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Economic and Environmental Implications of Charcoal Production in Kogi State, Nigeria

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Abstract: Nigeria's economic trees are declining in availability due to the continuous competition by charcoal producers and other productive users of hardwoods. Therefore, this work estimated the technical efficiency, economic, and environmental implications of charcoal production in Kogi State, Nigeria. A multi-stage sampling technique was used to sample forty-five (45) charcoal producers from Kogi West Senatorial Districts. Data were elicited through a well-structured questionnaire. Descriptive statistics, budgetary analysis, and stochastic frontier were used to describe the socio-economic variables and identify the sources of wood for charcoal production; estimate the profitability of charcoal production and its technical efficiency. The result of descriptive statistics shows that male respondents dominated the business of charcoal production and about half of the distribution was legally carrying out the business. Open forest and farmland areas were the major sources of wood used. The net income realized from charcoal production per cycle was ₦ 4,084.35. The mean technical efficiency was 0.5256. This implies that if the efficiency of resource use is increased by 47.44 percent, the charcoal producer would operate on the production frontier given the existing technology. Serious environment threats like deforestation, GHG emission, and bush burning are all adduced to charcoal production. It is therefore important for legal charcoal producers to form a viable cooperative in other to harness their resources, to make them more efficient, and expose illegal operators in the business of charcoal production. Our trees must also be saved by setting up an afforestation plan by the government at all levels.
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Introduction

Charcoal remains the dominant source of cooking and heating energy for 80 percent of households and it is an important source of income in sub-Sahara Africa (SSA) (Arnold, Kohlin, Persson, Shepherd 2006; Zulu and Richardson, 2013). Its production is considered the most important and earliest chemical engineering innovation of human beings (Antal and Gronli, 2003). Although fuelwood production remained constant in developing countries, the production and utilization of charcoal are still on the increase in many African countries (Tomaselli, 2007). Even in the urban household whereby charcoal usage is predominant for cooking is projected to increase as rural-urban migration of youths in search of jobs which the agricultural sector could not provide (Karekezi *et al*., 2008). Moreover, charcoal has its good side of being a local renewable energy source that can transform the economic growth of SSA countries (Arnold *et al*., 2006), especially in a situation now in Nigeria where the price of other domestic energy substitutes like kerosene, gas, and electricity are increasing. Other benefits of charcoal include easier transportation and more acceptability by households in villages (Saravanakumar *et al*., 2006).

Despite the economic importance of this resource, it is germane to be wary of its production processes whereby firewood is cut and split under the process of carbonization, distillation, pyrolysis, and torrefaction of wood (FAO, 2004). This makes us doubt the efficiency of the production of charcoal in most developing countries. Besides, its production process has been adduced to serious environmental threats by adversely affecting climate change. As charcoal has pricing value in the market, we need to determine the inputs and other costs incurred.

Nigeria which is so endowed in renewable resources exported a lot of wood whose estimate cannot be ascertained because of illegal operators that indiscriminately harvest economic trees. The government of Muhammadu Buhari passed a law to halt this illegality and accordingly, farmers in Nigeria do not only produce and supply charcoal to the urban societies and neighboring countries. This has helped to alleviate energy deficit or supply shortage and provides environmental benefits by protecting soil erosion and improving soil fertility through crop rotation. When the world is facing climate change problems caused by deforestation and urbanization and still producing charcoal while maintaining a cost-effective environmental balance is a dual advantage and needs to be encouraged. These types of activities necessitate the involvement of all concerned stakeholders involved in charcoal production and distribution efficiency. This includes improving the efficiency of the charcoal producers so that they can produce a vast quantity of charcoal within the existing resources to meet the energy needs of the consumers.

Objectives of the Study

The main objective of this study is to analyse the technical efficiency, socio-economic and environmental implications of charcoal production in Kogi State, Nigeria.

The specific objectives are to:

i. describe the socio-economic characteristics of charcoal producers in Kogi State.

ii. identify the sources of trees/wood and methods used for charcoal production in the study area.

iii. estimate the associated cost and returns on charcoal production in the study area.

iv. determine the technical efficiency of charcoal producers in the study area.

v. examine the effect of charcoal production on the environment of the study area.

Methodology

This study was carried out in Kogi State, Nigeria. The State has a lot of renewable resources in which forest resources are of very high economic value. At present, about 85 percent of the total land area is covered by untapped forest reservation containing important economic trees. A multi-stage sampling technique was employed to select Charcoal producers from the study area. The first stage involved the purposive sampling of the Kogi-West geographical zone; which is characterized by its forest savannah vegetation. The second stage was the random sampling of three (3) Local Government Areas (LGA) in Kogi-West, while the third stage involved the snow-ball sampling of two (2) communities that produces charcoal from each LGA. The final stage sampled five (5) Charcoal producers from each of the selected communities. The overall sampled respondent was fifty (50), Charcoal producers. This study made use of primary data collected through a well-structured questionnaire and interview schedule. Information related to the socio-economic characteristics of Charcoal producers, sources of trees/woods and methods employed for charcoal production, cost, and return of this enterprise and its impact on the environment were captured.

Descriptive statistics, Budgetary Analysis, and Stochastic Frontier Production Function were used to analyse the objectives of this study. Gross Margin (GM) and Net Income (NI) were calculated following Kay Johnson (1982) and Kay (1986). This was used to determine the profitability of charcoal producers in the study area.

$$GM = TR - TVC \dots \quad (1)$$

$$NI = GM - TFC \dots \quad (2)$$

The following ratios which are the measurement of profitability were estimated:

- Profitability Index (PI) or Return on sale = NI/TR
- The rate of return on Investment (RRI) = $NI/TC * 100$
- Rate of return on variable cost (RRVC) = $TR - TFC/TVC * 100$
- Operating Ratio (OR) = TVC/TR

Where,

$TVC = Total\ Variable\ Cost$

$TC = Total\ Cost$

$TR = Total\ Revenue$

$TFC = Total\ Fixed\ Cost$

The production function was log linearized:

$$\ln Y_i = \beta_o + \sum \beta_{ij} \ln X_{ij} + V_i - U_i \dots \quad (3)$$

Specifically, the production technology (Technical Efficiency) of charcoal producers in Kogi State of Nigeria was estimated as:

$$\ln Y_i = \beta_o + \beta_i \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + V_1 - U_1 \dots \quad (4)$$

Where: Y_i = Quantity of Charcoal Produced (kg/bag) per production cycle.

X_1= Area of land for production (hectares)
X_2= Cost of harvested logs (Naira)
X_3= Transportation cost (Naira)
X_4= Labour (man-days).
X_5 = Depreciation cost of fixed assets (matches, axe, barrow, shovel, drum/kiln, etc.).
X_6= Cost of raw materials (matches, water, kerosene, sacks, etc.).

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \quad (5)$$

Z_1 = Age of charcoal producer (years)
Z_2 = Production experience (years)
Z_3 = Education level (years)
Z_4= Gender (Dummy variable: 1 = male, 0 = female)
Z_5= Household size
Z_6 = Distance to the source of the wood (km)
δ_0, δ_1, δ_2....δ_6 are estimated regression parameters.

Results and Discussion

Description of Socioeconomic Characteristics of Charcoal Producers

The socioeconomic characteristics of charcoal producers in the study area are shown in Table 1. The charcoal producers in the study area are in their productive age with a mean age of 34 years. Male respondents dominated the business of charcoal production as they were about 71.1percent, while 28.9 percent were female involved in charcoal production. There are almost more married respondents (55.6%) involved in charcoal production. The average household size in the study area was 3, this indicated a small household size. Almost half of the respondents (49%) have a household size ranging from 1 and 2. This result has an equal percentage (37.8%) of respondents having primary and secondary education. The mean production experience (4.1 years) shows that the respondents have marginal experience in the business of charcoal production. About 55.56 percent of respondents had production experience below 5 years while the remaining 44.44 percent had above 5 years of production experience. The majority of the respondents (91.1%) carry out the business of charcoal production on a part-time basis. Likewise, about 46.7 percent of charcoal producers are illegitimately carrying out this operation, as necessary approval was not done by the government. Only 53.3 percent of the charcoal producer are legally permitted by the government to carry out the operation. The government has been making an effort to streamline indiscriminate felling of trees and reduce its devastating effect on climate change by imposing fees for producers to abate. Virtually all the respondents sourced for trees/wood from open forest and farmland. This could be the fact that the sites are not protected in the study area, very few respondents (22.2 percent) got wood from the lumbering site while 17.8 percent sourced for wood from saw mail. The open forest and farmland depict the high level of tree cutting from these sources. This has an indirect effect on the environment, thus affecting climate change. Also, the sources are usually exploited due to free or cheap access.

Table 1: Socio-economic Analysis

Age (years)	Frequency	Percentage	Mean
≤20	5	11.11	
21-30	19	42.22	
31-40	6	13.33	34.44
41-50	11	24.45	
>50	4	8.89	
Gender			
Male (1) Female (0)	32 13	71.10 28.90	
Marital status	Frequency	Percentage	
Single Married	20 25	44.40 55.60	
Household size	Frequency	Percentage	Mean
1 2 3	12 10 4	26.70 22.20 8.90	2.91

4 5 6	10 7 2	22.20 15.60 4.40	
Education (years)	Frequency	Percentage	Mean
No formal education (0) Primary (4-6) Secondary (10-12) Tertiary (>12)	3 17 17 8	6.70 37.80 37.80 17.70	9.5
Production Experience (years)	Frequency	Percentage	Mean
<3 3-4 5-7 >7	13 12 11 9	28.90 26.60 24.44 20.00	4.1
Nature of Business		**Forms of Business operation**	
Part time	Full time	Legal	Illegal
41 (91.1%)	4 (8.9%)	24 (53.3%)	21 (46.7%)
Source	Frequency	Percentage	
Open forest Limbering site Farmland Saw mail	45 10 43 08	100.0 22.2 95.6 17.8	

Source: Field Survey, 2017

Preference of Trees/Wood for Charcoal Production

The results in Table 3 presents a list of tree species used for charcoal production in the study area. *Triplochiton scleroxylon* commonly known as *Obeche* or *Arere*, *Melicia excelsa* (Africa teak/ *Iroko*), *Khaya senegalensis* (Mahogany), *Vitellaria paradoxa* (Shea tree/*Emi*) are used by at most fifty percent of the charcoal producers in the study area for production. *Nauclea diderrichi* (Africa linden or *Opepe*), *Afzelia africana* (Oak/*Apa*) takes precedence and is used to a different degree (22.2 percentage). The degree of usage of the following trees includes *Anogeissus leiocarpus* (15.6%), *Lovoa triclulioides* (15.6%), *Magnifera indica* (15.6%), *Tectona grandis* (13.3%), *Prosopis africana* (4.4%), and *Cassia fistula* (4.4%). All these tree species are widely used in Kogi State because of their hardness. In order words, hardwoods are the most preferred for charcoal production. These are however wood of economic importance. This result conforms with the work of Bhattarai (1998) and Essiet (2009) that hardwoods are used over the tropics and give higher charcoal yield than softwood. The hardness of these woods makes charcoal non-bristling as they have a higher specific gravity (Abbior 1990).

Table 3: Trees/wood species used in charcoal production

Scientific name	English/local name	Percentage	Rank
Khaya senegalesis	Africa Mahogany	37.8	3rd
Nauclea diderrichi	African Linden/Opepe	22.2	5th
Afzelia africana	African Oak/Apa	22.2	2nd
Melicia excelsa	African Teak/Iroko	42.2	2nd
Anogeissus leiocarpus	African birch/Ayin	15.6	6th
Terminalia superba	Ofram tree/Afara	4.4	8th
Tectona grandis	Teak	3.3	7th
Prosopis africana	Iron tree/gele	4.4	8th
Vitellaria paradoxa	Emi/Shea tree	3.1	4th
Cassia fistula	Cassia/Gytaranti	4.4	8th
Triplochiton scleroxylon	Obeche/Arere	48.9	1st
Lovoa trichilioides	Tiger wood /African whitewood / African walnut (Asala)	15.6	6th
Magnifera indica	Mango tree	15.6	6th

Source: field survey, 2017

Methods of charcoal production

As revealed in Table 4, the traditional method (Earth mound kiln) was mostly used (88.89%) in the study area. About 12.5percent adopted the improved method (mental kiln or drum). The improved method may not be affordable for charcoal producers because they are capital intensive (Ottu-danquah, 2010). However, the use of earth mound was the prominent method for charcoal production. Agyeman *et.al* (2012) also reported the prominent use of the earth mound kiln method.

Table 4: Method of Charcoal Production in the Study Area

Method	Frequency	percentage
Local/traditional Earth mound	40	88.89
Improved method (Metal Kiln)	5	12.50
Both	5	12.50

Source: Field survey, 2017

Figure 1: Earth Mound Method of Charcoal Production in Nigeria

Analysis of charcoal production profitability

The results of the profitability analysis are presented in Table 5. The average revenue obtained by charcoal producers in the study area was N23, 195.56 per the production cycle. Harvested logs had the highest percentage of the total cost of production with 37.35%, followed by land clearing (18.59%), labour (18.30%), transportation (15.46%), and Raw materials (10.13%). The total variable cost constituted 73.74% while the fixed cost constituted just 26.26% of the total cost of production.

Table 5: Total Cost of Charcoal Production (per cycle)

S/N	Item Amount (N)	Amount (₦)	Total Amount (₦)
A	Revenue Average, Sales per production cycle Total Revenue (Quantity Kg x Price)	**23,195.56**	**23, 195.56**
B	Variable Cost (Average)		
	land clearing	2,624.44	
	Harvested logs	5,273.33	
	Transportation	2,183.33	
	Raw materials (matches, water, fuel, sacks)	1,429.78	
	Labour (wood collection, splitting, and setting, monitoring, bagging)	2,582.45	
	Tax	711.11	

	Total Variable Cost Gross Margin (TR-TVC)	14, 093.33	 9,102.23
C	Fixed Costs Deprecation on machete Deprecation on axe Deprecation on Wheelbarrow Deprecation on shovel Deprecation on Drum Deprecation on Earth kiln	 1,239.11 952.57 268.87 1,075.85 443.85 1,037.63	
D	Total Fixed Cost Net Profit	5,017.88	 4,084.35

Source: Field survey, 2017

₦ 360 was equivalent to 1 USD

The enterprise had an average net income of ₦ 4,084.35 per production cycle.

Profitability index (PI), rate of returns on investments (RRI), rate of returns on variable cost (RRVC) and operating ratio (OR) were the parameters estimate for profitability (Table 6). The average PI for charcoal production was 0.39, indicating that out of every naira earned; about 39kobo accrue to the farmer as net income.

Table 6: Profitability Estimate of Charcoal Production

Measures of profitability	**Estimate**
Profitability index (PI)	0.3924126
Rate of return on investment (RRI)	47.627701
Rate of return on variable cost (RRVC)	0.01289807
Operating ratio (OR)	0.6075874

Source: Field survey, 2017

An RRI of 48 percent indicates that a producer earns ₦ 48 profit on every naira spent on charcoal production. RRVC was estimated to be about 0.01% per production cycle. In other words, every ₦1 cost incurred on variable inputs generates about ₦ 0.01k. This suggests that improvement in the profitability of charcoal production in the area will require increasing the efficiency of the use of these variable inputs. Moreover, the OR of 0.61 indicates greater total revenue over total variable cost. It can therefore be concluded that charcoal production in the area is a money-spinning enterprise.

Efficiency of Charcoal Production

The estimated sigma squared (σ^2) was 13% and statistically significant at 10 percent (Table 7). This shows a good fit and the correctness of the specified distributional assumption of the composite error term. Also, the magnitude of the variance ratio was 87%. This implies that systematic influences that are unexplained by the production are the dominant sources of random errors. Thus, there was an existence of technical inefficiency among the sampled charcoal producers. The estimated gamma coefficients showed that in the study area, there was an 87 percent variation in the output of charcoal due to differences in their technical efficiencies. Efficiency variables that have positive statistical significance are the area of land for charcoal production (X_1), cost of harvested logs (X_2), and depreciation cost on fixed assets (X_5). An increase per unit of these variables increases the probability of the output of charcoal producers. The co-efficient of these variables were significant at 1 percent level. The coefficient of transportation cost and labour used were negative, with labour significant at 5 percent level. This implies that an increase in the transportation cost and the cost of labour reduces the output of charcoal produced.

Table 7: Maximum Likelihood Estimates of the Parameters of the Stochastic Frontier Production Function

Variable	Coefficient	Standard error	t-value
Constant	6.684	2.539	2.633**
Area of land (Ha) (X_1)	1.041	0.170	6.113***
Cost of Harvested logs (₦) (X_2)	0.840	0.294	2.858***
Transportation cost (₦) (X_3)	-0.045	0.028	-1.606
Labour (Man-days) (X_4)	-0.409	0.151	-2.707**
Depreciation cost on fixed assets (₦) (X_5)	1.815	0.238	7.626***
Inefficiency model			
Age (years) (Z_1)	-0.919	0.494	-1.862*
Production experience (years) (Z_2)	0.207	0.113	1.828*
Education (years) (Z_3)	-0.136	0.116	-1.176
Gender (Z_4)	0.205	0.377	0.544
Household size (Z_5)	0.639	0.184	3.472***
Distance to the source of wood (Z_6)	0.206	0.174	1.183
Variance parameter			
Sigma squared (σ^2)	0.132	0.132	1.727*
Gamma (γ)	0.870	0.358	2.431**
Log-likelihood function	104.220		

*, **, *** significant at 10%, 5% and 1% respectively
Source: Field survey, 2017

The coefficient of age was negative and significant at the 10 percent level (Table 7). This negative sign suggests that the technical efficiency of charcoal production decreases with the age of the head of the household. Khundi *et al*. (2011) reported that the production of charcoal is less prevalent in old age household heads. The positive significance (10%) of production experience increases the efficiency of charcoal production in the. The coefficient of education on technical efficiency was not significant and is negative. This contradicts the report of Minten *et al*., 2013, who reported a positive effect of schooling on productivity in the charcoal sector. The positive sign of the coefficients for gender implies that households headed by males were more efficient than those headed by females. This result is consistent with that of (Khundi *et al*., 2011 and Adino, Aemro, and Tessema 2020) where they reported that charcoal production is less prevalent among females. The positive significance of household size implies that a larger number of household members can produce a higher volume of charcoal and increase their income than households that have fewer members, this could also reduce the cost of labour during production. Brobbey *et al*., (2019a, 2019b) confirms this assertion. The distance to the source of wood positively affected the technical efficiency of charcoal production but was not significant.

The results in Table 8 shows the distribution of respondents by their technical efficiency. About 4.44 percent of the respondents had below 0.30 technical efficiencies (TE), while 8.89 percent had theirs between 0.31 and 0.40. Also, those with TEs between 0.41 and 0.50 were 15.56 percent. The majority (71.11%) of the charcoal producers in the study areas had TEs of 0.51 and above.

Table 8: Technical Efficiency of Charcoal Producers

TE	Frequency	Percentage
≤0.30	02	4.44
0.31-0.40	04	8.89
0.41-0.50	7	15.56
0.51-0.60	25	55.56
0.61-0.70	2	4.44
>0.70	5	11.11
Minimum	0.1564	
Maximum	0.7982	
Mean	0.5256	

Source: Field survey, 2017

Environmental Impact of Charcoal Production

Figure 1 shows the environmental problems adduced with charcoal production in the study area. Carbon emission, deforestation, and land clearing were still the prominent effect of charcoal production on the environment.

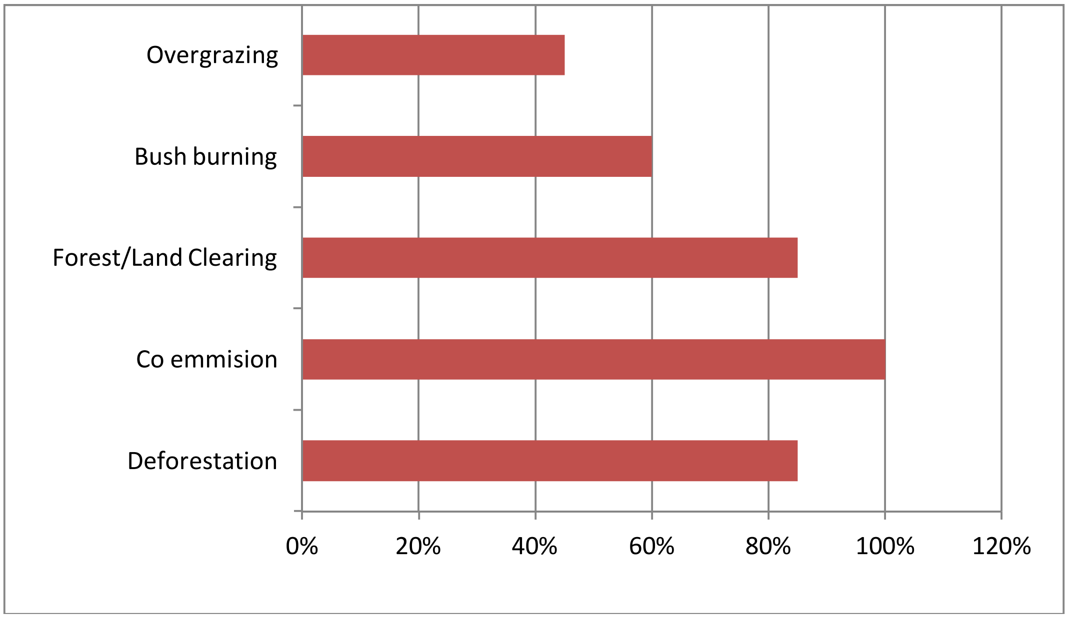

Figure 1: Indices for the environmental impact of charcoal production

Conclusion and Recommendation

In conclusion, the study revealed that the land, the harvested logs, and the labour used were the necessary inputs for making charcoal. The findings of the study showed that the mean technical efficiency was 0.5256. This result revealed that there is room to increase the technical efficiency of charcoal producers given the existing available resources. Carbon emission, forest clearance, and deforestation were the notable effect of charcoal production in Kogi State Nigeria. Since most of the wood used in the study for charcoal production was from the open forest, the government at all levels must save our economic trees from further exploitation by ensuring proper protection of the unprotected or open forest. The cost and lack of technical know-how on the use of kiln (improved production option) call for the training by concerned stakeholders on improved technologies used in charcoal production. This will reduce forest clearance and deforestation. Though profitable but charcoal producers should make it a goal to promote a balance in production and better management of natural vegetation. Also, an effort to encourage afforestation for charcoal production should be put in place to reduced extinction. The government should also set up an institutionalized framework that will regulate the production of charcoal by legitimate producers. Also, it is high time legitimate charcoal producers come together to form a viable cooperative to expose counterfeits in the business. This will also increase the efficiency of charcoal producers through resource pull.

References

1. Adino A., Aemro W., Tessema A. (2020). Analysis of economic efficiency in charcoal production in Northwest Ethiopia: A Cobb-Douglas production frontier approach. Trees, Forests, and People 2 (2020) 100020.
2. Agyeman K.O., Amponsah O., Braimah I. and Lurumuah S. (2012). Commercial charcoal production and sustainable community development of the upper west region, Ghana journal of sustainable development Vol.5, No 4.
3. Antal, M.J. and Gronli, M. (2003) The Art, Science, and Technology of Charcoal Production. Industrial Engineering Chemistry Research, 42, 1619-1640.
4. Arnold, J. E. M., Köhlin, G., and Persson, R. (2006). Wood fuels, livelihoods, and policy interventions: Changing Perspectives. *World Development 34*(3), 596–611.

5. Bhattarai, T.N. (1998). Charcoal and its socio-economic importance in Asia. Paper presented at the regional training on charcoal production, Pontiank, Indonesia organized by RWEDP.12PP.
6. Brobbey, L.K., Hansen, C.P., Kyereh, B., Pouliot, M., 2019a. The Economic Importance of charcoal to rural Livelihoods: evidence from a Key charcoal-producing area in Ghana. Forest Policy Econ 101, 19–31.
7. Brobbey, L.K., Pouliot, M., Hansen, C.P., Kyereh, B., 2019b. Factors influencing participation and income from charcoal production and trade in Ghana. Energy Sustain. Dev. 50, 69–81.
8. Essiet D. (2009). Future is charcoal export business the Nation Newspaper. Retrieved May 21, 2017.
9. FAO, 2004. Unified Bioenergy Terminology (UBET). Food and Agriculture Organization of the United Nations, Rome http://www.fao.org/3/b-j4504e.pdf.
10. Johnson, D.T. (1982). The business of farming: a guide to farm business management in the tropics. London and Basingstoke: ELBS/Macmillan.
11. Kay, R.D. (1986). Farm management, planning, control, and implementation. London, McGraw Hill., pp 65-126.
12. Karekezi, S., Kimani, J., Onguru, O., 2008. Energy access among the urban poor in Kenya. Energy Sustain. Dev. 12 (4), 38–48.
13. Khundi, F., Jagger, P., Shively, G., Sserunkuuma, D., 2011. Income, Poverty, and Charcoal Production in Uganda. Forest Policy Econ. 13, 199–205.
14. Minten, B., Sander, K., Stifel, D., 2013. Forest management and economic rents: evidence from the charcoal trade in Madagascar. Energy Sustain. Dev. 17 (2), 106–115.
15. Otu-Danquah, K.A. (2010). Current status of charcoal demand and supply and initiatives on improved cook-stoves. A presentation made during a kick-off meeting for TEZ/ESMAP survey on the energy access and productive uses for the urban poor, held in the snit guest-house conference room, Accra on 11/08/2010.
16. Saravanakumar, Z., Haridasan, T.M., Kasturi, B.R., 2006. Technical and feasibility study of conversion of long-stick wood to charcoal in a partial combustion metal kiln. Energy Sustain. Dev. 3, 17–25.
17. Tomaselli, I., 2007. Forests and energy in developing countries. Forests and Energy Working Paper No. 2, FAO, Rome, Italy.
18. Zulu, Leo C, and Richardson, R. B. (2013). Charcoal, livelihoods, and poverty reduction: Evidence from sub-Saharan Africa. *Energy for Sustainable Development* 17, 127–137.

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