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Baseline Assessment of Charcoal Production in Jama'a District, Toro Local Government Area, Bauchi State, Nigeria

Aliyu Isyaku*, Ahmed Abdullahi Chinade*, Abolarin Sanjo Kazeem**, Victor Istifanus*** and Maina Mam Ago******

**North-East Development Commission, Nigeria. **Department of Geography and Planning, Queens University, Canada. ***Department of Environmental Management Technology, Abubakar Tafawa Balewa University, Nigeria. ****Federal College of Forest Resource. Management, Maiduguri, Nigeria.*

Corresponding author: abolarin.sanjo@queensu.ca

Abstract

The increasing popularity of charcoal among urban households in Nigeria is due to rapid population growth and the lack of affordable alternative fuels. Erratic supply of modern fuels like kerosene and gas contributes to this trend. The widespread use of charcoal without considering its negative implications on the environment leads to adverse effects like increased flooding, soil erosion, and land degradation. This research aims to understand the situation better for informed decision-making and recommend appropriate control measures. This is done through a baseline assessment of charcoal production and the producers' willingness to accept (WTA) alternative sources of income, as well as charcoal producers' perspectives of charcoal production externalities, in the study area. The data for this study was collected using different set of questionnaires that were designed with respect to charcoal producers. The questionnaires cover socio-demographic information of the respondents, information on charcoal production and economic valuation. Descriptive statistics of Statistical Package for Social Sciences (SPSS) was used to estimate the quantity of charcoal produced and the number of people involved in charcoal production in the study area. Regression analysis was used to estimate producers' WTA. The results of the study revealed that all producers (100%) were aware of the problems caused by charcoal usage, such as eye irritation and skin burn for consumers and environmental degradation for producers (desertification, flooding, loss of soil fertility). All producer respondents were willing to change jobs from charcoal production to sustainable alternatives to reduce environmental pressure. Charcoal producers were willing to accept alternative jobs for a pay ranging from ₦31,000 to over ₦200,000.

Keywords: Charcoal, Energy, Producers, Willingness, Firewood

Introduction

Nigeria is gradually losing its last few patches of thick forest. According to the Food and Agriculture Organisation, the country has lost half of its forest cover in two decades and is losing 5% of its forest cover per year, the highest pace in the world. Experts warn that if the country continues at its current rate, it would lose all of its woods by 2047. One key cause for this is Nigeria's increasing need for charcoal, a cheap source of energy produced by pyrolysis, or the burning of wood at high temperatures in the absence of air (Mba, 2018). Firewood, charcoal, and black liquor are the three main components of wood fuels. Black liquors are waste products of the pulp and paper industries, whereas firewood and charcoal

are derived from trees. Wood fuel use is increasing in emerging nations, owing mostly to increased urban demand for charcoal. As a result, there has been unsustainable exploitation of forest resources, with significant environmental and social consequences (Mwampamba et al., 2013).

Uncontrolled and indiscriminate felling of mature and nearly-mature trees became the norm in the research area. Around 2.4 billion cubic feet of round wood were produced in 2000, with 85 percent of it used for fuel. This, together with illegal commercial logging and periodic droughts, has worsened land degradation in our forest. Several agricultural communities in Jama'a district, including Mara, Palama, and Zaranda, have been seen making charcoal without regard for the environmental consequences of their conduct throughout the years (Chomini et al., 2022). At the moment, 1.6 billion people lack access to electricity, and 2.4 billion lack access to modern cooking and heating fuels. As a result, limited energy impedes social service delivery, limits opportunities for women and children, and jeopardises environmental sustainability (UN-Energy, 2005).

Charcoal is the primary urban fuel and a major source of revenue in much of Africa and numerous rich countries. The production, transportation, and combustion of charcoal are crucial energy and economic cycles in many poor nations. Jamala et al. (2013). African wood fuel usage reached 623 million m^3 in 1994, according to the Food and Agriculture Organisation (FAO), and Africa has the highest per capita wood fuel consumption (0.89 m^3/year) compared to other continents such as Asia, which has 0.3 m^3/year. As a result, the production, transportation, and sale of charcoal constitute an essential energy and economic cycle that has a significant impact on the lives of many people (FAO, 2012).

The usefulness of charcoal as a source of energy cannot be emphasised when considering its home and industrial applications. It provides a lot of heat, is smokeless, can be used in small and affordable stoves, and is suitable for a wide range of industrial and domestic uses, particularly in urban settings. Charcoal is simpler to store and takes up less space than wood for the same amount of heat production; it is less readily ignited, making it safer to use than wood; and it is less easily lit, making it safer to use (Kao et al., 2014).

In Africa, access to modern, affordable and reliable energy services is a huge challenge, especially in Nigeria (Baiyegunhi and Hassan, 2014). In Nigeria, household cooking energy accounts for a major part of the total energy consumed (Emagbetere et al., 2016). The total energy consumption taken by the households in Nigeria is about 65%; this can likely be attributed to the under development of the industrial sector (Oyedepo, 2012). Household cooking consumes more energy than any other endues services in low income developing countries (Daioglou et al., 2012). Households need energy for various activities, chief among these is cooking which accounts for a greater percentage of the total domestic energy consumption (Oyedepo, 2012). Unfortunately, this area (household cooking energy consumption) has not received adequate attention from the international and local communities. Despite the abundance of renewable, environmentally friendly energy sources, about three billion people worldwide still use solid fuels for their basic needs which

include cooking (Hossain, 2012). In less industrialized countries, energy for cooking constitutes 70 to 90% of total energy (ESMAP, 2007). Biomass fuels (such as firewood, charcoal, and animal dung) are utilised to meet the cooking energy needs of about 2.5 billion people in these countries (WHO & UNDP, 2009). Wood and charcoal are the most often used solid cooking fuels, however their burning creates pollution that is hazardous to one's health (Bisu et al., 2016). Furthermore, solid fuel consumption has environmental effects such as increased greenhouse gas emissions, deforestation, and desert encroachment. Firewood is the earliest cooking fuel. It is more abundant in rural settings than in urban areas. It is synonymous with the use of wood fuel.

Energy is obtained by rural homes from a number of sources. Social, political, economic, and environmental factors all influence these households' choice of cooking fuel. Low education, family size, and other social factors. Government laws and policies, for example, can have a considerable influence on the choice of cooking fuel since some sources may be inaccessible, forcing households to seek alternative cooking fuels. Personal and household income levels, for example, have a substantial influence on the type of cooking fuel that a family will use. Despite the increased health hazards, most low-income employees prefer locally accessible cheap sources of cooking fuel (Malla & Timilsina, 2014).

Furthermore, the Jama'a region in Bauchi State's Toro local government area is endowed with lush flora that covers portion of the Lame Burra wildlife reserve. The region is home to a variety of fauna, water features, and plants. As a result, the inhabitants in the study region rely on all of these environmental resources for a living (Chomini et al., 2022).

For many others, charcoal manufacturing supplements their income and provides as a "safety net" in times of difficulty (Arnold & Persson, 2006; FAO, 2005; Mutimba 2005). As evidenced by Kenya, which has over 200,000 charcoal producers and over 500,000 people directly involved in the trade (producers, transporters, and merchants). Despite being a substantial source of income for millions of people worldwide, charcoal manufacturers receive just a small share of total revenues as compared to transporters and whole-sellers (Mutimba, 2005).

It is against this background that this study seeks to investigate charcoal producers' willingness to accept alternative sources of income and incentives, as a replacement for charcoal production, as well as their perspectives of charcoal production effects in Jama'a District of Toro LGA.

Research Questions

1) What is the quantity of charcoal produced in the study area?
2) What are the knowledge, attitudes and practices of charcoal producers towards charcoal production externalities?
3) What are the preferred tree species for charcoal production?
4) What is the producer Willingness to Accept (WTA) alternative means of livelihood?

Research Objectives

1) To estimate the quantity of Charcoal produced in the study area.
2) To assess the knowledge, attitudes and practices of charcoal producers towards charcoal production externalities.
3) To identify the tree species preference for charcoal production.
4) To determine the Producer's Willingness to Accept (WTA) alternative means of livelihood.

Methodology

Characteristics of Study Population

The research work covers Jama'a District of Toro Local Government Area. The area is highly affected by the problem of deforestation particularly Charcoal production which has adversely reduced the forest cover in the area. The area was selected based on the following criteria; 1) Toro Local Government Area is observed to be one of the largest LGAs in the State with much vegetative cover, 2) the vegetation cover in the study area is rapidly degrading due to rampant deforestation and charcoal production activities and 3) The areas selected can be accessible even during the rainy season.

Bauchi state is one of the states in the northern part of Nigeria that span two distinctive vegetation zones, namely, the Sudan savanna and the Sahel savannah. The Sudan savannah type of vegetation covers the southern part of the state. Here, the vegetation gets richer and richer towards the south, especially along water sources or rivers, but generally the vegetation is less uniform and grasses are shorter than what grows even farther south, that is, in the forest zone of the middle belt. The Sahel type of savannah, also known as semi desert vegetation, becomes manifest from the middle of the state as one moves from the state's south to its north. This type of vegetation comprises isolated stands of thorny shrubs.

Table 1. Population of the Study Area

ENUMERATED POPULATION FIGURES		2016 Projection	2017 Projection	2018 Projection
Bauchi State	4653066	6,593,118	6,821,138	7,057,045
Toro LGA	346000	490,261	507,217	524,759

Source: National Population Commission, Bauchi Field office, 2020.

Research Design

A cross-sectional research design was used in this study. This approach has the advantage to the researcher; to save time and collect data and information at a single point in time as stated by. The design is observational in nature and is known as descriptive research not causal or relational. Moreover, the design is suitable because it is fast and can

accommodate large number of study units at low cost. In this study, questionnaire was the main tool for data.

Sampling Techniques

Taking into account time allocated to conduct study and resource available: Zaranda, Mara, Palama and Rauta were purposively selected because of the large scale activities of charcoal producers in the area. The units of the study will be charcoal producers. Purposive sampling technique will be used in selection of sampling units. The list of charcoal producers will be obtained from community leaders and consumers will be randomly selected from the households.

Sample Size

The sampling technique to be adopted for this study is the purposive sampling technique. Purposive sampling technique is a form of non-probability sampling in which decisions concerning the individuals to be included in the sample are taken by the researcher based upon a variety of criteria which may include specialist knowledge of the research issue, or capacity and willingness to participate in the research. This will be based on different activities each of the respondents is doing.

For calculating sample size, we used Bukhari (2020) Sample Size Calculator i.e.;

Where:

Sample proportion (p) = 0.5

Population size (N) = 21,190

Margin of error (e) = 0.05

Z score (z) = 1.96

Confidence level = 95%

Sample size = 376.

The total sample size (376) was equally divided between the consumers and producers, with a total of 188 questionnaires going to the producer respondents.

Data Collection

Primary data was collected using different set of questionnaires that will be designed with respect to each charcoal producers and consumers. The researcher will use interview method through questionnaires administered to 376 respondents. This method will be useful to the researcher since it will help to obtain information even from respondents who have difficulties in reading and writing. These questionnaires will be supplemented by personal observation where the researcher will observe various activities done by charcoal producers and consumers. Prior to the main survey, a pre-testing will be done in order to test the validity of the questionnaires. A preliminary survey to establish sample frame, determine approximate time required in completing a questionnaire and conducting situational analysis of the study area.

Data Analysis

Quantitative data obtained from questionnaires was entered, coded and analysed using Statistical Package for Social Sciences (SPSS) and to be presented, using descriptive statistical tables, percentages, charts and graphs.

Test of validity and reliability of the Research Instrument

Validity of the research study refers to the extent at which data collected actually represent the phenomenon under investigation (Orodho, 2008). In order to ascertain the content validity of the tools of data collection, experts in research methodology were sought. In addition, a pilot survey will be conducted to help identify areas in the research instrument that might be ambiguous providing the intended responses (Katzenellenbogen & Joubert, 2007). Inadequacies identified during pilot survey was addressed to improve the quality of the research instrument and its validity.

Reliability of the instrument

Reliability of the research instrument in research study refers to an extent at which research instrument provides consistent data after repeated trials (Mugenda & Mugenda, 2003). If a research instrument is able to provide data or expected results consistently when used in repeatedly in the same population, it is considered reliable. In order to determine the reliability of the research instrument that was to be use, a pilot study will be conducted. In order to enhance the reliability of the study, interviewers will be train on data collection skills.

In addition, research subjects were encouraged to be honest when providing needed data and the confidentiality of the information given is assured to avoid desirability bias, which could have affected the reliability of the study findings (Katzenellenbogen & Joubert, 2007). The test and retest method were considered worthwhile for the confirmation of the reliability of the study instrument which can be easily ascertained at the event of the participants giving similar answers in two consecutive times.

Results and Discussion

Socio-Demographic Information of the Respondents

Findings from the study show that a majority (100%) of the respondents are male, with no female representation in the study. Per the locality of the respondents, the locality of ''Jama'a'' was more represented with 39.9%, followed by Zaranda and Falama localities, which accounted for 18.5% and 15.7% of the respondents respectively. Gaji locality was next in representation, with 13.5%, while Rauta locality was least represented, accounting for only 12.4% of the respondents. In terms of age, many (41.0%) of the respondents are between the ages of 31-45, followed by about 40.4% who were between the ages of 18-30, and 12.4% who were between the ages of 46-60.

Table 2. Demographic Information of the Producer Respondents

Variables	Frequency (n=178)	Percent
GENDER		
Male	178	100
Female	0	0
LOCALITY		
Jama'a	71	39.9
Falama	28	15.7
Gaji	24	13.5
Zaranda	33	18.5
Rauta	22	12.4
AGE		
18-30	72	40.4
31-45	73	41.0
46-60	22	12.4
Above 60	11	6.2
RESIDENCE STATUS		
Indigene	178	100
Non-indigene	0	0
THIS STUDY WILL PROVIDE NEW PERSPECTIVE FOR POLICY		
Agreed	178	100
Disagreed	0	0

Source: Field Survey, 2022.

The remainder of the respondents (6.2%) fall above the age of 60. For the residence status, the entire (100%) respondents claimed to be indigenes, with none (0%) identifying as a non-indigene. All (100%) of the respondents ''Agreed'' that the ''study will provide new perspective for policy'', as none (0%) ''Disagreed'' with the statement.

Charcoal Causing Environmental Degradation

When asked if charcoal causes environmental degradation, all (100%) of the respondents ticked ''Yes'', with none (0%) stating 'No.'

Table 3. Charcoal Causes Environmental Degradation

Responses	Frequency	Percentage
Yes	178	100
No	0	0
Total	**178**	**100**

Source: Field Survey, 2022.

Degradation Caused by Charcoal Production

With regards to types of environmental degradation problems caused by charcoal production, 'Desertification' was stated by many (46.6%) of the respondents, this was closely followed by 'loss in soil fertility' as reported by about 41.0% of the population. 'Flooding' was reported by only 12.4% of the respondents.

Table 4. Types of Degradation Problem

Degradation Type	Frequency	Percentage
Loss in soil fertility	73	41.0
Desertification	83	46.6
Flooding	22	12.4
Total	**178**	**100**

Source: Field Survey, 2022.

Sources of Trees for Charcoal Production

With regards to the source of trees for charcoal, all (100%) of the respondents stated that trees were gotten from Government forests. None (0%) of the respondents said they got their trees from private forest and their own lands. This is an indication that the government owned forests bear the brunt of forest depletion due to charcoal production. This is shown in table 5.

Table 5. Sources of Tree for Charcoal

Source of Tree for Charcoal	Frequency	Percentage
Govt Forests	178	100
Private Forests	0	0
Own's Lands	0	0
Total	**178**	**100**

Source: Field Survey, 2022.

Preferred Tree Species

From table 6, Tamarindus indica was indicated by 39.9% of the study, as the preferred tree species for charcoal production, next to this was Khaya senegalensis as indicated by 25.8%, and Parkia biglobosa as stated by 20.8% of the respondents. The least reported tree species for charcoal production was Gmelina arborea, as indicated by only 13.5% of the respondents.

Table 6. Preferred Tree species for Charcoal

Preferred Tree Species	Frequency	Percentage
Khaya Senegalensis	46	25.8
Tamarindus Indica	71	39.9

Gmelina arborea	24	13.5
Parkia biglobosa	37	20.8
Total	**178**	**100**

Source: Field Survey, 2022.

Methods of Charcoal Processing

In terms of charcoal processing method, all (100%) of the respondents that they used the traditional earth kiln method to process charcoal. None of the respondents indicated they use pit kiln method.

Table 7. Charcoal Processing Method

Processing Method	Frequency	Percentage
Traditional earth kiln method	178	100
Pit kiln method	0	0
Total	**178**	**100**

Source: Field Survey, 2022.

Charcoal Production and Livelihood

The respondents were asked if charcoal contributed to their well-being. All (100%) of the respondents indicated 'Yes'', agreeing that charcoal contributed to their well-being.

Table 8. Charcoal contribution to well-being

Does charcoal contribute to your well-being?	Frequency	Percentage
Yes	178	100
No	0	0
Total	**178**	**100**

Source: Field Survey, 2022.

Charcoal Harvest

As shown in table 9, in terms of charcoal harvest from a single production, majority (67.4%) reported that they harvest 5-10 bags from a single production, while about 32.6% reported to harvest less than 5 bags in a single production. None of the respondents harvest more than 10 bags in a single production of charcoal.

Table 9. Charcoal harvest from a single production

Rate of Charcoal	Frequency	Percentage
Less than 5 bags	58	32.6
5-10 bags	120	67.4
More than 10 bags	0	0

Total	**178**	**100**

Source: Field Survey, 2022.

Charcoal Cost

From table 10, about 61.2% of the respondents reported that they sell a bag of charcoal at between N2,100 and N2500, while about 38.8% of the respondents reported that they sell it for less than N2000.

Table 10. Cost of Charcoal Bag

How much do you sell a bag	Frequency	Percentage
Less than N2,000	69	38.8
N2,100 - N2,500	109	61.2
Total	**178**	**100**

Source: Field Survey, 2022.

Willingness to Accept (WTA) Alternative Job to Charcoal Production

From table 11, all (100%) of the respondents responded 'Yes' when asked if they will accept an alternative job to charcoal production. This indicates their readiness to switch to alternative jobs when provided with sufficing incentives.

Table 11. Will you accept an alternative job to charcoal production

Responses	Frequency	Percentage
Yes	178	100
No	0	0
Total	**178**	**100**

Source: Field Survey, 2022.

WTA (Amount) to Change Job

With regards to willingness to accept to change to an alternative job, majority of the respondents stated that they are willing to accept between N 31,000 and N50,000 to change to an alternative job. About 24.3% differed, stating that they would be willing to change to an alternative job, for over N200,000. Only 7.3% of the study were willing to accept between N 71,000 and N 100,000 to change to an alternative job.

Table 12. Willingness to change to an alternative job

Responses	Frequency	Percentage
N31,000 – N50,000	121	68.0
N71,000 – N100,000	13	7.3
Over N200,000	44	24.7
Total	**178**	**100**

Source: Field Survey, 2022.

Discussion of Results

Out of the 188 questionnaires distributed, 178 were recovered. Findings from the show study that all (100%) of the producer respondents are male, with no female representation in the study. This may be because men are known to participate in strength-demanding works like charcoal production. When asked if charcoal causes environmental degradation, all (100%) of the respondents ticked ''Yes'', with none (0%) stating 'No.' This shows that the charcoal producers in the study area have adequate knowledge of the negative impacts of charcoal production on the environment. This is a precursor that they will be willing to change occupation from charcoal production to a more environmentally friendly occupation.

With regards to types of environmental degradation problems caused by charcoal production, 'Desertification' was stated by many (46.6%) of the respondents, this was closely followed by 'loss in soil fertility' as reported by about 41.0% of the population. 'Flooding' was reported by only 12.4% of the respondents. This aligns with the findings of the research of Williams (2011), which report desertification as one of the major impacts of charcoal production on the environment.

Tamarindus indica was indicated as the most preferred tree species used by the producers for charcoal production. Next to this was Khaya senegalensis and Parkia biglobosa. The least reported tree species for charcoal production was Gmelina arborea. Going by this, Tamarindus indica would be the most depleted tree species in the study area. All of the respondents agree that charcoal contributed to their well-being. This is an indication that they solely depend on charcoal production for their means of livelihood, and they have to be provided with an equally paying job for them to leave charcoal production.

All of the respondents agreed to accept alternative jobs to charcoal production. This indicates their readiness to switch to alternative jobs when provided with sufficing incentives. They are willing to change for alternative jobs for a price range of N31,000 to > N200,000.

Regression Analysis on Producers' Willingness to Accept

Table 13 shows the rate at which the independent variables (age and locality) is predicting the dependent variable (willingness to accept to change to an alternative job). The R square (0.409) indicates that there is a sufficient relationship between the independent variable and the dependent variable variables. This is estimated that 40.9% of the dependent variables is explaining/explaining the dependent variables. 'Sex' is automatically excluded from the analysis because it was found to have no correlation with the dependent variable.

Table 13. Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.640[a]	.409	.404	.53016

a. Predictors: (Constant), Age, Sex, Locality

Table 30 portrays the fitness of the regression model for this study. The significant level is less than 0.05, and this shows the overall fitness of the overall conceptual model. This is also an indication that further conclusion can be made based on this result.

Table 14. Analysis of Variance

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	64.809	3	21.603	76.860	.000[b]
	Residual	93.597	333	.281		
	Total	158.406	336			

a. Dependent Variable: Willingness to pay for alternative energy sources

b. Predictors: (Constant), Age, Sex, Locality

Table 15 shows the interrelationship among the variables. The 'B' value depicts change in dependent variables in respect to the independent variables. The significance values indicate the fitness of the model, because they are all less than or equal to 0.05. It can be seen from the table that 'sex' has a negative relationship (-0.276) with the constant (WTA) and a significant value of 0.000. Variable 'locality' also has a negative relationship (-0.118) with the constant (WTA) and a significant value of 0.003. Variable 'age' has a positive relationship (0.334) with the constant (WTA) and a significant value of 0.000, which shows its predicting fitness. This means that when variable 'age' increases by 1 unit, WTA increases by 0.334 unit.

To test the interrelationship among the independent variables and to ensure they are truly independent and dependent on each other, a further multicollinearity diagnosis was carried out, and this can be seen in the column titled VIF (Variance Inflation factors). All factors for 'sex', 'locality' and 'age' are lesser than 10. This means they have no significant relationship with one another and they are truly independent. This further validates the fitness of the study regression model.

Table 15. Regression Analysis

Coefficients[a]

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**	**Collinearity Statistics**	
		B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
1	(Constant)	1.174	.190		6.189	.000		
	Sex	-.276	.046	-.309	-5.965	.000	.663	1.508
	Locality	-.118	.039	-.144	-3.037	.003	.789	1.267
	Age	.334	.048	.343	7.015	.000	.743	1.345

a. Dependent Variable: Willingness to pay for alternative energy sources

Conclusion

The study concludes that cash incentives will encourage charcoal producers participation and a pricing policy was necessary. Thus, descriptive statistics was employed to gather useful information on the current practices awareness regarding the hazard of charcoal production and usage. The study used stated preference approach inform of CVM where charcoal producers were asked to state their WTA a change in job. The findings from this survey revealed that regarding willingness to accept to change to an alternative job, all the producer respondents stated that they are willing to accept a change to alternative jobs for a pay ranging from ₦31,000 to over ₦200,000. Lastly, all (100%) of the producer respondents are also willing to change jobs from charcoal production to sustainable ones.

Recommendations

The estimated producers' WTA was at a range of ₦31,000 to over ₦200,000, as reported in this study, and is recommended for policy use. In addition, since the producers have positive dimensions of knowledge, attitudes and practices towards the negative externalities of charcoal production health and the environment, further sensitisation through mass media would go a long way in reinforcing this perspectives. Ensuring the usage of or switch to renewable sources of energy is difficult and takes a long transitioning time, especially in rural areas of Nigeria, and is a complex policy effort which requires employment, technologies, management costs; hence, measures to cater for these should be put in place to ensure a successful renewable energy policy and transitioning.

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