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SPECIES SELECTIVITY FOR CHARCOAL PRODUCTION IN THREE ECOLOGICAL ZONES OF NIGERIA

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ABSTRACT

Several factors influence the quantity of charcoal production in different parts of Nigeria. The study investigated species selectivity for charcoal production in three ecological zones of Nigeria. Data were obtained through the use of structured interview schedule administered to three hundred and twenty seven respondents selected through snowball. The data were subjected to descriptive and analysis of variance. The results show that the mean age of respondents was 44, male (88.1%), primary school leaving certificate (42.2%), married (92.0%), respondents with charcoal production as primary occupation is 41.0%. Mean for years of experience was 13 years and income mean from charcoal per annum was ₦217,336.4. Respondents made use of earth mound method to produce charcoal. Major source of trees for charcoal production is natural vegetation. Mean for number of trees spp. used is 10.6, charcoal yield of trees spp. (mean =7.6), availability of trees spp. (mean =13.2), and emerging trees spp. (mean=7.1). Charcoal is produced in both dry and wet season with average of 16,000kgs/annum. Analysis of variance inferred that there are significant differences between source of trees for charcoal production (F= 3.951), number of trees spp. used (F=173.824), charcoal yield of trees spp. (F=238.062), availability of trees spp. (F= 47.413) and emerging trees spp. (F=208.192). More foresters/environmental extension agents should be employed and equipped to monitor the activities of rural dwellers in the forest. Forest licensing and fees collection must be restructured, re-orgarnised and increased to prevent illegal logging.

INTRODUCTION

Charcoal production has been a major activity in both the rural and urban communities of Nigeria with the use of various methods and trees species available in each ecological zone. Globally, the use of woodfuels has been growing in line with population growth, so that the annual growth in demand is between 3 and 4 percent depending on the country (Amous, 2000). During the past two decades, a better understanding of wood energy systems has led to the recognition that supply sources are more diversified than was once assumed, including not only forest areas but also trees outside forests. Increased demand for charcoal within and outside the country have made the producers to be looking for various ways of meeting the challenges of selecting numerous trees species for charcoal production, some of which are of high and low yield.

Charcoal is often traditionally made from species that yield a dense, slow-burning charcoal. These species are slow growing and are therefore particularly vulnerable to overexploitation (World Bank, 2000). While less dense charcoal may have different physical properties, there is no difference in energy terms. Since charcoal is marketed by volume (piles, sacks, etc.), a heavier product gives consumers the impression of buying more. Although dense charcoal does indeed hold more energy by volume, this is not the case by weight. Where the use of alternative species for charcoal production is promoted it is going to influence the yield of charcoal as well as its quality.

In those places where charcoal serves as cooking fuel in a given country, the speedy introduction of procedures encouraging the use of light charcoal (sale by weight, quality-based prices, control over the species used, etc.) could limit overexploitation and encourage production from plantation species, to the considerable benefit of the environment and consumers (CIRAD, 1999). There is no much professional training and supervisory measures that could also help reduce the current pressure on species selectivity for charcoal production in Nigeria.

It has been noted that trees of high quality charcoal yield are location specific (Songsore, 2003). Thus, consumers will want to prefer buying charcoal with better combustion and cooking ability (Kammen*et al*., 2005). The quest to meet daily demand for charcoal supply have also made the producers to identifying and using economic trees that have long been preserved and have other better usage than for charcoal production (World Bank, 2000). One of the major factors that encourage this is high rate of poverty among the rural dwellers. For instance, in places where high consumption and strong market supply for charcoal are sources of livelihood, this put strong pressure on existing trees resources because of high population density, low income and/or severe climate conditions which eventually result into deforestation problems (World Bank, 2000).Weak policies on forestry resources have equally allowed uncontrolled felling of trees from the forest (SEI, 2002). Hence, the study attempted to assess species selectivity for charcoal production in three ecological zones of Nigeria.

METHODOLOGY

The study was carried out in three agro-ecological zones of Nigeria. Nigeria with a population of 140,003,542 (NPC, 2006) shares land borders with the Republic of Benin in the West, Chad and Cameroon in the east, and Niger in the north. Its coast lies on the Gulf of Guinea in the south with border Lake Chad to the northeast. Nigeria has an area of 923,768,00sq metres and lies between Latitudes 4^{o} to 14^{o} North and between Longitudes 2^{o}2’ and 14^{o} 30’ East. This is entirely within the tropical zone. Nigeria climate varies from the tropical at the coaster to sub-tropical further inland with two marked seasons. The rainy season begins from April to October and the dry season from November to March. Absolute maximum temperature in the coaster areas of the South is 37^{0}C while the absolute

minimum temperature is 10^0C. The climate is drier further north where extreme of temperature ranges from 45^0 to 06^0 are common.

The population of this study comprises of all charcoal producers in the three ecological zones of Nigeria. Multi-stage sampling technique was used to select respondents from the population of charcoal producers in the three ecological zones of Nigeria. From the six (6) ecological zones in Nigeria, fifty percent (50%) of the zones were purposively selected because they have potential for charcoal production. They are Tropical rain forest, Derived savannah and Guinea savannah zones. All the communities where charcoal is produced were purposively selected in each ecological zone, respectively. Fifty percent of rural communities in each ecological zone were selected using simple random sampling technique. Thirty percent of charcoal producers were selected from the population of charcoal producers available in each of the selected communities using simple random sampling technique. A total of three hundred and twenty seven charcoal producers in the selected ecological zones were used as respondents for this study.

Result and Discussion

Table 1.0 indicates that the modal age range is between 35 and 44 years (45.1%) with a mean age of 44 years. Across the vegetation zones, respondents were within the same age range of between 35 and 44 years old. This result is in consonance with the study of Stockholm Environment Institute (SEI) (2002), which reported that charcoal production appears to be dominated by the active age-range of between 35 and45years.Majority (88.0%) of respondents were males. In a related study by CHAPOSA (2002), it was revealed that 70.0% of charcoal producers were males, while Falco (2007) indicated that a high number of women in charcoal production were not expected due to the physical nature of the activity. Moreover, 92.0% of respondents were married. This implies that lot of money is being realised from the sale of charcoal. Also, 48.0% completed primary education and 30.3% had no formal education. Kammen*et al* (2005) in a similar study revealed that majority of the people involved in charcoal production in sub-Saharan Africa countries are not formally educated, hence they fit into charcoal production. Furthermore, 41.0% of respondents had charcoal production as primary occupation. Shacklon*et al* (2006), in a related study, noted that those who have farming as their primary income generating activity have the tendency to be involved in charcoal production activities because they clear lands which provide easy access to wood for charcoal production. The mean for the years of experience is 13, ±4.9. The modal class of respondents' years of experience was within the range of 11-15 years (39.8 %) whereas 35.1 percent of respondents have more than 15 years of experience in charcoal production. The mean of the annual income from charcoal production activities is ₦217, 336.4 (1448.9 dollar), ± 99571.4. Across the vegetation zones, rain forest mean is ₦ 190,421.9 (1269.5 dollar), ± 55819.4, derived savannah mean is 274,905.6 (1832.7 dollar), ± 99480.7 while the mean for the guinea savannah is ₦135929.4(906.2 dollar), ± 55911.4. Moreover, Kalumiana (2000) infers that 70.00% of the cash income was realised annually in Tanzania in an area

suitable for charcoal production while 20percent of cash was realised in areas with low availability of trees.

About 44.6% of respondents have household size of between 6and10, while 31.2% have between 11and15 persons with 8 as the mean household size. Majority of respondents (51.7%) made use of family members while 48.3% made use of hired labour in charcoal production activities.

Table 5.1: Socio-economic Characteristics of Charcoal Producers

Socio-economic characteristics	**Rain forest zone Age mean=46 Std dev.=9.3**		**Derived savannah zone Age mean=44 Stddev=8.2**		**Guinea savannah zone Age mean=43 Std dev.=8.0**		**Total respondents Age mean=44 Std dev.=8.5**	
Age (Years)	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
25-34	7	8.4	8	5.0	8	9.5	23	7.0
35-44	29	35.0	78	49.1	41	48.1	148	45.1
45-54	26	31.3	51	32.1	26	30.5	103	31.4
More than 54	21	25.3	22	13.8	10	11.9	53	16.5
Sex								
Male	73	88.0	138	86.8	77	90.5	288	88.1
Female	10	12.0	21	13.2	8	9.5	39	11.9
Educational Attainment								
No formal educ.	28	33.7	42	26.4	30	35.3	100	30.6
Koranic school	7	8.4	10	6.3	26	30.0	43	13.2
Pry. School	35	42.2	86	54.1	17	20.6	138	42.2
Secondary s	11	13.3	15	9.4	12	14.1	38	11.6
OND and above	2	2.4	6	3.8	-	-	8	2.4
Marital status								
Married	75	90.4	149	93.7	77	90.6	301	92.0
Single	5	6.0	7	4.4	5	5.9	17	5.2
Widow	3	3.6	3	1.9	2	2.3	8	2.4
Divorced	-	-	-	-	1	1.2	1	0.4
Primary occupation								
Crop farming	45	54.2	25	15.7	42	49.4	112	34.3
Fishing	9	10.8	-	-	30	35.3	39	11.9
Charcoal production	11	13.3	111	69.8	12	14.1	134	41.0
Trading	14	16.9	8	5.0	1	1.2	23	7.0
Civil servant	-	-	15	9.5	-	-	15	4.6
Hunting	4	4.8	-	-	-	-	4	1.2

Years of experience	**Mean=11 SD=4.3**		**Mean=14 SD=5.4**		**Mean=14 SD=4.2**		**Mean=13 SD=4.9**	
less than5years	9	10.8	17	10.7	6	7.1	32	9.8
6-10years	16	19.4	28	17.6	6	7.1	50	15.3
11-15years	51	61.4	40	25.2	39	45.8	130	39.8
More than15years	7	8.4	74	46.5	34	40.0	115	35.1
Charcoal Income/annum	M=290421.9 SD=99571,4		M=274.905.6 SD=99480.7		M=13.5929.4 SD=55911.4		M=217336.4 SD=99571.4	
≤100.00	-	-	-	-	20	23.5	20	6.2
101.000-200.000.0	38	45.8	30	18.9	48	56.5	116	35.5
201.000-300.000.0	40	48.1	30	18.9	16	18.8	86	26.2
301.000-400.000.0	5	6.1	85	53.4	1	1.2	91	27.8
Household size								
Less than6	22	26.5	34	21.4	23	27.1	79	24.2
6-10	23	27.7	78	49.1	45	52.9	146	44.6
11-15	38	45.8	47	29.6	17	20.0	102	31.2
Sources of labour								
Hired labour	21	25.4	108	67.9	29	34.1	158	48.3
Family members	62	74.6	51	32.1	56	65.9	169	51.7
Total	**83**	**100.0**	**159**	**100.0**	**85**	**100.0**	**327**	**100.0**

Source: Field survey, 2011

Species Selectivity factors for Charcoal Production in the selected Ecological Zones of Nigeria

Table 2.0 shows that 92.4% of the total respondents make use of earth mound method of charcoal production. The inherent advantages of the earth mound method such as conveniences and high yield of charcoal production may be reasons they continue to use the method. According to the World Bank (2008), charcoal is mainly produced with an earth mound technology in most countries of Africa.

Table 2.0 shows that 37.9% of the total respondents made use of between 6 and10 types of trees for charcoal production with a mean of 10 spp. Across the vegetations, 30.2% respondents in derived savannah and 61.2% in guinea savannah zones made use of between 6 and10 types of tree for charcoal production. In the rain forest, 55.4% made use of between 11 and15 types of trees to produce charcoal. The result of this study shows that there are more types of trees that can be used for charcoal production in the rain forest zone than in the other two vegetations. This study agrees with that of Bada *et al* (2009) which listed almost the same types of trees used by charcoal producers in a related study.

Table 2.0reveals that more than fifteen (15) species of trees currently available for production of charcoal as explained by 47.4% of the total respondents. Reflection across the vegetations depicts that 49.4% in rain forest and 71.1% in derived savannah zones had more than fifteen species of trees that are currently available for the production of charcoal, while 51.6% in guinea savannah shows that between 11and15 species of trees are currently available for charcoal production. This is in consonance with the findings of Malimbwi*et al* (2001), who reported that there are more tree species in all the rain forest belts of charcoal producing areas.

Table 2.0 reveals that 48.9% of the total respondents made use of between 6 and10 trees of high yield to produce charcoal with mean of 9 trees. Result across the vegetations shows that 69.9% respondents in the rainforest made use of between 11and15 species of high yield trees to produce charcoal. The study of Malimbwi*et al* (2001) supports this finding that there are better quality (high yield) trees available for charcoal production in the rain forest vegetation. Moreover, high yield trees are gradually going into extinction in the rain forest zone (SEI, 2002).

According to CHAPOSA (2002), charcoal producers are supposed to take wood from the cultivated land (agricultural land) to prevent deforestation of the vegetations. Table 2.0 reveals that 82.0% and 96.6% respondents source the trees used for charcoal production from natural vegetation and agricultural land, respectively. In a related study by CHAPOSA (2002), it was revealed that forest land is the major source of trees for charcoal production. Bada *et al* (2009) in their study observed that arable land is the major source of trees (wood) for charcoal production.

Table 2.0 reveals that 72.5% of respondents have started using between 6 and10 species of emerging trees whereas, 27.5% are using less than 6 emerging trees species. Across the vegetation zones, 88.0%, of respondents in the rain forest zone are using less than 6 species of emerging trees. Higher proportion (93.1% and 72.5%) of respondents are using between 6 and 10 species of emerging trees in the derived and guinea savannah zones of the study area, respectively. This implies that respondents have started using trees that have not been known for charcoal production. Some of these trees which have economic value are supposed to be preserved for their main uses.

Table 2.0: Distribution of Respondents on Species Selectivity for Charcoal Production in the Selected Ecological Zones of Nigeria

Methods used in charcoal production	**Rain forest zone**		**Derived savannah**		**Guinea savannah n=85**		**All respondents n=327**	
	F	**%**	**F**	**%**	**F**	**%**	**F**	**%**
Earth mound	83	100.0	151	95.0	68	80.0	302	92.4
Pit method			8	5.0	17	20.0	25	7.6
Total	**83**	**100.0**	**159**	**100.0**	**85**	**100.0**	**327**	**100.0**

Number of trees spp. Used	**Mean=11.2 Std. dev.=3.1**		**Mean=13.6 Std. dev.=4.3**		**Mean=4.4 Std. dev.=2.7**		**Mean=10.6 Std. dev.=5.3**	
Less than 6	1	1.2	3	1.9	24	28.2	28	8.6
6-10	24	28.9	48	30.2	52	61.2	124	37.9
11-15	46	55.4	10	6.30	9	10.6	65	19.9
more than15	12	14.5	98	61.6	-	-	110	33.6
Total	**83**	**100.0**	**159**	**100.0**	**85**	**100.0**	**327**	**100.0**
Readily Available trees spp.	**Mean=14 Std. dev.=3.7**		**Mean=14.7 Std. dev.=3.9**		**Mean=9.9 Std. dev.=3.5**		**Mean=13.2 Std. dev.=4.2**	
less than 6	-	-	1	0.6	8	9.4	9	2.8
6-10	14	16.9	33	20.8	32	37.6	79	24.2
11-15	28	33.7	12	7.5	44	51.6	84	25.2
more than15	41	49.4	113	71.1	1	1.2	155	47.4
Total	**83**	**100.0**	**159**	**100.0**	**85**	**100.0**	**327**	**100.0**
Charcoal yield of trees	**Mean=10 Std. dev.=2.5**		**Mean=8.2 Std. dev.=2.2**		**Mean=3.9 Std. dev.=0.9**		**Mean=7.6 Std. dev.=3.2**	
less than 6	2	2.4	10	6.3	75	88.2	87	26.6
6-10	23	27.7	127	79.9	10	11.8	160	48.9
11-15	58	69.9	22	13.8	-	-	80	24.5
Total	**83**	**100.0**	**159**	**100.0**	**85**	**100.0**	**327**	**100.0**
Emerging tree spp.	**Mean=4.4 Std. dev.=1.5**		**Mean=8.0 Std. dev.=1.3**		**Mean=7.8 Std. dev.=1.4**		**Mean=7.1 Std. dev.=2.1**	
less than 6	73	88.0	11	6.9	6	7.1	90	27.5
6-10	10	12.0	148	93.1	79	92.9	237	72.5
Total	**83**	**100.0**	**159**	**100.0**	**85**	**100.0**	**327**	**100.0**
Sources of trees for charcoal production								
Personal plantation	-	-	-	-	-	-	-	-
Natural vegetation	21	25.3	100	62.9	52	61.2	173	52.9
Agricultural land	49	59.0	59	37.1	33	38.8	141	43.1
Communal land	4	4.8	-	-	-	-	4	4.8
Buying of wood	9	10.8	-	-	-	-	9	10.2
Total	**83**	**100.0**	**159**	**100.0**	**85**	**100.0**	**327**	**100.0**

Source: field survey, 2011

Respondents' Level of Charcoal Production

Table 3.0 reveals that derived savannah (53.1%) produce the highest quantity of above 128000kg per season, followed by rain forest (30.1%) that produce between 64032Kg and 96000Kg and the guinea savannah (57.6%) with between 32 and 32000kg of charcoal per annum. The implication of the result is that, charcoal production in the derived savannah is usually high during both the

rainy and dry seasons. SEI (2002) in contrast to this study reveals in a study carried out in South Africa that the annual charcoal production was high in the rain forest zone than the derived savannah vegetation zone. It is only in the derived savannah zone of Nigeria that such quantities are possible.

Table 3.0: Distribution of Respondents based on the Level of Charcoal Production in the Selected Ecological Zones

Kilogram of charcoal	Rain forest zone		Derived savannah		Guinea savannah		Total	
Overall total Quantity	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
32 – 32000kg	11	13.3	-	-	45	52.9	56	17.1
32032– 64000	13	15.6	6	3.8	35	41.2	48	14.0
64032– 96000	25	30.1	1	0.6	-	-	32	9.8
96032-128000	5	4.9	67	42.1	1	1.2	72	21.9
More than 128000	30	36.1	85	53.5	4	4.7	119	36.2
Total	**83**	**100.0**	**159**	**100.0**	**85**	**100.0**	**327**	**100.0**

Source: Field survey, 2011

Differences between Species Selectivity for Charcoal Production across the Study Area

Table 4.0 reveals that there is significant differences between number of trees used for charcoal production (F= 173.824), readily available trees for charcoal production (F= 47.413), charcoal yield of trees (F= 238.062), sources of trees for charcoal production (F= 3.951) and emerging trees species (F= 208.192) for charcoal production across the study area at $p<0.05$. This implies that respondent's uses different number of trees for charcoal production and there is more readily available type of trees in each zone than the other. Charcoal yield of trees varies based on the ecological zone and sources of trees of trees are different in each ecological zone. There are more emerging trees species in each ecological than the other.

Table 4.0: Analysis of variance showing the Differences between Species Selectivity for Charcoal Production across the Study Area

Parameter	Df	Sum of square	Mean square	F value	P value	Decision
Number of trees used	2	4674.597	2337.298	173.824	0.000	Significant
Readily available trees	2	1325.683	662.842	47.413	0.000	Significant
Charcoal yield of trees	2	1971.525	985.763	238.062	0.000	Significant
Sources of trees	2	2.525	1.263	3.951	0.020	Significant
Emerging trees spp.	2	799.783	399.892	208.192	0.000	Significant

Source: Field survey, 2011

CONCLUSION

The mean age of respondents was 44 years, mostly males and married with low level of education. Less than 50.0 %41.0% had charcoal production as primary occupation with mean for the years of experience as 13and average annual income from charcoal production as ₦217, 336.4 (1448.9 dollar). Respondents from the derived savannah zone had more income from charcoal production, followed by rain forest and guinea savannah zone. Respondents have household size of between 6and10 and make use of earth mound method of charcoal production. Respondents made use of between 6 and10 types of trees for charcoal production More than fifteen (15) species of trees currently available for production of charcoal. Respondents made use of between 6 and10 trees of high yield to produce charcoal while they source the trees used for charcoal production from natural vegetation and agricultural land. Respondents have started using between 6 and10 species of emerging trees. There are significant differences between number of trees used for charcoal production, readily available trees for charcoal production, charcoal yield of trees, sources of trees for charcoal production and emerging trees species for charcoal production across the study area.

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