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Economic Analysis of Charcoal Production in Semi - Arid Region of Nigeria

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Abstract

The exploitation of forest resources for commercial charcoal production is a problem in Nigeria. The forest is rapidly becoming depleted due to the human quest for fuelwood. The fast disappearance of trees may influence climate change which may, in the long run, affect crop yields and deepen poverty. Thus, this study estimated the costs and returns as well as the determinants of charcoal production in the study area. Data collected were analysed using farm budget and multiple regression analyses. The farm budget analysis revealed an average profit per charcoal producer per annum of ₦68,700.00. The estimated multiple regression analysis revealed that quantities of woods, labour in man-days and producers' experience are the important determinants of charcoal production in the study area. Three main policy issues emerge from the results of this study. First, there is a need to promote cheap and effective fuel source like the briquette through the use of extension agents. The cost of electricity, kerosene and cooking gases should be lower than charcoal and firewood. Thirdly, there is a need to provide other alternative ways of life such as the provision of off-season employment to dissuade both rural and urban dwellers from energy- driven deforestation.

Keywords: Forest resources, Climate change, Deforestation

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Background to the Study

The rural dwellers in developing countries rely on biomass energy in the form of firewood, charcoal, crop residues, and animal wastes to meet their cooking and heating requirements (Michael, 2015). About 92 % of the 1.8 billion people living in poverty worldwide rely on forests to some extent for subsistence needs. It supplies about 93 per cent of the domestic and commercial cooking energy needs in developing countries (Food and Agricultural Organizations of the United Nations FAO, 2015). The links between fuelwood (firewood and charcoal) use and deforestation, well as expected fuelwood shortages have been established (Kauppi *et al.,* 2006). The number of people relying on fuelwood is expected to keep increasing with an estimate of about three-quarters of total residential energy in Africa by 2030 (International Energy Agency IEA, 2002). About 11.3 million hectares of forests are lost annually to agriculture, commercial timbering, uncontrolled fuelwood production and consumption. Unfortunately, 90 per cent of cleared forest are never replanted (FAO, 2015). Moreover, it has been estimated that charcoal consumption is often growing faster than firewood consumption in Africa and South America (Wurster, 2010).

The impact of wood fuel and its derivative (charcoal) on the energy requirements of developing nations cannot be underscored. The growing demand for charcoal in developing countries has resulted in localized deforestation in vulnerable areas. Charcoal is the dark grey residue consisting of Carbon and any remaining ash, produced by the slow process of heating wood and other substances in the absence of oxygen, called Pyrolysis. It is an impure form of Carbon, which contains ash. However, it is excellent domestic fuel, and can be made from virtually any organic material like wood, coconut shells, rice husks and bones, usually hardwood species like Acacia, Mangroves, Oaks and Prosopis are preferred for charcoal production. Charcoal though an old source of energy, is as well still a modern source of energy for cooking in both rural and urban centre's, Kammen and Lew (2005) reported that half of the world's population use biomass fuels for cooking and that in 1992, 24 million tons of charcoal were consumed worldwide, with developing countries accounting for nearly all consumption, while Africa alone accounted for 50%. In Nigeria, Charcoal is mainly used for cooking, roasting of suya, barbecue, maize, plantain, cocoyam and yam, blacksmithing and bronze-casting (Izekor and Kalu, 2007). Charcoal, in addition, is now an export commodity in Nigeria, with a large market in the EU, USA and Asia. The prices range from $170 - $300/ton. Tropical Africa accounts for 70% of the exports and the market is all year round (Essiet, 2009).

Quality charcoal burns cleanly and produces high heat. This important property, along with its low average ash content, makes charcoal desirable for metallurgy or as a domestic fuel. In weight, charcoal may be rather heavy to quite light depending on the weight of the dry wood of the various species used in its production. Charcoal is comparatively easy to ignite, and when of good quality burns evenly and without smoking. In many developing countries, charcoal and agricultural wastes constitute a major portion of total household energy consumption (Bamiro and Ogunjobi, 2015).

Many households in Nigeria are facing challenges of inaccessible to and unaffordable of clean, less dangerous and convenient cooking fuel. Studies have shown the sources of cooking energy in Nigeria to include electricity, liquefied natural gas (popularly known as cooking gas),

kerosene, charcoal, firewood, wood waste, and agricultural waste (Zaku *et al.,* 2013). The use of any of these sources of cooking fuel by a household has been faced with some challenges and also depends on the affordability, preference and availability. There have been long years of inconsistency in the supply of electricity while kerosene is faced with persistence scarcity and increase in price. The cooking gas is also very expensive and out of reach for the poor and low-income class (Babalola, 2011). The economic impact on households, therefore led to either a switch in the choice of energy preferred for domestic use or a situation of energy combination by different income groups. Many of the people in the rural areas, as well as low-income class in the urban areas therefore preferred to switch to charcoal or firewood which they considered less expensive and available (Zaku *et al.,* 2013).

Nigeria is the largest oil producer in Africa holds the largest natural gas reserves on the continent and was the world's fourth-leading exporter of liquefied natural gas. Despite these abundant resources many people in the country still rely on biomass energy in the form of firewood, charcoal, crop residues and animal waste (Zaku *et al.,* 2013). Thus, this study determines factors influencing charcoal production, examine the costs and returns and identify the challenges facing charcoal production in the study area.

Methodology

Study Area

The study was conducted in Maiduguri, Borno State of Nigeria. It has a total landscape of about 50,778 square meters, that lies roughly within latitude 11^{O} 30 to $12^{O}00$ North and longitude $13^{O}00$ to $13^{O}30^{1}$ East (BOSADP, 2001). It is located within the semi-arid zone of West Africa and Sudan savanna zone of northern Nigeria at an elevation of about 35metres above sea levels. It shares common boundaries with Konduga Local Government to the North and the Northwest, Jere Local Government to the south. The population was estimated at 521,492 (NPC, 2006). Maiduguri has an annual rainfall of about 300 – 700mm which commences from June to September with an annual temperature of between 28–40^{O} (BOSADP, 2001). The rainy season lasts for about 3 – 4 months in a year and it normally starts in June and ends in September with very few or rare case of rain starting in May. The dry season is usually long and very hot. The driest months are March and April while the coldest months are December and January. The mean relative humidity at noon fluctuates between 5% in December to January and 45% in July to August (BOSADP, 2001). Maiduguri is inhabited by people from diverse ethnic group dominant by Kanuri, Babur-bura, Marghi, Shuwa-arab and others such as Fulani, Yoruba, Igbo etc. the major occupation in Maiduguri is trading in which charcoal production is not an exception.

Sampling Technique

The charcoal producers in Maiduguri Metropolis of Borno State constitute the target population for this study. A three-stage sampling technique was used to select sample for the study. The first stage involved purposive selection of Mulai area in the outskirt of Maiduguri. The choice of this area was informed by a preliminary investigation which revealed that charcoal production is prominent in Mulai area than other places in Maiduguri. This may be due to its proximity to the forest and other charcoal making raw materials, the population is

low, and also based on the fact that observations have been made about charcoal production in this area, as charcoal kilns are usually seen and trucks loaded with tones of charcoal were also seen moving out of the area. In the second stage, 6 producer's associations were randomly selected from 8 producer's associations in Maiduguri Metropolis. In the third stage, 10 producers each from the six different associations were randomly selected to make a sample size of 60 producers.

Data Collection

Data were collected from the charcoal producers randomly selected within Maiduguri Metropolis, using questionnaires and interview schedule. Data was also collected on the socio-economic characteristics of respondents, which included ages, sex, educational level, year of experiences etc.

Data Analysis

Data collected on the socio-economic characteristics and challenges facing charcoal producers were analysed using descriptive statistics such as percentages and frequency tables. Data collected on the factors influencing charcoal production in the area were analyzed using multiple regression analysis. Also, data collected on the profitability of charcoal production were estimated using Gross Margin Analysis.

Multiple Regression Models

This involves the use of three functional forms (Linear, Double Log, and Semi-log forms). Best liner unbiased estimates (BLUE) the one that had the highest R^2, better F ratio and highly significant coefficient was selected as the lead equation. The model is explicitly expressed as:

$$Y_j = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + e$$

Where;

Y_j = Charcoal production in Naira

X_1 = Labour in Naira

X_2 = Wood in number of trees

X_3 = water quantity in litres

X_4 = Experience in years

X_5 = educational status (dummy variables; formal education = 1, non-formal education = 0)

b_0 = constant

$b_1 – b_5$ = estimated coefficient

Gross Margin (GM)

The analysis focuses on the returns to the producer after the total variable cost of production has been deducted. The model for estimating GM is outlined turns:

$$GM = TR – TVC$$

Where;

GM = Gross Margin of Charcoal producers per annum

TR = Mean total revenue per charcoal producer per annum

TVC = Mean total variable cost per charcoal producer per annum

Results and Discussion

Socio-Economic Characteristics of Charcoal Producers

The Socio-economic characteristics of the charcoal producers are shown in Table 1. The table revealed that charcoal production is dominant by males by 100%. This is not surprising because the operation is back-breaking and full of drudgery. This means the participation of charcoal production in the study area are mostly male and the reason could be as a result of seclusion or purdah system in the Muslim society but is corresponding with the finding of Fedrick (2005) that males are dominate in fuelwood marketing, charcoal production and other labour demanding agricultural activities.

There is a large age spread between charcoal producers that varied between 18 and 60years the activity appears to be dominated by the 30-40 years' age bracket. This is also not surprising since this is generally the most active age group in human life especially that the activity is energy sapping one. Only (21.7%) are below than 30 years, while 25% of the respondents are between 40 years and above age bracket. About 81.7% of the respondents are married with an average family size of six people. This influence charcoal production because a large family size will help cut labour cost.

The majority of the respondents (68.3%) are farmers. This is not surprising because most of the producers are from rural areas and farming is one of the primary occupations of the people of the Borno State, while the remaining does a wide variety of occupation which includes drivers, security guard, traders, and bricklayers.

The most preferable (38.3%) used tree species is *Prosopis Africana* this is due to its hardness and non-bristling quality. *Anagaceous leocapus* and *Tinnea glaucenscens* are ranked second and third with 16.7% both. Ranking fourth is *Acacia nilotica* 15% and lastly *Azadirachta indica* 13%. Other trees used as alternatives such are; *Tamarindus indica* although any hard savanna tree could be carbonized for charcoal.

The preference ranking has some serious consequences for the environment and sustainable development. It implies the preferred species will be extinct earlier than other species. As at present searching for these species into the depth of the savanna forest has increased. However, some trees were not mostly felled for charcoal production. Wet trees and trees that yield edible fruits are also not usually felled.

Table 1: Socio-economic characteristics of the respondent

Socio-economic	Frequency	Percentage
Gender		
Male	60	100
Female	0	0
Age		
Single	11	18.3
Married	49	81.7
Primary occupation		
Farming	41	68.3
Security	7	11.7
Driver	5	8.3
Others	6	10
Educational status		
No formal education	24	40
Primary education	11	18.3
Secondary education	6	10
Qur'anic education	19	31.7
Experience		
1-5 years	14	23.3
6-10 years	25	41.7
11-15 years	15	25
16 years and above	6	10
Most preferred spp		
Prosopis Africana	23	38
Anagaceous leocapus	10	16.7
Tinnea galaucescense	10	16.7
Acacia nilotica	9	15
Azadirachta indica	8	13.3

Source: Field survey 2018

Gross Margin Analysis in Charcoal Production

The result of the gross margin analysis is presented in Table 2. The result revealed that the total revenue obtained per person per month was ₦76, 700.00. The result also revealed variable in the production of charcoal in the study area. The table indicates the cost of labour amount to ₦ 4,500 per person per month, cost of wood at ₦3000 and cost of water to ₦500. The table indicates gross margin to ₦68, 700.00 per person per month which proved to be charcoal production to be profitable.

Table 2: Gross margin of charcoal production per producer per month

Item	Amount (₦)
Total revenue	**76,700.00**
Variable cost	
Labour	4500
Cost of wood	3000
Cost of water	500
Total variable cost	**8000**
Gross margin	**68,700.00**

Source: Field survey 2018

Regression Analysis Factors influencing Charcoal Production

The result of factors influencing charcoal production is presented in Table 3 the result of the coefficient of determination R^2 indicates 97.68% of the explanatory variables explained the variable in estimation.

The result in Table 3 revealed that labour had a coefficient of 2.35045 and significant at 5% level. This implies that as level increase by a unit the quantity of charcoal produced increases equal to the coefficient. This may be due to the fact that increase labour will enhance large quantity of charcoal produce.

The result in Table 3 also reveals a positive coefficient of 4.300203 and significant at 1% level for the quantity of wood used in charcoal production. This implies that. The quantity of charcoal produced is equal to the coefficient of wood used as a unit increase in wood utilization. A negative coefficient of -0.09345575 and significant at 1% was obtained for water in charcoal production. This indicates that water has a negative net relationship with the quantity of charcoal produced in the study area.

The result of charcoal production experience shows a positive relationship with the quantity of charcoal produced this was indicated by a coefficient of 15.58277 and significant at 5% level this implies that a unit increases in charcoal production experience will lead to increase in quantity of charcoal produced equal to its coefficient

The result of educational status indicates a negative relationship with a coefficient of -0.814905 and significant at 1% level. This implies that as educational status increase by a unit the quantity of charcoal produced was released by a value equal to the coefficients of educational status. This may be due the fact that as the respondent acquire more education they may abandon charcoal production for other valuable business

Table 3: Factors influencing Charcoal Production

Variables	Coefficient	Standard Error	t-value
Constant	6.744734	0.8052918	8.3812***
Labour	2.35045	1.128975	2.0823**
Wood used	4.300203	1.472546	2.9200***
Water used	-0.09345575	0.0191910	-4.8711***
Production experience	15.58277	6.750848	2.3123**
Educational status	-0.814905	0.2022097	-4.0322***
R-square	0.9768		

*** = Significant at 1% level; ** = Significant at 5% level

Challenges Facing Charcoal Producers

One of the major challenges facing charcoal production is the insurgency in the state which hinders movement in the forest in other to cut trees for the production of charcoal. Table 4 indicates that 41.7% of the respondents are affected by the insurgency in the states.

Table 4 also indicates 23.4% of the respondent suffers some form of irritation. They were, however, able to characterize them into types of irritation such as difficulty in breathing, coughing and gearing in the eyes. They also suffered from fatigue and body aches. All these are associated with heat, volatile organic compounds (vocs) and carbon monoxide (Northeastern States for coordinated air use management (NESCAUM 2006). Most of the respondent said they normally take drugs such as Panadol (paracetamol), milk and hot water with Robb (methylated balm) to recover. The technology itself has to do with the channeling of smoke or vents. Depending on the expertise of producers, they can evade smoke problems to varying degrees. This may cause grievous health challenges such as lung, blood, oxygen absorption problems and even cancers (NESCAUM 2006).

High cost or unavailability of transportation is also a problem. About 13.3% of the respondent claimed it affects their production. Other challenges facing producers include sourcing for marketers or buyers.

Table 4: Challenges facing Charcoal Producers

Challenges	Frequency	Percentages
Security reasons (insurgency)	25	41.7
High cost or unavailability of transportation	8	13.3
Sourcing for marketers or buyers	5	8.3
Health hazard	14	23.3
High cost of labour	8	13.3
Total	60	100

Source: Field survey, 2018

Conclusion and Recommendation

This study was set out to estimate the costs and returns as well as the determinants of charcoal production in the study area. Most charcoal producers are males, with an average of 35 years.

They have an average production year of 8 years and most have no formal education. Majority of them are married with an average household size of 6 persons. The production of good charcoal requires the use of very hardwoods; this has led to the preference of some trees over the other. The most preferred trees are *Prosopis African, Anagaceous leocapus, Tinnea glaucescens* which produces dense good charcoal. The challenges facing charcoal producers in Maiduguri metropolis area include; Boko Haram insurgency in the state. Irritation from smoke fatigue and body ache, coughing, difficulty in breathing and tearing of the eye, other challenges which are high cost or unavailable of transportation, high cost of labour, sourcing for marketers or buyers. The profit per production (₦68, 700.00) per month from charcoal production which is more than proceeds from the sale of agricultural produce will continue to lure deprived rural dwellers to charcoal production despite the way uncertainty in the security of the area and health risk associated with the production. Factors determining the charcoal production in the area are the quantity of wood, labour in man-days and producer's experience.

The study reveals that charcoal production is profitable in Maiduguri metropolis of Borno state, this is because it generates income to the producers, it also indicates that the business poses serious environmental and health hazard. If the insurgency, transportation cost and labour cost are regulated the profit might have increased. Three main policy issues emerge from the result of this study. First, there is a need to promote cheap and effective fuel source like the briquette through the use of extension agents. The cost of electricity, cooking gas and kerosene's should be lower than charcoal and firewood. Thirdly there is a need to provide other alternative ways of life such as the provision of off-season employment to prevent further deforestation.

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