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Fuelwood Resource Exploitation and Energy Demand in Selected Local Government Areas of Sokoto State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author ADI designed the study, wrote the protocol and guided the first draft of the manuscript. Author SBS reviewed the experimental design and all drafts of the manuscript. Authors SBS and AAY managed and performed the statistical analyses of the study. Authors AB and SM administered the questionnaires and wrote the first draft. All authors read and approved the final manuscript.

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ABSTRACT

Fuelwood is the primary source of energy for cooking and warmth in many developing countries. It is the most preferred source of energy in both rural and urban areas. Exploiters/cutters import fuelwood to the urban area where there is high demand for the commodity. Four Local Government Areas (LGAs) in Sokoto State were purposively selected. Four villages from each of the LGAs purposively selected and 10 respondents randomly selected from each village making a total of 160 respondents. Structured questionnaires were administered to elicit information on demographic features of the respondents, income generated, number of bundle exploited, species preferred, sources of fuelwood, impact on the environment, and possible constraints encountered in the business. Descriptive and inferential statistics were used to analyze the data. Binary logit regression was used to estimate maximum likelihood of the exploiters participation in the enterprise. The result

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revealed that exploiters generated income based on the numbers of bundles harvested per week, demand for fuelwood was high, and the *Combretum* spp were the preferred species, respondents acknowledged environmental impact. The binary regression indicated the factors of age, price, family size and number of bundle harvested were significant. Though the coefficient of family size and price per bundle were negative, the log-likelihood 186.503[a] was significant at 1% signifying a close relationship within the variables. While omnibus test gave a chi square value 21.333 indicating a better significant fit of the model. It was concluded that demand for fuelwood had increased with increase in population, urbanization. Exploiters generate income but harvest indiscriminately without replacement. Fuelwood business exploitation should be regulated by government agencies and woodlot establishment should be encouraged.

Keywords: Fuelwood; energy; exploitation; demand; Sokoto state.

1. INTRODUCTION

Forest is a source of livelihood for many farmers and rural households in developing countries, especially in sub-Saharan Africa [1]. Biomass is one of the most important renewable energy sources that contribute decisively to the energy needs of modern society and the environmental prediction, in both industrialized and developing countries. A very important source of biomass is wood and especially fuelwood [2]. The exploitation of fuel wood by the inhabitants of any area is an inevitable consequence of human existence. This is because fuelwood is a vegetal resource which provides the main source of domestic fuel for both the rural and urban household [3]. Approximately 2.5-3.0 billion people (40-50%) of the world population rely on wood for fuel, both for warmth and food preparation [4]. Global production of wood fuel is expected to increase moderately from 1885 million m^3 in 2000 to 1921 million m^3 in 2020. This shows the demand scenario of wood fuel, which is increasing rather than decreasing worldwide [5]. In fact Africa has the highest per capita fuel wood consumption of 0.31 m^3 per year compared to any other continent. In Africa, wood is depended upon for up to 58% of all the energy requirements, demand for wood supplies far exceeds the rate of growth [6]. It is pertinent to note that man's inventions of the use of the fire and the development of the art of cultivation made wood to be the supreme among all the sources of energy, it is the most abundant, cost less in places it is freely collected/exploited. However, as a result of population increase, man's dependence on wood as a source of fuel and energy started showing signs of inadequacy. This level of demand is evident in the alarming rate at which exploitation is taking place due to desire to have a steady supply of fuel wood, and other vegetal resources. Energy has a major impact on every aspect of our socio-economic life. It plays a crucial role in the economic, social and welfare development of any nation. Insufficient supply of energy restricts socio-economic growth and adversely affects the equality of life.

Consequently, fuelwood exploitation from natural environment, land use practice ignored conservation principle; protection techniques were conflicting with environmental sustainability. The capital formation for alternative energy sources were beyond the capacities of the rural economics [2]. This has both local and global environmental consequences, as well as implication of human health and livelihoods. In most sub-Saharan African countries, the rate of exploitation exceeds the global annual average of 0.8% [7]. The key drivers of deforestation in Africa are human activity and one of the most significant is removal of wood for energy [8]. Fuel wood consumption accounts for 90% of total African energy consumption. This makes wood fuel a major local and global environmental issue in Africa.

The biomass resource in Nigeria can be identified as wood, forage grasses, shrubs, others animal, waste arising from forestry. Agricultural, municipal, and industrial activities, as well as aquatic [9]. Wood, apart from being a major source of energy in form of fuelwood is also used for commercial purposes in various forms. For energy purposes, Nigeria is using 80 million m^3 (43.4 x 109 kg) of fuel wood annual. Although the biomass availability at 1973 was put at 9.1 x 1012 MJ, is expected that the overall biomass resource available at present is lower than the 1973 figure. This is largely due to the demand for wood [2]. According to UN, 2005 data on fuel wood consumption by household by countries, Nigeria ranks 4th with 129,944,069.4 m^3 consumption. Studies of northern Nigeria household energy demanded suggested that in

1999, it was estimated to exceed 2000 by a factor of 5.6-6.7, in the year 2010 by a factor of 6.8-8.8, and further to reach by the year 2020 by a factor 7.7-10.0.

With the continuous growth of the country's population and indeed that of the urban areas, this trend will become a threat to the environment, particularly the rural areas from where these fuel woods are harvested, with the rate of exploitation and utilization higher than its natural regeneration or replenishment. The demand of fuel wood in Nigeria's urban areas has been increasing due too the fact that other sources of energy are experiencing hike in prices [10,11,12].

The major objective of this study is to conduct survey on various techniques of fuelwood exploitation in relation to the demand within four local government areas of Sokoto state that are closer to the metropolis. On the light of this to establish estimate or predict the maximum likelihood of exploitation of fuelwood resource in the area, which is detrimental to the environments balance/ecology of the area.

2. METHODOLOGY

2.1 The Study Area

The study was conducted in four selected Local Government Areas of Sokoto state which is located in the extreme northwest of Nigeria, on latitudes 10°40^{1} and 13°35^{1}N and longitudes 3°30^{1} and 7°06E [13]. Temperature ranges from 27 to about 40°C in hottest months of March-May. Rainfall ranges between 500-700 mm per annum, with falls in August and September. The state falls within Sudan savannah zone, the natural vegetation is made of shrubs and varying density trees rarely exceeding 6m in height [14]. The trees are fire-hardy species: *Isoberlinia spp, khaya spp, Acacia spp, Parkia clappertoniana, Vitellaria paradoxum, Adansonia digitata* [14]. The major occupations of the inhabitants are farming, grazing, fishing, and trade.

2.2 Sampling Technique

Four LGAs were purposively selected out of the 23 local government areas in the state. The selected local government areas are Dange-shuni, Tureta west of state capital (metropolis), and Kware, Gwadabawa in the central. Based on active fuelwood exploitation activity, in addition they are less than 40km from the metropolis where fuelwood is transported or imported on daily basis. Four villages from each of the 4 local government areas were selected based on large expanse of forest reserves (gazetted and owned by the Sokoto state Government), presence of fuelwood tree species. Ten fuelwood cutters/ exploiters were randomly selected from each of the selected villages for the study making a total of 160 respondents for the study.

Table 1. Location of study area and sampling distribution

LGA	Village selected	Number of sampled
Dange-shuni	Bisalam	10
	Illela-bissalam	10
	Hetereti	10
	Tafkinkaiwa	10
Tureta	Gidan kare	10
	Kawara	10
	Kaura	10
	Dimasa	10
Kware	Gunduga	10
	Kwakwara	10
	Kalalawa	10
	Bankanu	10
Gwadabawa	Gidan Kaya	10
	Asara	10
	Mamman Suka	10
	Tungar Tudu	10
Total LGAs	16 villages	160

2.3 Data Collection and Analysis

Structured questionnaires were administered to elicit information on demographic characteristics of the respondents, species preferred for fuelwood, price of fuelwood, income generated, number of bundles harvested per week, nature of cutting, government regulation, awareness, membership of association, source of fuelwood, demand for fuel wood, environmental impact, problem encountered in the business.

Data collected were analyzed using descriptive statistics in form of frequencies and percentages. Binary logistic regression model was also carried out in which the dependent variable Y is a dichotomous variable taking the value 1 or zero.

Y = 1 if the person exploited fuel wood, O otherwise

The model is specified as

$$Y1 = \beta o + \beta x_1, \beta x_2 + \beta x_3 + \beta x_4 + \beta x_5 + \beta x_6 + \beta x_7 + \mu$$

Where

β is the coefficient
X_{1-} X_7 are the factors
X_1 = age of respondent
X_2 = family size
X_3 = number of bundle harvested
X_4 = price per unit of bundle
X_5 = source of fuelwood
X_6 = educational level of the respondent
X_7 = nature of cutting of fuelwood (selective or indiscriminant)

3. RESULTS AND DISCUSSION

Table 2 present reasons that led to demand for fuelwood in the area. Though multiple responses were recorded in all the reasons given, scarcity of the fuelwood (79.37%) in the metropolis was considered as the major reason for fuelwood demand, followed population increase and alternative source of other energy with over 60% of the respondents believing that the higher the population the more likely for fuelwood to be scarce.

Table 2. Demand for fuelwood

Reason	Frequency	Percentage*
scarcity of fuelwood	127	79.37
Population increased	111	69.37
Price of alternative (kerosene)	96	60.0
All of the above	103	64.37

**More than 100% multiple responses recorded*

The fuelwood cutters advanced some reasons for demand of their commodity (fuelwood) both in rural and urban areas, due to the fact that energy is essential for cooking and other heating needs of the family. Scarcity of fuelwood was rated high due to the increase consumption of fuelwood, thus making it scarce as nearby by forests were exploited, or depleted because of regular utilization and rise of wood prices, sends signals to suppliers (cutters) that the product is desired by consumer. Hence, they will allocate more resources (Labour, time, technology and capital) to cutting down trees, leading to deforestation and increase in quality of fuelwood supplied in the area. Population increase leads to more utilization of the fuelwood for cooking heating and economics activities. In Nigeria, prices of alternative fuels sources are on the rapid increase, thus further made fuelwood as a cheap source of energy to both rural and urban users. This result is in agreement with findings of [11,12].

Table 3 presents the views of the cutters on the most preferred species of fuelwood available in the areas as demanded by the consumers. Though there are many species that are considered for fuelwood production, *Combretum nigricans* was the most preferred species due to its dryness ability and highly combustible and affordable. Similar result was obtained by [15] while reporting on fuelwood collection and marketing pattern in Sokoto state, where fuelwood collectors mostly preferred *Combretum spp* for efficient energy value. Consequently, the wood cutters move into the bush to identify and exploit these preferred species. However, this act is embedded with serious problem of extinction of these species from the areas. Thereby increasing imbalance in the forest flora and instability in these species as the regeneration period is relatively long. Thus the cutters are forced to move further into bush to search of this preferred species to satisfy.

Table 3. Fuelwood species preferred by the consumers/users

Fuelwood species	Frequency	Percentage*
Combretum nigricans	96	60.0
Combretum micranthum	61	38.12
Guinera senegalensis	38	23.75
Pillostigma reticulatum	16	10.0
Prosopis africana	21	13.12

**More than 100% multiple responses recorded*

Table 4 presents the income generated by exploiters/cutters on weekly basis. The process of fuelwood exploitation involves a number of stages ranging from selection of wood tree, failing, cutting, choping, sundrying, bundling and transporting, thus a week is the minimum period required to complete the cycle a bundle of fuelwood reaches the urban consumer. Exploiters earning the sum of ₦ 23,000 - ₦ 28,000 constitute the highest frequency (34.37%), followed by ₦ 8000 - ₦ 13000 (16.25%). The least frequent group was those with above ₦ 42,000 only being the highest income earners per week.

Respondents with ₦3000-8000 were lowest earners and respondents on this category are mainly young cutters, with less age and experience in the business. While those that belong to the group of ₦23001-28000 formed the majority among the cutters. Mostly in this area middle aged and experienced dealers buy from them to transfer to metropolitan markets. In addition this group usual had more hands to assist in the exploitation, processing, sorting and

identification of species of fuelwood. The extent of income generation was attributed to the experience of cutter, number dealers available, number of hands engaged by the cutter, quality of wood produced, and available collection centre. It could be observed that the cutters make some modest income to earn living and some sustainance, therefore it could be diffucult for cutters to abondoned the enterprise for other income generating businesss in the rural setting. Despite the fact that there are certain environmental harzards and ecological inbalances associated with the venture. This finding is in line with that of [3,8] that in fuel wood exploitation cutter/exploiters generate some level of income in the business.

Table 4. Income generated per week from fuelwood exploitation at Sokoto State Forest

Amount (N)	Frequency	Percentage
3000-8000	8	5.0
8001-13000	26	16.25
13001-18000	23	14.37
18001-23000	11	6.87
230,001-28000	55	34.37
28001-32000	73	8.12
32001-37000	10	6.25
37001-42000	6	3.75
Above 42000	8	5.0
Total	160	100

Table 5 shows the result of the logistic regression analysis considering the participation as the dichotomous dependent variable which was modeled against the respondent's socio-economic characteristics, which includes age, family size, number bundle harvested, prices of the bundle, education, source of the fuelwood and the nature of the cutting practiced. The result indicates that age, family size, bundles harvested, price per bundle are factors that influenced participation in fuelwood cutter/ harvesting/exploitation positively. Though family size, price per bundle, and educational level of respondents had negative coefficients (-0.206, -0.002, and -0.675) respectively, The implication of this is that for every increase in year of education, there is less participation in fuelwood exploitation due to increase in knowledge or education, and this makes the individual not to participate in deforestation because of the negative impact on the forest resources/ environment.

Family size had negative coefficient but significant, implying that the fuelwood cutter with more family size may likely be unable to supply enough labour for exploitation since other members of the family engaged in other enterprises than fuelwoood cutting. Prices at point source of collection attract lower value, because no value had been added to the commodity at that point. In addition, there is belief that forest products are free goods at point source. The source of the fuelwood was also negative, and not significant indicating that the ultimate source of the fuelwood at any point of collection is the forest being the major supplier. While age and number of bundle harvested (0.111 and 0.003) were positive and significant, meaning that the age of participant allows them select, identify and reach out to the dealers easily because of experience gathered over time. This also implies more number of bundles harvested. It was also observed that those respondents with more age were found to have more bundles harvested. However, the nature of cutting was not significant thus could be attributed to the fact most cutters harvested indiscriminately any grown up fuelwood tree either live, dead, or preferred species in other to generate more income from the business. The log likelihood of 186.503a indicates there is close

Table 5. Maximum likelihood estimate of fuelwood exploitation factors

Variables	Coefficient	Std error	Zero	P-value
Constant	-3.722	1.470	19.289	0.007***
Age	0.111	0.350	4.192	0.001***
Family size	-0.206	0.081	0.383	0.011**
Bundles harvested	0.003	0.001	3.219	0.015**
Price per bundle	-0.002	0.007	0.743	0.715*
Source	0.268	-0.395	0.435	0.498*
Education	-0.675	0.415	2.936	0.104NS
Nature of cutting	0.510	0.413	1.232	0.217NS
Log-likelihood	186.503[a]			
Omnibus test	21.335			0.003***

*NS = Not significant, ***significant at 1%, ** significant at 5%, * significant at 10%*

relationship within the variables considered in the model. The omnibus test of the model gave the overall fit test with a chi-square value of 21.335 and significantly better.

Problems and constraints encountered by the fuelwood cutters were assessed and presented in Table 6. Series of activities are involved from the exploitation, transportation, and final delivery to the consumers in urban areas. The problems enumerated were on occupational hazard, infrastructures, relation with agency and environmental impact.

Table 6. Problems encountered in fuelwood exploitation

Problem	Frequency	Percentage*
Occupational hazard	160	100.0
Access tax	67	41.87
Manual operation	160	100.0
Infrastructure (Road)	133	83.12
Environmental impact	121	75.0

**More than 100% multiple responses recorded*

The respondents expressed a number of problems they encountered in conducting the operation of fuelwood exploitation. All the respondents enumerated various occupational hazards of bites, stings (scorpion, snakes, insects and other higher animals) which often may lead to the death of the cutters. Problems of drudgery as a result of using manual tools such as axe, diggers and cutters which resulted in low productivity. Other problems mentioned were access tax charged by local governments' revenue collectors on the roads to the urban area. Infrastructures such as road networks, feeder roads and culverts mentioned among the general problems, other problems include intimidation from forest guards. All these had negatively impacted on the side of the exploiter causing delays in the smooth running of the business. Environmental impacts were equally highlighted in terms of species depletion of both plants and animals, extinction of some species of flora and fauna, lost of vegetation cover, evidence erosion and soil degradation were some of the impacts noticed by the exploiters.

Some aspects and dynamics of the fuelwood exploitation earlier discussed have implications for the fragile environment. It was observed that the rate of exploitation is increasing by day which is indicative of increased rate of deforestation. The increase in deforestation in the area is due to the fact that Sokoto metropolis depends on fuelwood as their primary energy source. If necessary measures are not put in place in some years to come all the forest within 50 km of Sokoto metropolis would be relics of the past. However, efforts of the stakeholders, exploiters/ cutters, government agencies and the community at large and NGOs have a role to play in addressing this situation for it requires a collective responsibility. On the other hand making all the necessary effort to develop other alternative sources of energy to augment fuelwood would give a leeway for over dependence on fuelwood resource.

4. CONCLUSION

Fuelwood is the major energy utilized for heating and cooking. As a result of increase in population, quality of life, urbanization over time, and rising cost of other energy sources (kerosine, gas and electricity), the demand for fuelwood exploitation has increased. Fuelwood cutters though they generate income in harvest trees indiscriminately without replacement. Rate of fuelwood exploitation is associated with age, number of bundles harvested, price, and educational level of the respondents.

Based on the objective and the findings of the study the following recommendations are made:

1. Fuelwood collection should be regulated by government agency
2. Encouragement on private woodlot establishment by investors
3. Intensive mass campaign on tree planting to replaced the already exploited
4. Enlightenment on the dangers as well as the possible future exploitation of fuelwood to both urban and rural populace.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Abebaw D. Household determinants of fuelwood choice in urban Ethiopia: A case study of Jimma town. Journal of Developing Areas; 2007.
2. Sanda AU, Sambo AS, Mikailu AS. Fuelwood consumption pattern in fakai

district: A lesson for rural energy planning and policy in Nigeria. Nigerian Journal of Renewable Energy. 1991;2(1):54-59.
3. Ikurekong EE, Esin JO, Mba AC. Rural fuelwood exploitation in Mbo local government area: A Nigeria coastal settlement. Ethiopian Journal of Environmental Studies and Management. 2009;2(3):44-55.
4. Adeniyi G, Felix O. Socio-economic aspects of fuelwood business in the forest and savanna zones of Nigeria: Implications for forest sustainability and adaptation to climate change. Global Journal of Human Social Science. 2011;11(1):44-56.
5. FAO. Energy demand and fuelwood crisis. FAO Technical Report. Rome; 2000.
6. FAO. Country report and wood production and consumption. FAO Working Document; 2002.
7. Nancy C. Fuelwood issues restated. 1994; 32:44-50.
8. Anthony OO, Ojochenemi IO. Econometric analysis of factors influencing fuelwood demand in rural and peri-urban farm households of Kogi State consilience. The Journal of Sustainable Development. 2012; 8(1):115-127.
9. Garba B, Bashir AM. Managing energy resources of Nigeria studies n energy consumption pattern in selected rural area of Sokoto State. Nigeria Journal of Renewable Energy. 2002;10(1 and 2):97-107.
10. Kyiogwom WB, Rades MJ, Garba B. Economics of household energy consumption and its enviormental implcialtons in a semi-arid area of northern Nigeria. Nigeria Journal of Renewable Energy. 1997;5(1&2):61-63.
11. Abdulrahman FW, Okolo NC. Available energy for cooking an class of users in Sokoto metropolis. Nigerian Journal of Renewable Energy. 2005;13(1 and 2):43-47.
12. Babayara YY, Saleh WT. Urbanization and the choice of fuelwood as sources of energy in Nigeria. J. Hum Ecology. 2010; 31(1):19-26.
13. GPS. Geographic coordinates for Sokoto State. Garmin GPS Device Model 3.02.1; 2015.
14. Awodola AM, Oboho EG. Conditions of deforestation in the semi-arid zone of Nigeria. International workshop on biology and society in the history of the sahel and savannah. Held at University of Maiduguri. 1991;18.
15. Shamaki SB. Fuelwood Collection and Processing in Sokoto State, Nigeria. In: Onyekwelu, J.C., V.A.J. Adekunle and D.O. Oke (eds.). Climate Change and Forest Resources Management: The Way Forward. Proceedings of the 2nd Biennial National Conference of the Forests and Forest Products Society, Akure. 26th-29th, April; 2010.

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