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Fuelwood Energy Production and Use by Farm Households in Imo State, Nigeria-: Implications for Forest Resource Conservation

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ABSTRACT

Fuelwood demand is continuously increasing in Imo State which leads to the conversion of forest lands to grasslands. Producers and users of fuelwood need to be aware of how much fuel wood they produce and use and the negative effects of their activities in Imo State so as to conserve their forests and preserve the environment. This study was designed to analyse the fuelwood production and use situations in Imo State so as to explore ways of meeting the increasing domestic and industrial demand for fuel wood and at the same time protect forest trees and the environment for future use. Data were collected with structured and validated questionnaire from 120 randomly selected respondents composed of 60 fuel wood users in the semi-urban and rural areas of Imo State. Data were analyzed using both descriptive statistics such as means, percentages, frequency distribution and Likert scale technique, as well as inferential statistics such as z-test, analysis of variance, scheffe test and ordinary least squares multiple regressions model. Results show that exposing farmland to wind erosion and scarcity of timber products are the most pronounced adverse effects of fuel wood production processes in the study area. The quantity of fuel wood produced and used per household per month were 7.61kg and 1.9kg respectively, while 499.35kg and 23.33kg of charcoal were produced and used per household per month respectively. Fuel wood production in Imo State is profitable and a producer earns a profit of N46.79 naira on every N100 naira invested in the production. The important factors influencing the quantity of fuel wood produced are type of wood, tenancy status, occupation, household labour force, distance of farmland to home, market for fuel wood and traditional laws, while the important factors influencing the quantity of fuel wood used are income level, level of education, type of kitchen, type of food prepared, type of occupation, price of fuel wood and price of alternative energy source such as kerosene and cooking gas. The traditional institution and government should be vigilant and enforce the laws to protect the forests and the environment. They should also need to examine the driving force behind the deforestation of the environment in the state.

Keywords: *Fuelwood, Forest Trees and Environment, Household Labour Force, Producers and Users.*

INTRODUCTION

Fuelwood is wood that is harvested from forestlands and combusted directly for useable heat in the residential and commercial sectors and power in the electric utility sector (Akther *et al*., 2010). In the United States, these sectors account for 30% of current consumption of forestland biomass and about 20% of total biomass energy consumption.

Wood fuels are a renewable and climate-friendly energy source because they are considered carbon neutral if used and produced in a sustainable and efficient manner. Wood fuels consist of four main commodities: fuelwood (also called firewood), charcoal, black liquor, and wood waste (Digernes, 1980).Fuelwood is used extensively in most developing countries and is collected from the forest, often as fallen branches or twigs. In domestic applications, it is converted into heat in simple ovens, often for cooking, baking, or drying, and/or is used for space and water heating. The fuel gases are also used for the smoking of food products (Schuen-emann *et al*., 2018). Contrary to popular belief, the gathering of fuelwood is not responsible for large-scale deforestation; however, it can contribute to localized forest and soil degradation.

Larger issues associated with the traditional use of fuelwood are the health effects of using inefficient stoves in poorly ventilated areas. This leads to emissions of pollutants such as carbon monoxide, methane, and nitrogen oxides that carry serious health risks. For instance, those pollutants are known to cause respiratory infections, adverse pregnancy outcomes and tuberculosis (Jagger and Shively, 2014). In addition, the collection of fuelwood is hard physical labor. Women are mostly responsible for collecting fuelwood and cooking, women and small children are most adversely affected. Commercial fuel wood is also used as an industrial source of energy in many developing countries (Cooke *et al.,* 2008). Typical industrial uses include curing and drying, food processing, and lime and brick burning. Although the total amount of wood consumed by the industrial sector is much smaller than that consumed by households, it is nonetheless significant. For example, in Kenya and Sri Lanka, 26 and 18% of fuelwood is used by industry, accounting for more than 70 and 65% of all industrial energy use, respectively (Hoffmann *et al.,* 2015).

Charcoal is produced from wood through carbonization or pyrolysis. The wood is heated in a closed container that is devoid of oxygen. The absence of oxygen prevents the wood from burning to ashes; thus, the wood decomposes to charcoal, among other residues. Charcoal plays an important but a much smaller role than fuelwood in both industrial and household sectors of most developing countries (Sola *et al.,* 2016). In households, it is used for tasks similar to those of fuelwood, but a switch from fuelwood to charcoal provides numerous benefits. Those include the fact that charcoal generally does not decompose in storage, it burns without smoke for the most part, it does not create dangerous flames while cooking, and it requires a simple stove whose heat output is relatively easy to control. As a result, a switch to charcoal often represents an increase in the quality of life. The disadvantages of charcoal use are related primarily to the inefficiencies inherent in its production and use.

Production efficiency in most developing countries ranges between 8 and 28% and is a function of moisture content and type of equipment. Charcoal is also inefficient in use. Although charcoal stoves are more efficient than fuelwood stoves (20–35% versus 10–25%), charcoal stoves are much less efficient than modern fuel stoves such as kerosene (35–50%) and electric stoves (75–85%). The combined production and use inefficiencies have important consequences for the abundance of local wood resources given that cooking with charcoal often uses three to four times more wood than does cooking with fuelwood. Charcoal is also used in industrial settings in both developing and developed countries, for instance, in the production of iron and steel, in metallurgy, and in the chemicals industry.

The other two categories of wood fuels are derived from secondary sources and consist of black liquors from pulp production and wood waste from forest products industries and other products from society such as wastepaper. Wood fuels account for approximately 7% of the world's total energy supply and are an extremely important source of energy in many developing countries. According to the Food and Agricultural Organization (FAO), developing countries consume approximately 77% of the world's supply of wood fuels, and this in turn accounts for 15% of total energy consumption in the developing world. Consumption in developed countries accounts for the remaining 23%, but this share amounts to 2% of total energy consumption in the developed world. Of course, substantial regional and national differences exist. Developing countries rely mostly on fuelwood and charcoal, but in most developed countries the pulp and paper industry is instrumental in supplying and using such energy. For instance, in 1997 in New Zealand, black liquor accounted for nearly 100% of all energy derived from forest products, and in Japan, Portugal, Sweden, Norway, and Finland, it accounted for 95, 87, 81, 79, and 80%, respectively.

The smoke produced when fuelwood and crop residues are burned is a pollution hazard because of the nitrogen, particulates and other pollutants in the smoke. Emissions from wood and crop-residue burning are a threat to public health because of the highly respirable nature of the 200 chemicals that the emissions contain. Of special concern are the relatively high concentrations of potentially carcinogenic polycyclic organic compounds and particulates. Sulfur and nitrogen oxides, carbon monoxide, and aldehydes are also released, but with wood there are usually smaller quantities than with coal.

The wood resources of the agricultural ecosystem are used to meet the requirements of several end uses. Of these, cooking is the most important, but it is essential to reckon with other end uses (Brouwer *et al*., 1989). In the household sector, for instance, fuelwood is also consumed for water heating and space heating. In addition, fuelwood is used in all the traditional industries which require heat energy. It is only very recently that these small scales industrial uses of wood fuel in rural areas have started to be investigated (Douglas, 1981). In particular, attention is being focused on brick-burning, tile-making, pottery, processing of tobacco, tea, cardamom, black-smithy, soap-making, etc. Wood is also used as a structural material in buildings and animal-drawn vehicles. The scarcity of wood resources implies the possibility of conflicts between wood as a cooking fuel and wood for other end ages.

The specific objectives of the study are to analyse the socioeconomic characteristics of fuelwood producers and users, describe the production of fuelwood and assess the effects of fuelwood production processes on the forest resources and environment, determine the quantity of fuelwood produced and consumed as energy source by farm households in Imo State, Nigeria.

Materials and Methods

The study was conducted in Imo State, Nigeria (Figure 2). It is located in the South Eastern part of Nigeria with a total land mass of about 25,289.40km^2 (State Directorate of Land Survey and Urban Planning, 1995) and has a population of 2.485 million people (NPC, 1991). Imo State lies within the humid tropical ecological zones of Nigeria with relative humidity ranging between 50% and 70% (Meteorology Department, Ministry of Lands and Survey, 1995).

Imo is one of the 36 States of Nigeria and is in the south east region of Nigeria. Owerri is its capital and among the largest towns in the state. Its other notable towns are Orlu, Obowo, Oguta, Mbaise and Okigwe. Located in the south-eastern region of Nigeria, it occupies the area between the lower River Niger and the upper and middle Imo River.

Imo State is bordered by Abia State on the East, River Niger and Delta State to the West, Anambra State on the North and Rivers State to the South.[5] The state lies within latitudes 4°45'N and 7°15'N, and longitude 6°50'E and 7°25'E with an area of around 5,100 sq km.

The economy of the state depends primarily on agriculture and commerce. One of the primary agricultural productions is the production of palm oil.

The Orashi River has its source in Imo State (named after a powerful Nigerian family with the family name Imo). Imo River, being the major river in the state, drains through Abia State, where it is joined by Aba River from the north, and Akwa Ibom State into the Atlantic Ocean. Otamiri River and its 9.2 km length tributary, Nworie River, flow in the state.

There are other rivers and creeks in the state including Onas Creek in Ohaji/ Egbema, Okitankwo River in Umudi, Oramurukwa River in Emekuku/Emii/Ulakwo and Ohia and Efuru Rivers in Okigwe.

The state has several natural resources including crude oil, natural gas, lead, Calcium Carbonate and zinc.

Profitable flora including iroko, mahogany, obeche, bamboo, rubber tree and oil palm. Additionally white clay, fine sand and limestone are found in the state.

Imo State major towns include Emekuku Isu, Okigwe, Oguta, Orlu, Atta Ikeduru, Akokwa, Mbaise, Mbaitoli, Mbieri, Ohaji/Egbema, Orodo, Nkwerre, Ubulu, Ngor- Okpala, Omuma, Owerri, Mgbidi, Awo-Omamma, Izombe, Orsu, and Amaigbo, Umuowa Orlu, Isu/Umuozu, Iho Dimeze.

Agriculture is the primary occupation, but due to over-farming and high population density, the soil has greatly degraded.

The rainy season begins in April and lasts until October, with annual rainfall varying from 1,500mm to 2,200mm (60 to 80 inches).

An average annual temperature above 20 °C (68.0 °F) creates an annual relative humidity of 75%. With humidity reaching 90% in the rainy season. The dry season experiences two months of Harmattan from late December to late February. The hottest months are between January and March. With high population density and over farming, the soil has been degraded and much of the native vegetation has disappeared. This deforestation has triggered soil erosion which is compounded by heavy seasonal rainfall that has led to the destruction of houses and roads.

One primary source of revenue for Imo State Government is from palm oil production contributed by both large scale and small scale production.

Figure1. *Fuel wood Harvest from the study area.*

Figure2. *Map of Imo State, Nigeria*

Sample Selection

A representative sample was chosen using a multi stage stratified sampling procedure. Imo State was stratified according to agricultural zones into the existing three agricultural zones namely: Owerri, Okigwe and Orlu. One semi-urban local government area was purposively selected while one rural local government area was randomly selected from each agricultural zone of the state making a total of 6 local government areas in the state. The purposive selection of the semi-urban local government areas was to ensure that the local governments selected were actually semi-urban.

The sampling frame for the selection of respondents was the list of households that produce and use fuelwood in each community compiled for the purpose of the study with the assistance of the resident extension agents. 120 respondents composed of 60 fuelwood producers and 60 fuelwood users were used for the study.

Data Selection

Preliminary visits were made to the three agricultural zones in Imo State before actual data collection began. This was to enable the researcher to familiarize with the study area. Data collected were on variables such as household size, education, distance of farm to home, occupation, marital status, tenancy status, capital, fallow length, household labour force, market for fuelwood, production processes for fuelwood, traditional laws against fuelwood collection, amount spent on fuelwood energy, costs of fuelwood production, returns from fuelwood production, household income, type of dwelling house, type of kitchen, type of food prepared at home, type of occupation, price of fuelwood, price of alternative energy sources, constraints to fuelwood production, use and awareness of forest resource conservation in Imo State, Nigeria.

Data Analysis

Descriptive statistical techniques such as means, Likert type scale, frequency and percentages were used to analyze the data collected.

Results and Discussions

Socio-Economic Characteristics of Fuelwood Producers and Users

Age

The age distribution of fuelwood producers and users is shown in table 1. The age of the respondents ranged between 25 and 58 years. 45% of the fuelwood producers were within the age range of 37-42 years while 16.7% and 15% of the fuelwood producers were within the age range of 25 – 30 years and 49 – 54 years respectively.

31.7% of the fuelwood users were within the age group of 43-48 years while 20% and 16.7% of them belonged to 37 – 42 years and 49-54 years respectively.

Table1. *Distribution of Fuelwood Producers and Users According to Age*

Age (Years)	Producers frequency	%	Users Frequency	%
25-30	10	16.7	4	6.7
31-36	5	8.3	*7*	11.6
37-42	27	45.0	*12*	20.0
43-48	6	10.0	*19*	31.7
49-54	9	15.0	*10*	16.7
55 and above	3	5.0	*8*	13.3
Total	60	100	*60*	100

Mean Age	40.2 years		*44 Years*	

EDUCATION

The distribution of fuelwood producers and users according to educational attainment is shown in table 2. The education level of the respondents ranged between 0 and 21 years. 35% of the fuelwood producers and 23.3% of the fuelwood users attended primary education.

Table2. *Distribution of Fuelwood Producers and Users According to Educational Attainment*

Educational Attainment And Years Spent in School	Producers Frequency	%	Users Frequency	%
No Formal Education (0)	17	28.3	9	15.0
FSLC (1-6)	21	35.0	14	28.3
WASC/GCE (7-12)	11	18.4	11	18.4
TC11/OND/NCE (13-14)	9	15.0	13	21.7
HND/Degree (15-18)	2	3.3	8	13.3
Higher Degree (19 and above)	0	0.00	5	8.3
TOTAL	60	100	60	100
Mean Level of Education	10.9 years		13.3 Years	

Source: *Survey data, 2006*

HOUSEHOLD SIZE

The distribution of fuelwood producers and users is shown in table 3. The sizes of respondents ranged between 1 to 15 people and the table revealed that 46.7% of the fuelwood producers and 60% of the fuelwood users had 13 persons in their households followed by 31.7% of the fuelwood producers and 25% of the fuelwood users that had only 9-12 persons in their respective household.

The implication of these findings were that households with more persons produced more fuelwood and this could be attributed to the fact that fuelwood production requires more hands to break and cut wood, assemble and tie the wood cum carry to the place of storage or sale as shown in figure 1 (Scheid *et al*., 2018).

Table3. *Distribution of Fuelwood Producers and Users According to Household Size*

Household Size (Number of Persons)	Producer Frequency	%	User Frequency	%
1-4	*5*	8.3	2	3.3
5-89	*8*	13.3	7	11.7
9-12	*19*	31.7	*15*	25.0
13 and above	*28*	46.7	*36*	60.0
Total	*60*	100	*60*	100
Mean Household Size	*11Persons*		*13 persons*	

Source: *Survey data, 2006*

Experience

The fuelwood producers and users years of experience were presented in table 4. 43.3 % of the fuelwood producers acquired 11-16 years' experience while 23.4% and 15% of them acquired 7-22 years and 5-10 years' experience respectively.

These assertions meant that fuelwood production started many years ago and the producers have acquired much experience in the production. This finding was in agreement with (Soussan *et al*., 1991) who clarified that fuelwood usage started many years ago.

Table4. *Distribution of Fuelwood Producers and Users According to Years of Experience*

Years of Experience	Producers Frequency	%	Users Frequency	%
5-10	9	15.0	4	6.7
11-16	26	43.3	*10*	16.7
17-22	14	23.4	*13*	21.6
23-28	8	13.3	*12*	20.0
29 and above	3	5.0	*21*	35.0
Total	60	100	*60*	*100*
Mean Years of Experience	15.8 years		*13.3years*	

Source: *Survey data: 2006*

Marital Status

56.7% of fuelwood producers and 60% of fuelwood users are married while 23.3% of the producers and 30 % of the users are widowed as shown in table 5. This discovery indicated that fuelwood production and use are experienced by both single and married people in the study area.

Table5. *Distribution of Fuelwood Producers and Users According to Marital Status*

Marital Status	Producer Frequency	%	User Frequency	%
Single	5	8.3	2	3.3
Married	34	56.7	36	60.0
Divorced	4	6.7	3	5.0
Widowed	14	23.3	18	30.0
Separated	3	5.0	1	1.7
Total	60	100	60	100

Source: Survey data, 2006

Occupation

Majority, 66.7% of the fuelwood producers are farmers while 28.5% of them are artisans. This could be attributed to the fact that farmers and artisans go to the farm and forests very often and use the opportunity to produce fuelwood.

Most of the fuelwood users 31.7% are food vendors while only 256 of them are farmers. Heltberg *et al.*, (2000) findings were in line with the discoveries of this study.

Table6. *Distribution of Fuelwood Producers and Users According to their Occupation*

Occupation	Producers Frequency	%	Users Frequency	%
Farmer	40	66.7	15	25.0
Trader	3	5.0	12	20.0
Food Vendor	0	0.00	19	31.7
Civil Servant	0	0.00	4	6.7
Artisan	17	28.3	10	16.6
Total	60	100	60	100

Source: *Survey data 2006*

Type of House

The types of houses where the fuelwood producers and users live in are shown in table 7. 63.3% of the producers and 53.3 % of the users live in block houses while 30% of the fuelwood users and producers live in mud houses. The result further indicated that none of the fuelwood producers and 1.7% of the fuelwood users line in brick houses.

Table7. *Distribution of Fuelwood Producers and Users According to Types of Houses they live in.*

Type of House	Producers Frequency	%	Users Frequency	%
Brick House	0	0.00	1	1.7
Block House	38	63.3	35	53.3
Batcher/Wooden House	4	6.7	6	10.0
Mud House	18	30.0	18	30.0
Total	60	100	60	100

Source: *Survey data, 2006*

Sex

Table 8 showed that 70% of the fuelwood producers and 26.7% of the fuelwood users are males while 73.35 of the fuelwood users and 305 of the fuelwood producers are females.

These findings indicated that both males and females are involved in the production and use of fuelwood.

Table8. *Distribution of Fuelwood Producers and Users According to Sex*

Sex	Producers Frequency	%	Users Frequency	%
Males	42	70.0	16	26.7
Females	18	30.0	44	73.3
Total	60	100	60	100

Distance

The distribution of fuelwood producers and users according to the distance from their homes to the farmland and market respectively is shown in table 9. The data on distance for the respondent ranged between 0.11 and 1.49 while the table showed that most (33.3%) of the fuelwood producers had their homes located less than 0.2km to their farmlands and forests where they produce fuelwood, while 23.3% of them live 0.2 – 0.5 km to the farmlands and forest where fuelwood is produced.

Table9. *Distribution of Fuelwood Producers and Users According to Distance*

Distance (Km)	Producers Frequency	%	Users Frequency	%
<0.2	20	33.3	33	55.0
0.2-0.5	14	23.3	17	28.3
0.6-0.9	10	16.7	8	13.4
1.0-1.3	9	15.0	2	3.3
1.4 and above	7	11.7	0	0.0
Total	60	100	60	100
Mean Distance	0.16		0.35	

Types of Fuelwood

The types of fuelwood produced and used in the study were presented in table 10. 100% of the fuelwood producers produce firewood while 28.3 % of them produce charcoal. Also, 13.3% and 6.3% of the fuelwood producers produce saw dust and wood shavings respectively. The results however showed that all (100%) of the fuelwood users use fuelwood while 38.3% of them use charcoal. Also 20% and 15% of the fuelwood users' use saw dust and wood shavings respectively.

Fuelwood is obtained mainly from trees, but many shrub species also serve as a source (Dewees, 1989). Since there is a great pressure on land for agriculture, the growth of fuelwood trees is generally restricted to separate areas, or woodlots. But due to the conflict between food, fodder and fuel requirements, it is becoming increasingly difficult to find land, even of the non-arable variety, for woodlots.

Charcoal is the most important commercial fuel derived from wood. Smoke free, capable of controlled use in a small and cheap stove, and also capable of producing greater heat than wood, it is suitable for a wide variety of industrial and domestic uses and especially for use in an urban environment (Mwampamba *et al.,* 2013). It can also be used as a reducing agent in metallurgy and as an absorbent in filters. In most developing countries it is the chief form, in which wood fuel is used in towns, but in a few countries, such as Nigeria and Zimbabwe, fuelwood is preferred to charcoal, and cooking on open fires is widespread, even in the towns. Charcoal is also easily stored, takes up less space than wood for a given production of heat and does not deteriorate; it is more easily handled in transport and distribution and is less easily ignited so that it is safer to use than wood (Makungwa, *et al*., 2013). It can, however, produce fumes, even asphyxia in poorly ventilated rooms, and is also generally regarded as a dirty fuel with large quantities of dust.

Significant quantities of wood are used in the building sector. Wood, is utilized both directly as a structural material in the form of lumber and indirectly as a fuel for the production of fired bricks and tiles. In both these applications, twigs and branches are usually not used and logos which can only come from felled trees are required (Cardoso *et al.*, 2012). Brick-burning in particular generates considerable demand for wood especially when it in achieved with batch production - in a specific region in South India, approximately 0.4 tonnes of fuelwood is used to burn a 1000 bricks (Jagadish 1979). It is becoming clear that, in many parts of the Third World, the depletion of fuelwood resources will inhibit the success of building programmes based on burnt bricks and tiles. This implies a conflict between fuelwood and shelter,

The dependence on fuelwood for cooking is not a rural phenomenon only; in most developing countries, the use of fuelwood and charcoal in urban areas is significant (Guta, 2014). In India, for instance, about 20% of the total population lives in towns and cities and approximately 65% of the urban households use firewood as a cooking fuel - this corresponds to about 30 million tonnes (Government of India, 1979).

Table10. *Distribution of Fuelwood Producers and Users According to Types of Fuelwood*

Types of Fuelwood	Producers Frequency	%	Users Frequency	%
Firewood	60	100	60	100
Charcoal	17	28.3	23	38.3
Saw dust	8	13.3	12	2.0
Wood shavings	5	8.3	9	15.0

Source: *Survey data, 2006*

Conclusion

This study assessed the fuelwood energy production and use by farm households in Imo State, Nigeria. It can be concluded from the results that fuelwood producers and users acquired experience from many years of toiling in forest vegetation. These assertions meant that fuelwood production started many years ago and the producers have acquired much experience in the production. Moisture content, ash content and volatile matters are the key parameters to be determined to predict the carbon content of the species. Preference wood fuels by households are not only on the basis of energy properties of fuelwood but also by including the availability, flammability and proximity to the study area. The preference choice of tree species for fuelwood should rely on scientific assessment to satisfy the local communities at large.

It is advisable to conduct further study on the present status and coppice management of the preferred tree species.

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