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Rural Dwellers' Perception of Effect of Charcoal Production on the Environment in Guinea Savannah Zone of Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author POE designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SOO managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Despite the law promulgated by the Federal Government of Nigeria prohibiting illicit felling of trees, the number of charcoal producers is on the increase coupled with a sharp rise in the quantity of charcoal produced with its attendants environmental consequences. Thus, this study investigated rural dwellers' perception of the effect of Charcoal Production (CP) on the environment in Guinea Savannah Zone of Nigeria. Eighty five respondents were selected through multistage sampling procedure. Data were collected through the use of structured interview schedule and were analysed, using both descriptive and inferential statistics. Findings show that the mean age of charcoal producers was 43 years. Majority (90.5%) was males, 90.6% of the charcoal producers were married and 35.3% had no formal education. Majority (80.0%) of the respondents made use of earth mound method of CP and 52.9% of them produced between 32 kg and 32000 kg of charcoal per annum. Most of the respondents (62.7%) perceived that charcoal production could lead to erosion,

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while 62.4% of them perceived that charcoal production would not only reduce the available trees for future use but also reduce the available air in the environment (54.1%). Regression result showed that farming activities (β= 0.305), farming system (0.301), years of experience (β= 0.365) and sources of trees (β= 0.280) were implicated in the level of perceived environmental effects of charcoal production in the study area. Thus, high level of perceived environmental effects of charcoal production was recorded. Therefore, charcoal producers should be educated on the effects of CP on the environment and to participate actively in the replacement of trees.

Keywords: Charcoal production; farming system; deforestation; rural dwellers.

1. INTRODUCTION

In developing countries, the pressure on natural resources is more acute because nearly 70% of the populace are involved in subsistence-based ventures and live in the rural communities [1]. According to Charcoal Production in South Africa [2], both men and women are involved in different stages of charcoal production to make ends meet. Thus, reliance on natural resources for food and energy implies that people source for their daily needs from their immediate environment [3]. Half of the world's population use biomass fuels for cooking and heating and the world's production of fuelwood increased between 1970 and 1995 from 1362.4 million^3 to 1875.9 million^3[4].

It is worth noting that some countries like China, Kenya, France, and Italy, have moved towards developing other sustainable means of getting energy and preserving their forests. Ref. [4] observed that wood consumption for fuel in Africa is about 520 million^3 per year. About 70% of these fuel woods are consumed in Nigeria, Ethiopia, Democratic Republic of Congo, Kenya, Tanzania, Ghana, Sudan, Mozambique and Uganda. Nigeria tops the list in Africa with 231,479.7 ton^5 in 1992 and 377,630.0 tons^5 in 2009. The high dependence on the production and use of charcoal has resulted in environmental degradations during production [5].

Deforestation as a result of charcoal production has negative implications for the local and global environment [6]. It can lead to erosion, threaten biodiversity and accelerate climate change. The reduction of forest cover also reduces the existing capacity to disintegrate carbon, and release the already fixed carbon. Emissions during charcoal production are significant resulting in various environmental problems. Many African nations have had over three quarters of their forest cover depleted. Moreover, the global warming potential of current and largely inefficient methods of charcoal production (pyrolysis) is considered to be higher than that of emissions during combustion [7].

Charcoal production in recent time is responsible for large scale felling of wood which may lead more directly to deforestation. Ref. [8] emphasized that in Africa, more trees had been felled to make way for agricultural or livestock purposes than is used for fuel, and that about 80% of charcoal wood is taken from land clearing.

According to [9] while considering the rate of deforestation in tropical regions, estimates of global humid tropical forest area change for the period 1990-1997 were produced for four regions: (1) Pan Amazon and Central America, (2) Brazilian Amazonia and Guyanas, (3) Africa, and (4) Southeast Asia. The annual deforested area for the humid tropics is estimated at 5.8 ± 1.4 million hectares with a further 2.3 ± 0.7 million hectares of forest where degradation can be visually inferred from satellite imagery. Ref. [10] opined selectivity of trees for charcoal production has reduced to between 11 and 15 species in the guinea savannah zone of Nigeria.

As a result of the agitation for agricultural transformation in Nigeria, the need for rural energy development has been on the increase in the last two decades [11]. Data on various issues of production, quantity and environmental effects of charcoal production in Nigeria are not sufficiently available and these have had adverse effects on the various development plans for the energy sector in particular and the country in general.

Charcoal production is very prominent in Benue, Kogi and Niger States of Nigeria where there are guinea belts that support its production .Forests are decimated; economic trees meant for fruit production are felled for charcoal production and farm lands have been used excessively without

considering its future implications on the environment.

However, the potentials of this agro-ecological zone to support charcoal production are questionable. It is pertinent, therefore, to examine various issues of charcoal production and their effects on the environment.

1.1 Objectives of the Study

The general objective of the study was to assess the perceived environmental effects of charcoal production among the rural dwellers in guinea savannah zone of Nigeria. The specific objectives were to; identify the selected socio-economic characteristics of charcoal producers in the study area; assess the methods used in charcoal production in the study area; determine the level of charcoal production in the study area; and ascertain the perceived effects of charcoal production on the environment of rural dwellers of the study area.

2. METHODOLOGY

2.1 Study Area

The study area is the guinea savannah zone of Nigeria (Figs. 1 and 2). This zone is the largest part of the savannah zone and is sometimes divided into the southern guinea savannah which consists of the following States; Benue, FCT, Plataeu, parts of kwara State and Niger States and northern guinea savannah (which consists of Kaduna State). It is the broadest vegetation zone in the country and it occupies almost half of its area. It is located at the centre of the country, extends southwards to southern Nigeria and pushes northward beyond Zaria. It covers an area that has 100 – 150 cm of annual rainfall and where the wet season lasts for 6 - 8 months. It has trees species such as the false balsam copaiba *(Daniellia oliveri),* used for carving mortars and pestles for pounding yam, *Terminalia, Lophira, Afzeila, Daniellia and Vitex, Khaya senegalensis* (the poor mahogany) are the species found in the guinea savannah. The northern guinea savannah consists of species such as *Isoberlinia doka and I. tomentosa* which formed the bulk of the scattered woodland. Other tree species are locust bean tree *(Parkia filicoidea),* shea butter tree *(Butyrospermum parkii)* and mangoes *(Mangifera indica)*. Comparatively, there are fewer trees in the northern guinea savannah than in the southern guinea savannah. During the rainy season, the whole zone is green and covered with tall grasses that grow and reach maturity rapidly and thus become fibrous and tough. In the dry season they tend to die and disappear and one can see for kilometres. This clearing is due to several periodical bush-burning that occurs during the dry season between November and April, carried out to either assist in farm clearance or hunting. The long period of dry season in this zone favours large scale production of charcoal. The common trees are Acacias, Baobab, and Shea-butter [12].

2.2 Experimental Design

Multi-stage sampling procedure was used to select respondents from the population of charcoal producers in guinea savannah zone. Major charcoal producing communities were identified through snowball. Nine charcoal producing communities were randomly selected. These are Doka, Ubaya, Bida, Borgu, Edati, Katcha, Awajir, Layun, and Obi communities. Fifty percent (50) of the rural communities in the zone were selected using simple random sampling technique. For good representation and ease of locating the respondents, 30% of 283 from the registered charcoal producers were selected using simple random sampling technique. A total of eighty five charcoal producers were used as respondents for this study. A Likert-type five point rating scale of “strongly agree” to “strongly disagree” (with scores 5-1 for 9 positively worded statements and 1-5 for 9 negatively worded statements respectively), respondents were requested to indicate their opinion on each of the 18 selected statements about perceived environmental effects of charcoal production among rural dwellers in the study area. The mean of each question was calculated by multiplying each frequency of the rating scale by the rating score and sum together. Then, divide the total by N, where N=85.The instrument was pre-tested in Katsina State and split-half method was employed to analyse the result for the reliability of the instrument. A correlation co-efficient of r = 0.74 was obtained and the instruments were considered good enough.

2.3 Data Analysis

Data collected were analysed using SPSS (version 17.0) statistics for descriptive, paired samples t-test regression and correlation coefficient r=Cov (x,y)/. A paired t-test was used to compare the means of the positive and negative statements.

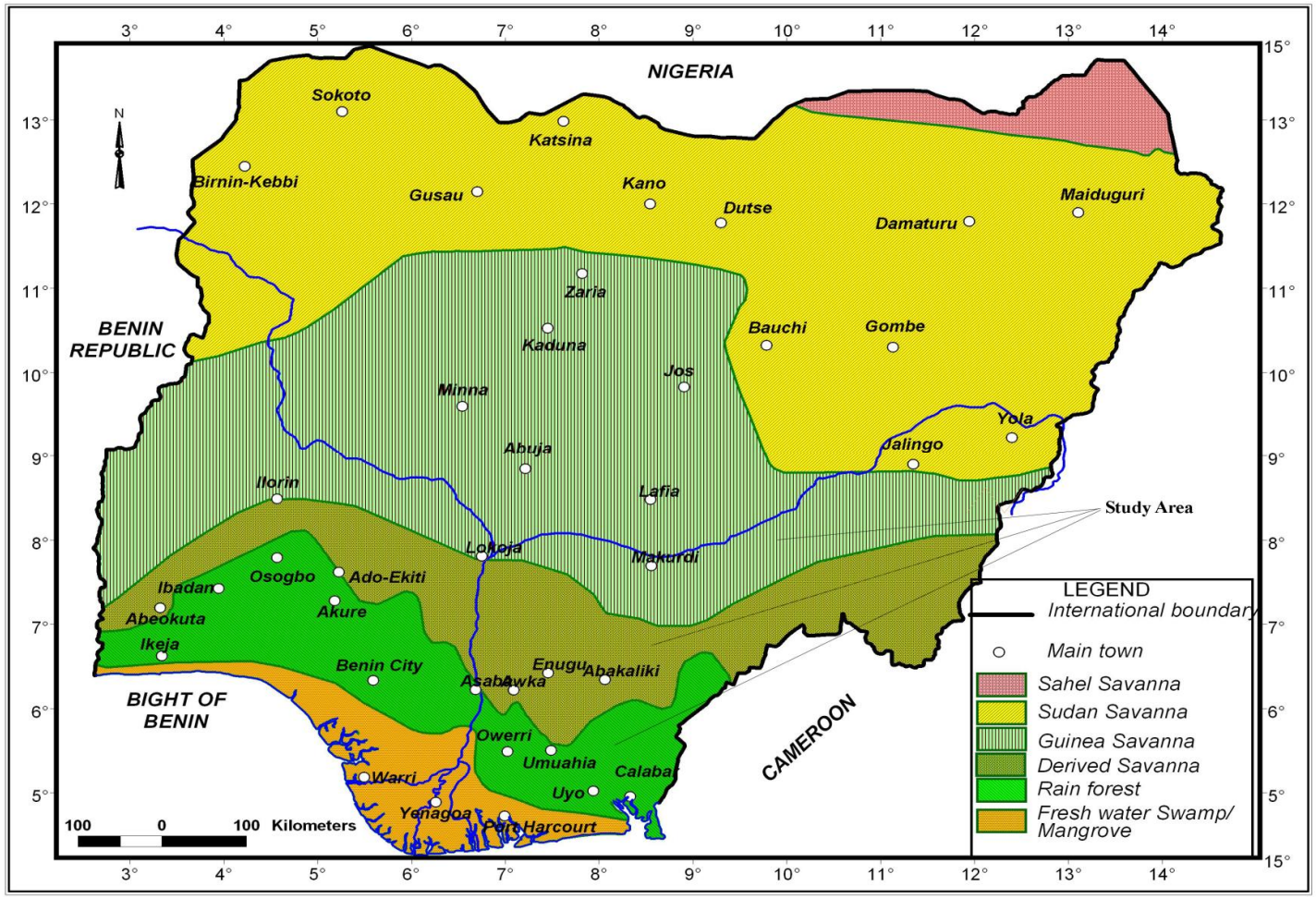

Fig. 1. Map of Nigeria showing the agro-ecological zones

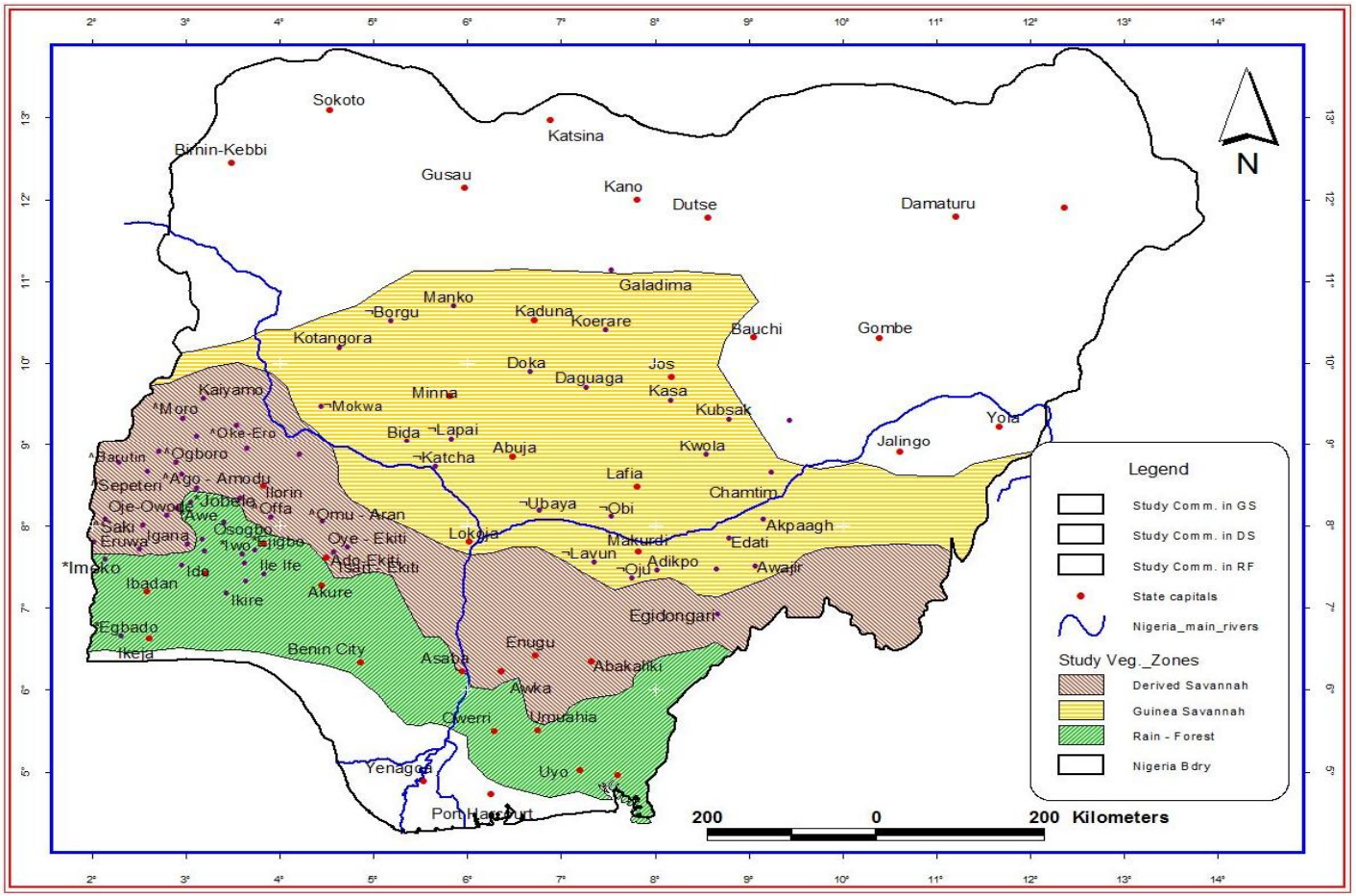

Fig. 2. Map of Nigeria showing major charcoal producing communities in the agro-ecological zones

Where:

r= indicate the direction and strength of the linear association between x and y variables.
X= independent variable
Y= dependent variable

The data were analysed at 0.05 level of significance.

Multiple regressions were used to determine the effects of the independent variables on the dependent variable. The model was expressed as:

$Y=a+b_1X_1$..... ..... $_+b_nX_n + e$

Where Y= Level of perceived environmental effects of charcoal production (score value) a=constant term

b_1 b_2…..b_n = Regression coefficients
e = error
X_1 X_2 …X_n= Regression parameters which are
X_1= Age (in years)
X_2= Sex (M=1, F=0)
X_3= Marital status
X_4= Educational attainment
X_5= Primary occupation
X_6= Secondary occupation
X_7 = Farming activities (score value)
X_8 = Farming system (score value)
X_9= Income from charcoal production (score value)
X_{10} = Source of trees
X_{11}= Membership registration
X_{12}= Household size
X_{13}= Means of transportation
X_{14}= Years of experience
X_{14}= Source of labour

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of Respondents

Table 1 indicates that mean age of respondents was 43 years. This shows that they are in their productive ages. Sex is a vital variable on issues relating to livelihood strategies. Majority (90.5%) of respondents were males. This result is not in consonance with the study of [13], which reported that charcoal production appears to be dominated by young men. Majority (90.6%) of respondents were married, 35.3% of the respondents had no formal education, 30.0% attended Koranic School and 20.6% had primary school leaving certificate. In this zone, 49.4% had crop farming and 35.3% fishing as primary occupation while, 82.4% had charcoal production as secondary occupation. Ref. [14], in a related study, noted that farmers have tendency to be involved in charcoal production because they clear lands which provide easy access to wood for charcoal production. Also, 47.0% made use of pick up vans, 52.9% had household size of between 6 and 10, 65.9% made use of family labour. Mean annual income from charcoal production was ₦135,929.4 (906.2 dollar) with standard deviation (SD) of 55,911.4. An average of (56.5 percent) earned between ₦101,001 and ₦200,000 per annum. In addition, almost all charcoal producers carried out land clearing, weeding, stumping and burning while, 96.6% practiced shifting cultivation and 38.8% practiced mono cropping. More than a half of the charcoal producers did not register with the charcoal association and 83.5% and 100.0%) sourced trees from natural vegetation and agricultural land, respectively.

3.2 Methods of Charcoal Production

Table 2 shows that 80.0% of the respondents made use of earth mound method of charcoal production while 20.0% made use of the pit method. This suggests that earth mound is very prominent in zones. In a related study by [15], surface (earth mound) method was found to be the most commonly used method of charcoal production in many parts of Nigeria because it is less labour intensive.

3.3 Respondents' Annual Output from Charcoal Production

The data in Table 3 reveal that slightly greater than half (52.9%) of the respondents produced between 32 kg and 32000 kg of charcoal per annum while 41.2% produced between 32,032 kg and 64,000 kg. This implies that the quantity of charcoal produced per annum is at an average level. Ref. [2] inferred that the output from charcoal production depends on the season, availability of water, types of wood, vegetation and occupation of the producer. However, all these variables relatively support charcoal production in the study area.

Table 1. Socio-economic characteristics of charcoal producers

Socio-economic characteristics	Freq.	%	
Age (Years)			**Age mean=43, SD=8.0**
25-34	8	9.5	
35-44	41	48.1	
45-54	26	30.5	
More than54	10	11.9	
Sex			
Male	77	90.5	
Female	8	9.5	
Educational attainment			
Non formal educ.	30	35.3	
Koranic school	26	30.0	
Pry. School	17	20.6	
Sec. school	12	14.1	
Marital status			
Married	77	90.6	
Single	5	5.9	
Widow	2	2.3	
Divorced	1	1.2	
Primary occupation			
Crop farming	42	49.4	
Fishing	30	35.3	
Charcoal production	12	14.1	
Trading	1	1.2	
Sec. occupation			
Crop farming	14	16.4	
Charcoal production	70	82.4	
Weaving	1	1.2	
Years of experience			**M=14, SD=4.2**
<5years	6	7.1	
6-10	6	7.1	
11-15	39	45.8	
>15	34	40.0	
Annual income from charcoal production			**M=217,336.4 SD=99,571.4**
Less or equal ₦100.000.00	20	23.5	
100.001-200.000.00	48	56.5	
200.001-300.000.00	16	18.8	
300.001400.000.00	1	1.2	
Household size			
<6	23	27.1	
6-10	45	52.9	
11-15	17	20.0	
Source of labour			
Hired labour	29	34.1	
Family labour	56	65.9	
Membership registration			
Registered	30	35.3	
Non-registered	55	64.7	

Table 2. Distribution of respondents based on methods of charcoal production

Methods of charcoal production	Freq.	%
Earth mound	68	80.0
Pit method	17	20.0
Total	85	100.0

Table 3. Distribution of respondents based on the annual output from charcoal production

Total quantity per annum in kilogram: 32 kg= 1 bag	Freq.	%
32 kg and 32,000 kg	45	52.9
32,032 kg and 64,000 kg	35	41.2
64,032 kg and 96,000 kg	-	-
96,032 kg and 128,000 kg	1	1.2
More than 128,000 kg	4	4.7
Total	85	100.0

3.4 Perceived Effects of Charcoal Production on the Environment

Table 4 reveals that 64.7% and 62.4% of the respondents strongly agreed respectively that charcoal production could lead to erosion and continuous involvement in charcoal production may reduce the available trees for future use. About 55.3% said that if charcoal production continued it might reduce production of crops. In addition, 54.1% and 47.1% strongly agreed respectively that charcoal production might reduce available air in the environment and might reduce water availability in the environment. Whereas, 44.7% said charcoal production might have negative effects on the fertility of agricultural lands respectively.

This implies that the respondents perceived that charcoal production could lead to deforestation, charcoal production might have negative effects on the fertility of agricultural lands, continuous involvement in charcoal production might reduce the available trees for future use, charcoal production could expose land to erosion, charcoal production might reduce water availability in the environment, micro-organisms might be threatened because of charcoal production, flooding is always enhanced during charcoal production, charcoal production might reduce air availability in the environment, charcoal production could lead to loss of organic matter in the soil, ashes from charcoal production might not be useful to the environment, soil fertility might not be enhanced by not replacing the cut trees and movement of lorries on lands during charcoal production might compact the soil. Ref. [16,17,18], (some self citations deleted) noted that in most African countries where charcoal production is predominant, problems and challenges such as ecosystem degradation; deforestation, increased erosion, infertile land, low crop yield, acceleration of climate change and threatened biodiversity are consequences of charcoal production. Based on this outcome, the expectation should be a stop to charcoal production. However, focus group discussion revealed that poverty and lack of high paid jobs made rural dwellers to ignore the implications of the perceived effects of charcoal production on the environment, despite the fact that the government and allied government agencies such as the environmental department, agricultural extension sector guide and campaign are against indiscriminate felling of trees. This implies that there is no enforcement of the laws guiding the use of forest resources.

3.5 Positive and Negative Responses on Perceived Effects of Charcoal Production on the Environment

Table 6 reveals that there was significant difference between only question 8 among the positive and negative questions the respondents attended to on the perceived effects of charcoal production on the environment (t=0.004). However, there were no significant differences among questions 1 to 7 and 9. This implies that questions 1 to 7 and 9 were similar (replica of each other) after transformation of the responses scores.

3.6 Result of the Regression Analysis Showing the Contributions of the Selected Socio-economic Characteristics to Perceived Environmental Effects of Charcoal Production in the Guinea Savannah Zone of the Study Area

Table 7 shows that farming activities (β= 0.305), farming system (β=0.301), years of experience (β= 0.365) and sources of trees (β= 0.280) were important explanatory variables that informed perceived environmental effects of charcoal production by the respondents in the study area.

Household size (β=-0.258) and membership of association (β=-0.172) were negatively related to level of perceived environmental effects of charcoal production. This implies that the lesser the household size, the more their perceived environmental effects of charcoal production since they have to use hired labourers who will produce charcoal in large quantity. The result shows coefficient of determination of 0.627 which implies that all the socio-economic characteristics considered for the study contribute only 63.0% to perceived environmental effects of charcoal production.

Table 4. Distribution of the respondents according to perceived effects of charcoal production on the environment

S/N		Guinea savannah zone N=85										
Statements on environmental related problems (Positive questions)		SA		A		U		D		SD		MEAN
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	
1	Soil fertility could be enhanced by replanting cut trees	58	68.2	25	29.4	-	-	2	2.4	-	-	4.61
2	Charcoal production may have negative effects on the fertility of agricultural land	38	44.7	10	11.8	2	2.4	19	22.4	16	18.8	3.41
3	Continuous involvement in charcoal production may reduce the available trees for future use.	53	62.4	32	37.6	-	-	-	-	-	-	4.62
4	Having more trees on land may not improve the quality of air and water	-	-	1	1.2	-	-	38	44.7	46	54.1	1.48
5	Charcoal production could expose land to erosion	55	64.7	7	8.2	1	1.2	4	4.7	18	21.2	3.90
6	If charcoal production continues it may reduce production of crops	47	55.3	32	37.6	-	-	2	2.4	4	4.7	4.36
7	Charcoal production may reduce water availability in the environment	40	47.1	23	27.1	-	-	4	4.7	18	21.2	3.74
8	Flooding is always enhanced after charcoal production	51	60.0	28	32.9	1	1.2	3	3.5	2	2.4	4.45
9	Charcoal production may reduce air availability in the environment	46	54.1	20	23.5	-	-	3	3.5	16	18.8	3.90

Table 5. Distribution of the respondents according to perceived effects of charcoal production on the environment

S/N		Guinea savannah zone N=85										
Statements on environmental related problems (Negative questions)		SA		A		U		D		SD		MEAN
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	
1	Micro-organisms may not be threatened because of charcoal production activities	19	22.4	4	4.7	-	-	22	25.9	14	47.1	2.17
2	Charcoal production may encourage quick regeneration of plants	16	18.8	7	8.2	1	1.2	24	28.2	37	43.5	1.63
3	Movement of lorries on lands during charcoal production may not compact the soil	15	17.6	1	1.2	-	-	29	34.1	40	47.1	3.92
4	Charcoal production may not necessarily change rainfall pattern	16	18.8	2	2.4	-	-	35	41.2	32	37.6	3.76
5	Charcoal production could increase the fertility of soil	16	18.8	17	20.7	1	1.2	14	16.5	37	43.5	3.46
6	Charcoal production could not lead to deforestation	23	27.1	3	3.5	-	-	26	30.6	33	38.8	3.50
7	Charcoal production may not lead to immense land degradation.	32	37.6	22	22.9	-	-	12	14.1	19	24.4	2.57
8	Charcoal production could increase organic matter in the soil	2	2.4	-	-	-	-	39	45.9	44	51.8	4.44
9	Ashes from charcoal kiln can be useful to the environment	4	4.7	7	8.2	-	-	28	32.9	46	54.1	4.23

Table 6. t- Test of mean positive and negative responses on perceived effects of charcoal production on the environment

Statements	Mean positive response	Mean negative response	t- value	Sig
1	4.61	2.17	- 0.17	0.891ns
2	3.41	1.63	-1.21	0.439ns
3	4.62	3.92	1.91	0.306ns
4	1.48	3.76	-0.86	0.548ns
5	3.9	3.46	0.36	0.778ns
6	4.36	3.5	0.77	0.585ns
7	3.74	2.57	-0.76	0.586ns
8	4.45	4.44	169.0	0.004*
9	3.9	4.23	2.82	0.217ns

**significant at p ≤ 0.05 t – value and significant level; 0.004 is highly significant at 99.996 % confident limit*

Table 7. Regression analysis showing the contributions of the selected socio-economic characteristics to perceived environmental effects of charcoal production in the guinea savannah zone R^2 =0.627

Variables	B	B	t-ratio	Significant
(Constant)	-0.739	-	-0.817	0.416
Age	0.010	0.088	0.899	0.372
Farming activities	0.389	0.305*	3.399	0.001
Farming system	1.487	0.301*	2.902	0.024
Sex	-0.087	-0.029	-0.332	0.741
Marital status	0.168	0.104	1.192	0.237
Educational attainment	0.121	0.145	1.651	0.103
Primary occupation	0.037	0.055	0.402	0.689
Secondary occupation	0.008	0.011	0.106	0.916
Years of experience	0.377	0.365*	3.001	0.004
Household size	-0.331	-0.258*	-2.710	0.008
Source of labour	-0.356	-0.193	-1.569	0.121
Membership registration	-0.301	-0.172*	-2.021	0.047
Income from charcoal production	1.602E-6	0.102	1.197	0.235
Sources of trees	0.310	0.280*	2.800	0.020

4. CONCLUSION

The study shows that males were predominant in charcoal production and they took the activity as a secondary occupation. They sourced woods from both natural vegetation and agricultural lands. Bush burning and shifting cultivation contribute to charcoal production. The respondents perceived that charcoal production could lead to deforestation, flooding, have negative effects on the fertility of agricultural lands, reduce the available trees for future use, expose land to erosion, reduce water availability in the environment, may threaten micro-organisms, reduce air availability in the environment, lead to loss of organic matter in the soil and movement of lorries on lands during charcoal production and may compact the soil. Charcoal production, therefore, was perceived to cause serious environmental problems that should be discouraged. It is therefore recommended that there is need for stringent natural resources management measures through enforcement of the law that guide the use of the forest resources; such a law that will help to curb and recommend selective/controlled felling of trees. On the credit side, charcoal production is important to the economy of Nigeria as well as to the producers. However, considering its side effects, tree plantation should be embarked upon by the three tiers of government. In addition, an active commission

should be set up which could be tagged "Tree Replacement Commission of Nigeria". Charcoal producers should be encouraged and forced to participate in the replacement of trees. Seedlings of trees should be supplied to rural dwellers on time and in large quantity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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