely to switch over to fuel wood alternatives like gas and electricity thereby reducing the tendencies of environmental degradation through deforestation in search for energy. This is consistent with the theoretical prediction that as households get more educated, there will be a greater demand for firewood substitutes. This is due to the increased understanding of fuel characteristics, taste, and preference for better fuels that comes with education.

Household size (X_5): The estimated coefficient of the household size of respondents using fuelwood is significant and positive at 5 % level. This means that given the household level of income, an increase in its members can expose the household to a certain degree of poverty. Subsequently, the household can find it difficult to meet with its energy consumption demand and inevitably, the household has to resort to fuel wood consumption due to its affordability and/or proximity. Uhunamure *et al.*, (2017) stated that household size is amongst the factors that influence household choice of energy. To meet their demands, larger households needed more energy than smaller households.

Monthly income (X_7): The estimated coefficients of monthly income of respondents using firewood was significant and negative at the 5% level of probability inferring that, assuming all other factors remain constant, the respondent with a greater income is more likely to move to modern fuel. In other words, fuelwood use declines as household heads' monthly income rises. As people's purchasing power rises in response to an increase in income, households may utilize more alternative domestic fuels like kerosene and gas, which would reduce their need on fuelwood. This concurs with the theoretical expectation that as household income increases; household demand for modern energy sources will increase. The influence of income on the use of fuelwood may be attributed to improved socioeconomic status which drives the household upward on the energy ladder. This agrees with the findings of Maurice *et al.* (2015) who reported that the higher the income of the head of household, the greater the flexibility of shift to the desired household fuel.

Cost of alternative fuel (Gas) (X_9): The coefficient of cost of alternative fuel (LPG) is positive and statistically significant at 1% level implying that as the cost per litre of LPG increases the consumption of fuelwood increases. This is expected because households tend to consume more of fuelwood than LPG because it is relatively cheaper and also readily accessible especially for people in rural areas.

Table 9: Multiple Regression of Factors Influencing Households' Fuelwood Consumption

Variable	Coefficient	Standard error	T-stat	P-value
Constant	-17978.6	8059.207	-2.23082	0.026971**
Age	-0.27044	1.354288	-0.19969	0.841953
Gender	236.8507	248.1957	0.95429	0.341261
Marital status	2918.578	1294.113	2.255274	0.025362**
Educational status	-0.15168	0.041875	-3.62232	0.00038***
Household size	436.9328	229.7644	1.901656	0.058869**
Main occupation	-000159	0.062947	0.02521	0.97991

Table 9: Continued

Variable	Coefficient	Standard error	T-stat	P-value
Monthly income	-2827.57	1178.858	-2.39856	0.017517**
Cost of Fuelwood	7.435208	27.06364	0.274731	0.783849
Cost of Gas	7557.562	2778.099	2.720407	0.007182***
R	0.92825			
R square	0.783405			
Adjusted R square	0.731168			
Observations	240			

** and *** indicate significance at 5% and 1% probability levels.

CONCLUSION

This study analyzed household fuelwood consumption as cooking energy and the implications on the environment in vandeikya local government area of Benue State, Nigeria. The study found that, majority of the respondents were married and within their active ages. The study also showed that majority of the respondents *had at least one form of education with secondary education having the highest share*. Majority of the respondents were farmers with low level of income and large family sizes. The major energy type for cooking in the study area is fuelwood which is mostly combined with charcoal and often times kerosene, liquefied petroleum gas and electricity. Fuels are not totally switched in the study area, but a multiple fuel stacking is followed whereby new fuels and technologies for cooking are added and even the most traditional systems are not entirely displaced or abandoned. There are variation in the cost price of solid fuels like fuelwood and charcoal in the study area. This is usually due to distance covered to collect the fuelwood and charcoal. The prices are higher in locations where it must be transported from far distances to the point of sales. The overall average cost price of a bundle of firewood stood at N200 in the study area. The average cost price of kerosene in the study area is N750/litre, charcoal, N2500/50kg bag (N50/kg), electricity, N61.5/kwh and gas, N780/kg. Lack of cheaper energy alternatives, large family sizes, easy availability were the major reasons for choice of fuelwood as household cooking energy in the study area. The study revealed that deforestation, global warming, indoor and outdoor pollution, violent windstorm, erosion, biodiversity loss and desertification were the perceived environmental effects of fuelwood consumption in the study area. Marital status, household size, cost of gas were the variables that positively influenced the consumption of fuelwood by households while educational status and monthly income had negative relationship with fuelwood consumption in the study area. In order to develop a case for intervention on the most effective and environmentally friendly option for domestic energy among rural households, this study makes a vital contribution to policy makers, researchers, and residents of rural homes.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. The study discovered that the most popular fuels were firewood, charcoal, and kerosene, in that order. Given the unavoidable negative effects that these fuels have on the environment and human health, it is crucial for the government and energy stakeholders to develop strategies to help households rely less heavily on hard fuels like firewood and charcoal. It is important to promote the use of clean, alternative energy sources, particularly liquefied petroleum gas (LPG).

2. The government should foster the growth of the infrastructure required for the production of biofuels for domestic consumption. Instead of the current ineffective usage of unprocessed biomass, this will assure the economic utilization of the abundant biomass resources in the area. To achieve this, the government should enlist the assistance and knowledge of the nation's pertinent energy research institutions in the manufacturing of methanol fuel and biogas fuel, which will initially be subsidized for consumers before being deregulated and embraced by commercial interests.

3. The government should create an enabling environment for development of infrastructures necessary for production of bio fuels for household use. This will ensure the economic utilization of the biomass resources that abound in the area, rather than the present inefficient use of unprocessed biomass. To achieve this, the government should enlist the assistance and knowledge of the nation's pertinent energy research institutions in the manufacturing of methanol fuel and biogas fuel, which will initially be subsidized for consumers before being deregulated and embraced by commercial interests.
4. Sensitization programmes should be organized for residents on alternative energy sources and the corresponding alternative energy technologies made

available and affordable to residents. Also, tree planting campaign should be embarked upon by both residents and relevant authorities to replenish the depleted forest resources and for its sustainability.

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