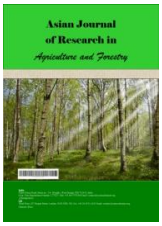

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Assessment of Tree Species for Fuelwood Consumption in Northern Guinea Savannah Eco-region: A Case Study of Selected Local Government Areas of Katsina State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author AIS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MBU managed the analyses of the study. Author MMO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Evaluation of preferred tree species for fuelwood consumption in selected local overnment area of Katsina State was studied. Random sampling techniques was used to administer thirty (30) questionnaire in each of the four (4) selected local government areas to make a total of one hundred and twenty (120) questionnaires. One hundred (100) were retrieved. The result revealed that *Isoberlinia doka* was the most preferred (24%) tree species for fuel consumption because of its high fire retaining capacity, low smoke and low moisture holding capacity while C*assia species* and *Odina barteri* were the least (3% each). The major (70%) source of fuel wood supply to the market was from the forest. Funtua local government consumed more Fuelwood/head/year (64.06t/person/year) than all the other selected local government areas, while Sabuwa had the least (38.64 t/person/year). Fuelwood was the major (33%) energy source while gas (2%) was the

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least. Socio economic characteristics of the respondents were also examined. The percentage of male was 68%, while that of their female counterpart was 32%. Majority (50%) are married with many (35%) having 7-8 house hold size. 37% of the respondents had primary education while 26% had no formal education and majority (42%) were farmers. However, it is recommended that there is need for artificial regeneration of tree species exploited in form of woodlots, community forest plantation for continuous supply of wood on a sustainable bases and also other alternative sources of energy such as kerosene stove, gas cooker, solar etc should be encouraged and subsidized to the general populace to reduce the pressure on forest reserve.

Keywords: Fuelwood; Northern Guinea; eco-region; Katsina; consumption; tree species.

1. INTRODUCTION

Wood is an organic carbon based material that reacts with oxygen in combustion and natural metabolic processes to release heat [1]. Wood biomass may be considered as chemical energy storage from the point of view of utilization because the energy biomass of oxygen system is obtained from solar radiation, which is collected and stored by trees during the process of photosynthesis [2]. Fuelwood can be said to be a source of energy derived by burning wood material like logs and twigs and is common among the rural dwellers. It is a traditional source of energy, which has remained the major source of fuel for over half of the world's population [3,4].

According to UNDP [5], the share of various sources of the primary energy supply in Nigeria is made up of oil - 10.4%; gas - 6%; hydro - 0.6% and commercial renewable energy - 83%. The greater portion of the commercial renewable energy is wood, while other agricultural wastes constitute the remaining smaller portion. The over-dependence on fuelwood for energy is chiefly because of its relatively low price and easy accessibility [6]. Other reasons are the constraints in the supply of the convectional fuels and the growing population with a large segment still falling below income that cannot afford the cost of conventional fuels [6]. In selected local government areas of Katsina State where there is a large poor population, poverty is the most significant parameter that derives extensive traditional use of fuelwood and residue [5]. Fuelwood is consumed in diverse ways and at different levels and the life of the majority of the local dwellers in these local government areas depend either directly or indirectly on the fuelwood. However, meeting rural household wood fuel needs in the country has become a herculean task due to the enormous quantity of wood required. Daily consumption of firewood by the rural communities in Nigeria is estimated at 27.5 million kg/day [7]. This observation was also buttressed by another data published by the Solar Cooking Archive (2011) which put the estimate of Nigeria's fuelwood consumption as a percentage of energy at about 87%. Therefore, majority of Nigerian rural people have been using and will continue to use the dried biomass fuels for energy in many years to come.

Over the years, almost every tree species is used all over the world for fuelwood. In the forest zone (Southern Nigeria), the list of the crop species for fuelwood cannot be completed because different tree species are available. Most of the species have been used for fuelwood as well as for moderation of the other wood products. In savanna zone (Northern Nigeria) more than fifty (50) species are being harvested for fuelwood consumption as well as for production of other wood [1]. The supply of the fuelwood to those who need it today is by far lesser than the demand for it in Western and Eastern Africa, where the rural house hold gather fuelwood themselves while the town dwellers depend on it to a very large extent, and in some towns almost entirely on purchased fuelwood and charcoal. The fuelwood consumed in most African countries especially Nigeria comes from the uncultivated bush, forest reserves and plantation. Nigeria is a country with large fuelwood deficit zones, mainly in the north, while in some southern areas, production exceeds consumption [1,8]. These areas supply the deficit zones. Therefore, a balance between annual re-growth and consumption has to be struck on a national level.

According to the Forest Resources Assessment (FRA) Country's Report (FRA, 2005) and [9] that Nigeria is having a total wood removal from the forests amounted to 86,626,797 m^3 and the removal for fuewood from forests in the year 2005 was 72,710,935 m^3, the difference being made up by industrial round wood, which accounted for 13,915,862 m^3. However, wood may also come from areas outside the forests like scrubland, savanna and grassland as no other data is available on these sources in

Nigeria. A reasonable estimate has to be made based on figures from neighboring countries. But neither from neighboring Benin, Cameroon nor from Ghana data is available. The FRA 2005 Country Report from Senegal however, present data on the growing stock on the other wood land [9] which allows to conclude that the growing stock on "other wooded land" is about 7% of the growing stock in forest. We assume the same percentage to be true for Nigeria. Adding 7% to 86,626,797 m^3 gives 92,690,673 m^3 as the total harvest of wood from forest and other wood land combined. In Nigeria the shares of fuelwood proper and wood for making charcoal is not known. We assume it to be about the same as in Chad that is 78% and 22%, respectively of all the wood used for cooking energy [10].

Eighty percent (80%) of Nigerians reside in the rural areas, while over 90% of these rural dwellers use fuelwood for both domestic and industrial cooking [11,7]. Unchecked sourcing of fuelwood in developing countries results in various ecological problems such as deforestation, desert encroachment, desertification, soil erosion, ozone layer depletion and climate change. This has been substantiated by various researchers [12,13,14,7,1]. The objective of this study is to investigate the preferred tree species for fuel consumption in selected local government area of Katsina State with a view of improving their production through artificial regeneration in form of woodlots, community forest plantation, Agroforestry for continuous supply of the species on a sustainable basis.

2. METHODOLOGY

2.1 Study Area

The study was conducted in four selected (4) local government areas of Katsina State. The Local government were selected on the basis of high rate of poverty level and deforestation due to non-availability and high cost of kerosene and cooking gas in the areas. These local Governments include:

(i) Sabuwa Local Government Area
(ii) Dandume Local Government Area
(iii) Faskari Local Government Area
(iv) Funtua Local Government Area

(i) Sabuwa Local Government Area

Sabuwa local government area is located on latitude 11º48'N and longitude 7º94'E of the equator. The local government share boundaries with Dandume local government to the north and Faskari local government to the west. The local government has a projected population of 136,050 people [15]. It has 400 mm – 1100 mm of rainfall per year, maximum temperature of 41ºC and minimum at 22ºC with a maximum wind speed of 14 km/hr [16].

(ii) Dandume Local Government Area

Dandume local government is located on latitude 11º83'N and longitude 70º16E of the equator. The local government share boundary with Sabuwa local government to the south and Faskari to the east. The local government has a projected population of 145,739 people [15]. It has an annual rainfall between 399 mm – 1999 mm with an average raining day between 90-105. It has mean maximum temperature of 40ºC and a minimum of 21ºC with a maximum wind speed of 14 km/hr. The local government has a relative humidity of 74/14 [16]. The people in the local government grow crops like maize, sorghum, soya beans, yam, cowpea, sugarcane, etc.

(iii) Faskari Local Government Area

Faskari local government is located on latitude 11º48'N and longitude 71º42'E of the equator. The local government share boundary with Bakori to the east, Sebuwa and Dandume to the South. The local government has projected population of 196,035 people with an annual rainfall between 400 mm–11000 mm, average raining day between 90–100 with maximum temperature of 41ºC and a minimum of 22º [15]. The local government has maximum wind speed of 14 km/hr with relative humidity of 73/14 [16]. The people in the local government are farmers and grown crops like cowpea, sugarcane, rice, sorghum, etc.

(iv) Funtua Local Government Area

Funtua local government area is located on latitude 11º51'N and longitude 72º86'E of the equator. The local government area shares boundary with Faskari to the west, Dandume to the south and Bakori to the east. The local government has a projected population of 225,571 people [15] with an annual rainfall of 389 mm – 1099 mm, average raining day of 89 – 103. It has maximum temperature of 40ºC and a minimum of 21ºC with maximum wind speed of 14 km/hr [16]. The relative humidity is 74/14. The people in the local government grow crops

like sugarcane, cotton, yam, pepper, sweet potatoes, cowpea, soya beans, sorghum, millet, maize, etc.

2.2 Data Collection and Source

Primary and secondary data were used for this study. The primary data were collected through the use of questionnaires while the secondary data were collected through the use of journals, textbooks, conference proceedings, etc. The questionnaire for the primary data was designed to elicit the following information:

(i) Socio-economic characteristics of sampled respondents such as age, sex, marital status, education background, etc.
(ii) Species most favored and reasons for their selections
(iii) Sources of fuel wood supply to the respondents
(iv) Reason for selectivity, etc.

2.3 Sampling Procedure

A sampling frame of one hundred and twenty (120) questionnaires were administered in the selected four (4) Local Government Areas with each having (30) questionnaires using random sampling techniques. One hundred (100) questionnaires were retrieved. The four (4) Local Government Areas were selected on the basis of high rate of poverty level and deforestation due to non – availabilility and high cost of kerosene and cooking gas in the areas.

2.4 Analytical Techniques

The following analytical tools were used to analyze the data collected:

(i) Descriptive Statistics
(ii) Formula to calculate consumption per head, per year

2.5 Determination of Fuel Wood Consumption

Consumption/head/year in each of the local government areas were calculated using the formula below:

$$C/h/y = NW_{GI} \times PL_G$$

Where

C/h/y = fuel-wood consumption/head/year
NW_{GI} = National fuel-wood Consumption per head index
PL_G = Population of each selected local government areas

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of the Respondents

Some socio-economic characteristics are known to influence tree species for fuelwood consumption in the selected local government area of Katsina State. The variable analyzed include: age, marital status, gender, educational status etc.

Table 1. Socio-economic characteristics of sampled respondents

Variable	Respondents	Percentage (%)
Age in years		
10 - 20	12	12.0
21 - 30	18	18.0
31 - 40	39	39.0
41 - 50	16	16.0
51 and above	15	15.0
Marital status		
Married	50	50.0
Single	20	20.0
Divorced	10	10.0
Widowed	12	12.0
Widower	08	8.0
Gender		
Male	68	68.0
Female	32	32.0
Educational level		
Primary	37	37.0
Secondary	12	12.0
Tertiary	10	10.0
Quranic	15	15.0
No formal education	26	26.0
Household size		
1 - 2	04	4.0
3 - 4	15	15.0
5 - 6	25	25.0
7 - 8	35	35.0
10 and above	21	21.0
Occupation		
Farmers	42	42.0
Civil servant	10	10.0
Business	30	30.0
Others	18	18.0
Total	100	100.0

Source: [4]

Table 2 revealed that 39.0% of the respondents were between the age brackets of 31 – 40 years.

This implies that they are at the middle and economically active age which could have positive effect on their standard of living. Sodimu, et al. [1] observed that age bracket has a positive influence on preference of fuelwood species. 50% of sampled respondents are married while 25% are single. 68% are male while 32% are female. 37% of the respondents had primary school education, 26% had no form of formal education, 15% had Quranic education, 12% had secondary school education, 10% had tertiary education. This indicates that a great percentage of the respondents in the selected local government area of Katsina State had formal education at various levels. This finding has therefore reflected the importance of education in preference of fuelwood species. Zira and Boni [17] observed that the more individuals are exposed to any form of education, the more likely they will have a better understanding of their environment. However, 35% of the respondents (majority) had a household size of 7-8, 25% have 5-6, 21% had 10 and above which implies high consumption of fuelwood.

3.2 Sources of Fuelwood Supply of Respondents

Various sources of fuelwood supplied to the respondents were observed to influence the preference of the species for fuelwood consumption in the selected study site. The variable analyzed include: market, wood lot and forests.

Table 2 revealed that 70% of the fuelwood consumed in the study area comes from the natural forest, 20% of the fuelwood are purchased from the market while only 10% comes from wood lots. The percentage from the wood lots is minute because neither community forest nor private forest was involved in the supply of fuelwood. This might be attributed to lack of technical knowhow, level of education etc. which resulted in non-engagement in commercial tree planting and wrong timing in forestry planting programmes. However, many of the existing natural forest were being depleted due to the pressure by fuelwood collectors to meet the ever rising demand of fuelwood for domestic uses (cooking). This corroborates with the observation made by Abdullahi, et al. (2018) that the overharvesting of forest (fuelwood) increases with the scale of people's needs.

Table 2. Sources of fuelwood supply of sampled respondents

S/N	Sources	Respondents	Percentage (%)
1	Market	20	20.0
2	Wood lot	10	10.0
3	Forest	70	70.0
	Total	100	100.0

Source: Field Survey, 2018

Table 4 revealed that Funtua local government consumed more fuelwood/head/year (64.06t/ person/year) than all the other local government areas while Sabuwa had the least (38.64t/ person/year). The population of each local government area used was based on the census of 2006.

Table 3. Determination of fuelwood consumption/head/year

S/N	Selected local government areas	Natural consumption per head/index (t / person / year)	Population of each local government areas	Consumption head of each local government (t/p/year)	Area (Km^2)	Density (pop /km^2)
1	Sabuwa	0.284	136050	38.64	642	212
2	Daudume	0.284	145739	41.40	792	184
3	Faskari	0.284	196035	55.67	1750	112
4	Funtua	0.284	225571	64.06	448	504

Source: Field Survey, 2018

Table 4. Use of alternative source of energy

S/No	Sources	Respondents	Percentage (%)
1	Fuelwood	83	83
2	Kerosene	10	10
3	Electricity	5	5
4	Gas	2	2
	Total	100	100

Source: Field Survey, 2018

Table 5. Respondent's preferred tree species for fuelwood consumption

S/No	Botanical name	Local name (Hausa)	Respondents	Percentage (%)	Reasons for preference
1	*Isoberlinia doka Craib & Stapf.*	Doka	24	24	High fire retaining capacity, low smoke, low moisture holding capacity
2	*Acacia species(Houtt)*	Acacia	12	12	High fire retaining capacity, low smoke, low moisture holding capacity
3	*Tamarindus indica Linn.*	Gundagura	8	8	Low fire retaining capacity, low smoke, high moisture holding capacity
4	*Ficus species Blume.*	Dulu	4	4	Low smoke, low fire holding capacity
5	*Eucalyptus species Linn.*	Tuari	15	15	High moisture holding capacity
6	*Khaya senegalensis Ders.*	Mahogany	5	5	Low smoke, low fire holding capacity
7	*Butrospermum paradoxum (Gaertn.f.)*	Dyiya	5	5	High fire retaining capacity, low smoke, low moisture holding capacity
8	*Anogeissus leiocerpus (DC) Gull & Perr.*	Merike	7	7	High fire retaining capacity, low smoke, low moisture holding capacity
9	*Danielia oliveri Rolfe.*	Ogea	8	8	Low fire retaining capacity, low smoke, high moisture holding capacity
10	*Cassia species (Lam)*	Cassia	3	3	Low smoke, low fire holding capacity
11	*Prosopis Africana (Gull & Perr) Taub.*	Kiriya	6	6	Low fire retaining capacity, low smoke, high moisture holding capacity
12	*Odina barteri (Oliv.)*	Faru	3	3	Low smoke, low fire holding capacity

Source: Field Survey, 2018

However, there are direct relationships between human population and wood fuel demand, hence, the cutting down of wetwood can be said to be on the increase. The rate of consumption of fuelwood in Nigeria exceeds the rate of production (Yusuf, 2002). It is therefore right to say this renewable source of energy would sooner or later be scarce, should this form of exploitation continue.

3.3 Uses of Alternative Source of Energy

Alternative source of energy in the selected local environment were also analyzed. The alternative types of energy assets include: fuelwood, kerosene, electricity and gas.

Table 4 shows that majority of the respondent (83%) are using fuelwood as source of energy. 10% uses kerosene, 5% electricity and 2% uses gas. Reason given by the respondents was that, fuel-wood is a free gift of nature, very cheap and easy to come-by compared to other sources of energy.

3.4 Respondents Preferred Tree Species for Fuelwood Consumption

Preferred tree species for fuel consumption in the selected local government areas were analyzed. Some of the factors considered for the selection include:

(i) Fire retaining capacity of the wood (low/high)
(ii) Smoke ability of the wood (low/high)
(iii) Fire holding capacity of the wood (low/high)
(iv) Availability (readily, scarce, available, etc.)

Table 5 revealed that *Isoberlinia doka* was the most preferred (24%) tree species for fuelwood consumption. The selection of the tree species was attributed to its high fire retaining capacity, low smoke and low moisture holding capacity. The characteristic of the selection is in accordance with FAO [18]. This species is closely followed by *Eucalyptus species* (15%), *Acacia species* (12%) while *Cassia species*, *Odina barteri* are the least preferred with 3% each.

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Isoberlinia doka, Acacia species and *Eucalyptus species* are the most preferred tree species for fuelwood in the study areas. The preference of these was due to their high level of fuel, low smoke level, density and ease of establishment. Alternative source of energy are either too costly or not available which makes majority of the people to rely solely on fuelwood consumption. Quantity of the fuelwood consumed/head/year in each of the selected local government is an indication that people had inherited the habit of fuelwood consumption which makes it difficult for them to accept changes easily. However, majority of the fuelwood collected was from the natural forest and only a few people replaced the trees after cutting.

4.2 Recommendation

Based on the study, the following recommendations were made:

(i) Other alternative sources of energy such as use of kerosene stove, gas cooker, solar, etc. should be encouraged and subsidized to reduce pressure on the forest estate (fuelwood).
(ii) There is need for artificial regeneration of tree species exploited in the form of woodlots, community forest plantation, etc. for continuous supply of fuelwood on a sustained basis.
(iii) Farmers should be encouraged to interplant forest crops with forest trees in form of agroforestry system to increase supply of fuelwood to the general populace.
(iv) More funds should be channeled to the forestry sectors through their relevant ministry and Forest Research Institute for establishment and management of fast growing tree crops for woodlots.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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