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AN EMPIRICAL ASSESSMENT OF THE IMPACT OF CHARCOAL PRODUCTION ON DEGRADATION OF FOREST ECOSYSTEM IN DELTA STATE, NIGERIA

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ABSTRACT

This study assesses the contribution of charcoal production to degradation of the forest ecosystem in Delta State, Nigeria. It aimed to evaluate the catchment area and quantity of logs obtained from the forest vegetation. Data were obtained from a Focus Group Discussion (FGD) and questionnaire, which covered demographic characteristics of the target population, nature, sources, quantity and distance to points of raw materials for charcoal production administered on a sample selected by multi-stage sampling technique. The study reveals that charcoal production leads to the depletion of forests as each charcoal production kiln utilized 117.52 tonnes of logs annually, harvested from 50,272 Km^2 of forest in the area. Quantity of trees harvested for charcoal production was positively related ($r=0.472$, $p<0.01$) to distance to points of harvest. It is recommended that alternative, clean and cheaper sources of energy should be provided to forestall further depletion of the forest vegetation the area.

Keywords: Charcoal production, Ecosystem, Energy resources, Delta State, Forest degradation, Nigeria

INTRODUCTION

Human activities in the rural areas of Nigeria require the production and consumption of various types of energy resources. Energy types commonly consumed in these areas are light and heat. Light energy is used for the illumination of homes at night while during the day the sun energy serves the same purpose. Though the moon sometimes provide illumination at night, the most common source of light are oil lamps, kerosene lanterns and in some cases, electricity from gasoline generators. On the other hand, heat energy is required for both domestic and industrial activities. Heat energy is used to process most products or output of the various primary occupations that predominate in rural areas.

For instance, fishes caught from fishing expeditions, games from hunting, etc. are either cooked or dried before consumption or preservation. Similarly, farm produce are processed by subjecting them to varying degree of heat.

Heat energy utilized in the rural areas is derived from the sun or solar energy which averages about 110kg-cal in the study area (Akintola, 1983). Also, heat energy is obtained from the transformation of other energy sources or types; a process that can be referred to as production. The main source of heat energy produced in these areas is charcoal, a form of bio-fuel, which is derived from the systematic combustion

of fuel wood, mostly hard wood found in the forest biome.

The spatial or environmental study of charcoal production can be considered from four perspectives: namely, sources of raw materials used for charcoal production, transport network which assuage the spatial disparity between demand and supply o he product, the uses and spatial demand for charcoal, and the imbalance in the man-environment system caused by the production of charcoal. However, this study focuses on the fourth perspective by estimating the rate of depletion or degradation of forest vegetation over time and space; an imbalance in the man-environment system in the area.

Charcoal is an odourless, tasteless, impure form of graphitic carbon residue obtained from the partial combustion of carbonaceous material, mostly plants, under a condition of a limited access to air (Abdolahi and Hosseini, 2014). In spite of modernisation, the major markets for charcoal are in the urban centres, where it serves as substitute for fuel wood (Igben *et al.*, 2014). More so, these centres have not completely transited from the use of bio-fuels due to low level of technological development and poverty.

In Nigeria, the study area inclusive, production of charcoal is usually done in the periphery of urban centres mainly within the forest ecological zone. This is because both the material input and output of the production process are gross and bulky. Consequently, they are located mid-way between the source of raw materials (forests) and the major markets (urban centres). Charcoal production impacts on the different components of the environment; namely, atmosphere, lithosphere, hydrosphere and biosphere. For instance, the burning of wood releases carbon dioxide into the atmosphere, the heat from the kilns increases the temperature of the soil and the surrounding air. In addition, its production releases wood smoke that contains a wide variety of pollutants such as particulate matters, poly aromatic hydrocarbons, carbon oxide,Nitrogen oxide, Sulphur oxide, volatile organic compounds (VOCs) etc. Particulates can serve as vehicles for the transport of microorganisms such as viruses and bacteria to the lungs and blood stream.

With reference to the forest ecosystem, the production of charcoal in the forest zones of the world according to Chidumayo and Gumbo (2012) is often perceived to have devastating ecological and environmental effects. Mba (2018) asserted that felling of trees for charcoal production without any reforestation programme exacerbates forest depletion and add to the accumulation of carbon dioxide in the atmosphere; and consequently increasing the rate of climate change. In a similar vein, Ellegard and Nordstrom (2003) opined that the traditional method of charcoal production, which involves burning in an earthen kiln, impacts the environment by way of forest depletion, land degradation and climate change. Tassie *et al.* (2021) study on the socio-economic and environmental effects of charcoal production activities of households in Mecha District in Ethiopia revealed that annual charcoal production as well as emission of greenhouse gases are increasing. Also, socio-economic factors; namely, land sizes, agricultural extension and eucalyptus forest cover

commonly found in the area have more significant effect on the production of charcoal than demographic variable such as age, sex, family size etc. The authors also asserted that the environment is affected by way of air pollution which leads to associated respiratory health problems.

Ogundele, *et al.* (2012) study on the effects of charcoal production on soils around kiln sites in Ibarapa area of south western Nigeria revealed that the production of charcoal resulted in insignificant decrease in soil organic matter (extractable iron, Cu, Zn, Mg) at 0-10cm and 10-20cm soil levels probably because of the humid climate of the derived savanna zone where the area is situated. Conversely, Mba's (2018) study onthe assessment of charcoal production process and the environmental impact in Kaduna, Nigeria, noted that the production of charcoal impacts on the soil and the ecosystem. According to Eniola (2021), the major problem of charcoal production is deforestation, which affects the environment in many ways; increased soil erosion, worsen climate change and threaten biodiversity.

Furthermore, Charcoal production, according to Chidumayo and Gumbo (2012), is estimated to have contributed 7 per cent to global deforestation in 2009. Ogundele, *et al.* (2011) stated that the estimation of the World Bank that charcoal production in Nigeria in 2011 was 4,022,763 tonnes is rather conservative as much of the production were not captured. Nevertheless, there has not been any known study that considers, by actual measurement, the degree of forest degradation induced by the felling of trees for the production of charcoal; hence, this study attempts to measure the rate of forest depletion through charcoal production in the forest ecosystem of Delta State, Nigeria. The null hypothesis that there is no relationship between the distance from kiln sites to points of raw material and quantity exploited was postulated in the study. The outcome of the study would provide data on development of an enduring and sustainable energy sources particularly in the rural areas.

MATERIALS AND METHOD

Study Area

The study area, Delta State is located in Nigeria. It occupies about22, 159 square kilometres between Latitudes $5^0$00' and $6^0$30' north and Longitudes $5^0$00' and $6^0$45' east. The climate of the area is a microcosm of the tropical climate characterized by uniformly high rainfall and temperature. The average annual rainfall is high, about 228.5cm and is heaviest in July (Aweto and Igben, 2003). Mean temperatures ranges between 24^0C (75.2^0F) and 27^0C (80.4^0F), with no significant variation between day and night. Relative humidity is normally over 90 per cent in the early morning, but falls to between 60 and 80 per cent in the afternoon (Udo, 1970).

The area comprises four ecological zones: namely, coastal barrier island or ridges, mangroves, fresh water swamp forest and lowland rainforest. However, Igben *et al.* (2014) divided the state into three ecological zones; namely, mangrove, freshwater swamp forest and the lowland rainforest as shown in Fig. 1. This division is based on the fact that the coastal barriers or ridges along the shore of the Atlantic Ocean is sandy with little or no vegetation cover.

The population of the area in 2006 was 4,098, 391 persons, made up of 2,074,306 males and 2,024,085 females (NPC, 2007). The capital of the state is Asaba. Other major towns of over 200,000 persons are Agbor, Warri, Ughelli, Sapele, Effurun, Ogwashi-Uku, Oghara, Abraka, Ozoro and Kwale. The people of the area engage in numerous economic activities most of which are land intensive and dependent on the ecology of the area. These occupations include farming, fishing, hunting, palm nuts collection and processing, lumbering, fuel wood collection and charcoal production. Other occupations are manufacturing, civil service and trading (Igben, 2012)

charcoal production and its effects on the surrounding forest vegetation, was used in the study. Its adoption was influenced by the need to find the meaning and obtain understanding of the phenomenon of forest degradation through a careful and methodical assessment of charcoal production activities. Data utilised in this type of research, according to Ogundipe *et al.* (2005) are usually obtained by observation and measurement.

Sources and Types of Data

Primary and secondary data were used in the study. The former was obtained from questionnaire administered on a sample population of workers of charcoal producing kilns. The questionnaire covered

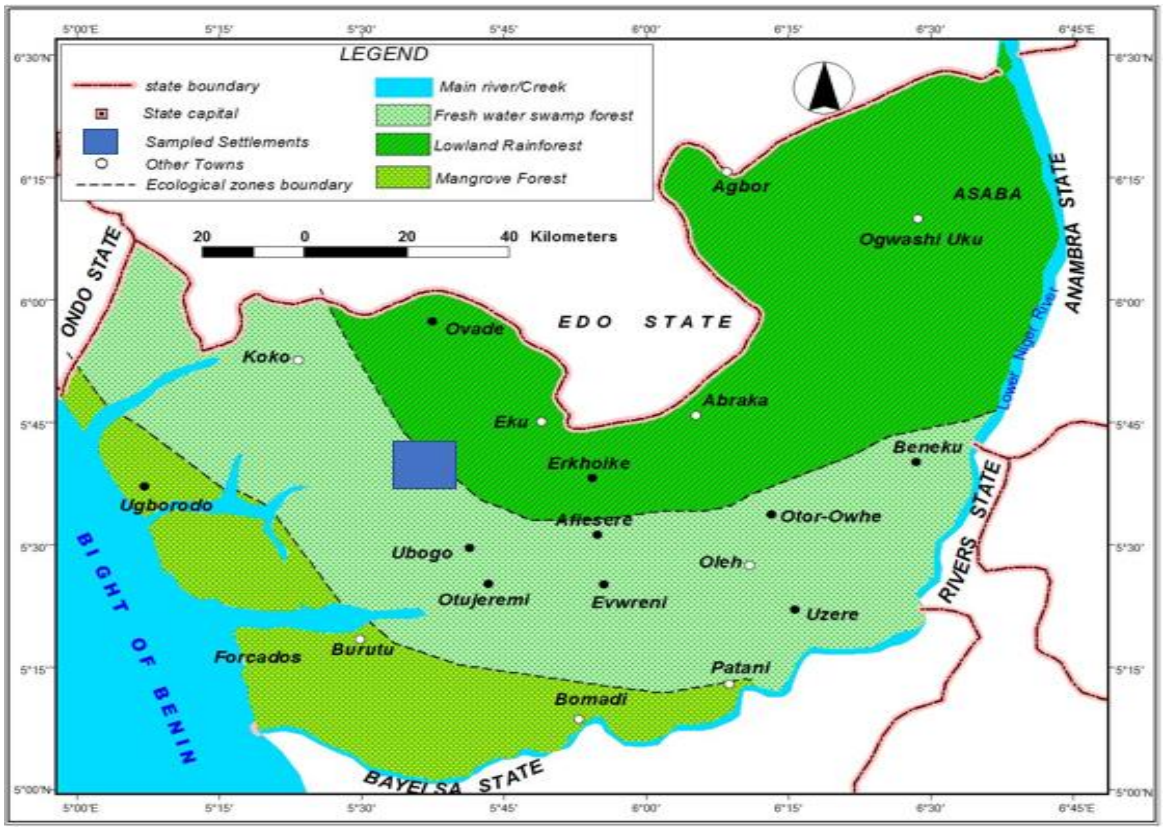


Figure 1: The Study Area showing the Forest Ecosystems
Source: Adapted from Igben (2012).

Research Design

The descriptive research design, which involved a description of the process of

demographic characteristics of the target population as well as information on

charcoal production activities such as nature, sources and quantity of raw materials, and distance to points of raw materials.

Population and Sample

The target population for this study include persons, irrespective of gender, who are engaged in the production of charcoal in the area. The multi-stage sampling technique was used to select sample. The stages employed in selection of sample were; (i) identification of charcoal production clusters in the forests of the area. The identified clusters were located at Okirigwe, Amukpe, Ibada-Elume and Otomewo settlements (ii) random selection of one cluster from the four major clusters in the area, and (iii) random selection of 50 workers from a total of 63 workers in the cluster. The selected cluster is located in Amukpe in Sapele Local Government Area (LGA) of state. It comprised 17 kilns whose owners were purposively included in the survey. In other words, all the owners of kilns in the cluster were chosen for the study. This choice was deliberate as they were in a better position to estimate the quantity of raw materials utilised and their sources. In spite of this, the quantity was further verified by monitoring and physical measurement of weights of logs at the deferent kilns for four (4) weeks (from 3rd to 31st March, 2022) by the researcher.

The catchment area of the material inputs into charcoal production was determined from the radial distance traverse to the points of tree felling for the purpose of charcoal production. Thus, the annual quantity of materials used per kiln and the areal exploitation was derived thus;

$(AQx52)$……(i)

Where, AQ = Average weekly quantity per kiln

Also, catchment area of the exploitation of wood logs is derived thus;

(πr^2) …… (ii)

Where, π =3.142; r= Radial distance from kiln site to points of raw materials

Data Analysis

Information collected from the questionnaire was coded and frequencies, means of events or occurrence worked out. They were further presented in tables and graphs. The hypothesis that there is no relationship between the distance from kiln sites to points of raw material and quantity exploited was tested using the Pearson Correlation (r_p) Analysis. The test is a measure of the degree of linear relationship between two variables. It provides an index r known as the correlation coefficient, which value ranges from -1 through 0 to +1 indicating situations of perfect negative relationship, no relationship and perfect positive relationship respectively (Stockemer, 2019). In using this technique, weekly quantity of logs is the dependent variable (y), while distance from kiln site to points of raw materials is the independent variable (x). The analysis of data in the study was facilitated by the use of Statistical Package for Social Sciences (SPSS, Version 23).

RESULTS AND DISCUSSION

Socio-demographic Characteristics of Respondents

The socio-demographic variables of the sampled population considered in the study are age and sex composition, educational and religious background.

Age and Sex Composition of Respondents

Table 1 shows that 50 respondents were interviewed in the study. Out of this, 48 respondents or 96 per cent were between 20 and 60 years. Those between 56 and 60 years old were 10 respondents or 20.0% and those in the 51-55 years were 9 respondents, representing 18.0 per cent. While 7 respondents or 14.0 per cent were between 46-50 years, nine (9) respondents or 18.0 per cent and 4 respondents or 8.0 per cent respectively were between for 41-45 and 31 - 35 years old. Three and 5 respondents or 6 and 10 percent were in the age group of 21-25 and 26-30 years. Those below 20 years, above 60 years between 36-40 years was 1 respondent or 2.0 percent each. This finding is in line with Igben (2012) study of labour force in ten settlements in Delta State, which showed that 73.1 per cent of the rural labour force was above the age of 46 years.

Educational and Religious Characteristics of Respondents

In addition, 30 respondents representing 60 per cent had no form of formal education. While 11 respondents or 22.0 per cent and five (5) respondents or 10 per cent had primary and secondary education respectively, only 4 respondents representing 8 per cent had vocational training in welding, tailoring and hair dressing. None had tertiary education.

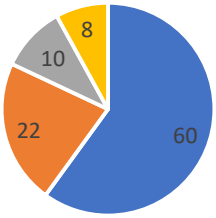


Figure 2: Educational Status of Respondents

Table 1: Age and Sex Composition of Respondents

Age Group (Years)	Males	Females	Total	Percentage
Less than 20	1	-	1	2.0
21-25	3	-	3	6.0
26-30	4	1	5	10.0
31-35	3	1	4	8.0
36-40	1	-	1	2.0
41-45	5	4	9	18.0
46-50	6	1	7	14.0
51-55	8	1	9	18.0
56-60	4	6	10	20.0
Above 60	1	-	1	2.0
Total	**36**	**14**	**50**	**100.0**

Source: Fieldwork, 2022

More so, 36 respondents or 72.0 per cent were males in contrast to 14 respondents or 28.0 per cent who were females. Also, majority of the 44 respondents representing 88.0 percent were Christians. This finding is expected because Christianity is the dominant religion in the area (Imoroa, 2000). While 12.0 per cent practise African Traditional Religions (ATR).

Material Inputs into Charcoal Production

The input of charcoal production is logs of various species of hard wood obtained from the surrounding forests. Mature trees, usually with high calorific value are selected, fell and their trunks and branches cut into logs measuring between 1 to 1.5metres as shown in Plate 1. Thereafter, they are left for some time to dry. The logs are transported to kilns by head, wheel-barrows and sometimes by tricycles and pickup vans, where the distance is long and the roads allow such (Plate 2). The logs are buried in mounded or pit kiln and incinerated under a condition of limited air for a few days until they are completely burnt to charcoal, as shown in Plate 3. The burning is controlled intermittently with water (Plate 4). The output, after cooling is broken into smaller chunks and packed in sacks of various sizes ready for the market.

Plate 1: Logs of hard wood

Plate 2: A Tricycle loaded with logs of wood

Plate 3: A charcoal production Kiln

Plate 4: A kiln with a drum of water for controlling the rate of burning logs

Table 2 presents the quantity of wood utilised in the selected production cluster for a period of four weeks of this investigation

39.0tonnes were used in Week 4. The quantity of logs used in the various kilns per week ranges from 1.2 to 3.1 tonnes with weekly average per kiln at 2.26 tonnes, thus the annual quantity of logs utilised per kiln is estimated thus;

(AQ x 52) tonnes, Where AQ is the Average weekly quantity per Kiln;

(2.26 x 52) = 117.52 tonnes per annum

Also, the catchment area per kiln can be estimated by (πr^2), where π =3.142; r= Radial distance from kiln site to points of raw materials

3.142 x 40^2 =50,272 Km^2

Thus, 117.52tonnes of wood were harvested from 50,272 Km^2annually from

Table 2: Material Inputs into Charcoal Production (Weight of wood logs in Tonnes)

Kilns	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Total**
1	1.2	2.4	1.8	1.6	7.0
2	2.0	1.9	2.2	1.8	7.9
3	1.6	1.4	1.7	1.8	6.5
4	2.1	3.0	1.6	2.0	8.7
5	3.1	2.8	2.9	3.0	11.8
6	2.8	1.8	2.3	2.6	9.5
7	2.3	1.9	1.8	1.7	7.7
8	1.9	2.1	1.8	2.2	8.0
9	1.8	2.2	1.9	2.1	8.0
10	1.8	1.9	1.6	1.7	7.0
11	2.1	2.2	2.4	2.3	9.0
12	2.9	3.1	2.8	3.0	11.8
13	2.4	2.1	2.3	2.4	9.2
14	2.1	2.4	2.4	2.5	9.4
15	3.0	3.0	2.8	2.7	11.5
16	2.1	2.4,	2.1	2.6	9.2
17	3.1	2.8	2.9	3.0	11.8
Total	**38.3**	**39.4**	**37.3**	**39.0**	**154.0**

Source: Fieldwork, 2022

Table 2 shows that a total of 154.0 tonnes of logs were used in the 17 kilns in the cluster for a period of four weeks. Of this quantity,38.3 and39.4tonneswere used inWeek 1 and 2 respectively. While 37.3 tonnes of logs were utilised in Week 3, the forest for use in one kiln in the study area.

Distance to points of exploitation

The study also investigated the influence of distance on the quantity of wood

harvested for charcoal production in the area. Table 3 shows the quantity of logs harvested vis-a-vis distance to points of harvest.

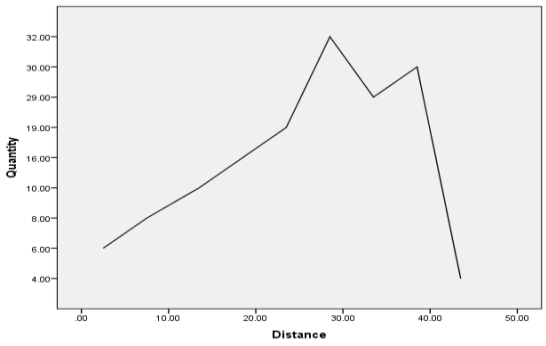
Table 3: Estimated Distance to points of exploitation

Estimated Radial Distance (Km)	**Quantity of Logs (Tonnes)**
Less than 5	6
5 – 10	8
11 – 15	10
16 – 20	16
21 -25	19
26 -30	32
31 – 35	29
36 – 40	30
Above 40	4

Source: Fieldwork, 2022

Table 3 reveals an increasing quantity with increasing distance from less than 5 km, with harvested quantity of 6 tonnes to 26 - 30 km with 32 tonnes. However, for the distance 31 – 35km, 29 tonnes were harvested. This increased to 30 tonnes for the distance 36 – 40km. Nevertheless, there was a sharp drop in quantity of logs to 4 tonnes for distance above 40 km. The trend is graphically represented in Fig. 3. The implication of this trend is that the maximum distance traversed by charcoal producers in order to sustain their profit levels is 40km from the kiln sites. This view was corroborated by three owners of kilns in a Focus Group Discussion (FGD).

Figure 3: Relationship between Quantity and Distance to Points of Raw Materials



The hypothesis that there is no relationship between the distance from kiln sites to points of raw materials and quantity exploited was postulated in the study was tested using The Pearson Correlation Analysis (r). The result showed that r = 0.472, thus indicating a direct and positive relationship between the two variables. The relationship was also found to be significant at 0.05 and 0.01 probability levels, as indicated in Table 4

Table 4: Correlations between the distance from kiln sites to points of raw materials and quantity of logs exploited.

		Distance	Quantity
Distance	Pearson Correlation	1	.472
	Sig. (2-tailed)		.200
	N	9	9
Quantity	Pearson Correlation	.472	1

CONCLUSION

This study measured the quantity of wood used in the production of charcoal with a view to determining the contribution of charcoal production to the degradation or depletion of the forest ecosystem in the study area. Primary data were obtained from a sample chosen by multi-stage sampling technique, complemented with a Focus Group Discussion (FGD). The study revealed that charcoal production impacts

on the depletion of forests as each kiln utilized 117.52 tonnes of wood logs annually, harvested from 50,272 square kilometre of forest in the area. In addition, quantity of trees harvested for charcoal production was positively related to distance to points of harvest. In sum, charcoal production results in the ecological imbalance of the forest biome. Consequently, it is recommended that alternative and cheaper sources of energy should be provided to forestall further depletion of the forest vegetation.

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