Determinants of charcoal production and marketing in the Mankranso forest district in the Ashanti region of Ghana

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A B S T R A C T

This study sought to investigate the determinants of participating in charcoal production and trade as well as explore the marketing strategies used by charcoal value chain actors and the challenges confronting the charcoal business. A multistage sampling approach was employed to sample 120 respondents in five communities in Ahafo Ano South District. Descriptive statistics, binary probit regression and qualitative approaches were used to analyze the data. The results revealed that education, household size, marital status, ethnicity, farm size, proximity to the production site and regulations on charcoal production are the significant determinant of charcoal production with diverse effects. Also, gender, education, marital status, ethnicity, the quantity of charcoal produced, cost of packaging material, FBO membership, availability of storeroom, regulation of charcoal production, and ready market are the determinants of charcoal marketing. The qualitative discussion revealed that charcoal producers and traders utilise a couple of marketing strategies. Thus, pricing strategies such as pan seasonal, pan territorial, cost plus pricing and competitive pricing are all used by the respondents. Also, charcoal is packaged into different sizes and weight which ranges from mini bag, maxi bag and jumbo bags. Again, the margin analysis indicated that retailers make more margins than the other authors in the charcoal value chain. Averagely, retailers make 28.30 per 50 kg bag when dealing directly with farmers. The most pressing challenges faced by the respondents are levies paid, the tedious nature of charcoal production and trade, limited access to credit, lack of government support, limited transport system and lack of storage facilities. It is therefore recommended that other tribes in the producing areas need to be educated on the potential fortunes in charcoal production to orient them towards engaging in the venture. Moreover, investment should be channelled towards developing charcoal markets and also improving accessibility by improving road networks and making available means of transport to the producing areas to aid market access.

1. Introduction

Charcoal is a solid residue made primarily of carbon that is produced by destroying wood and distilling it without air (UN-DESA, 2019). Smallholder farmers using the Modified Taungya System (MTS) primarily produce charcoal by felling trees in the Savannah and forest transition areas and burning them in earth kilns[1]; Mohammed et al., 2015). According to this approach, Sub-Saharan Africa produces 65 % of the world's charcoal, with Nigeria, Ethiopia, Ghana, Tanzania, and Madagascar being among the leading producers (see Fig. 2: *Author's design*).

Charcoal production and marketing have been known as vital components of Ghana's energy
sector, providing fuel for cooking and heating in both rural and urban areas (Adjei et al., 2018). The affordability and availability of charcoal make it an essential energy source for many households across the country. According to Agyeman et al. (2019), numerous towns in the Ashanti Region of Ghana have benefited significantly from the production and marketing of charcoal. Within this area lies

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the Mankranso Forest District, which is renowned for its rich forest resources and thriving charcoal industry. In these particular areas, charcoal production and marketing have developed into significant livelihood strategies for many households, providing work opportunities and a source of money.

A common practice in Ghana's rural and peri-urban regions is the production of charcoal through the process of pyrolysis, which transforms wood into a carbon-rich fuel source (Kwakye et al., 2017; Dzomeku et al., 2016). Charcoal is used mostly for cooking and heating. Marketers sell charcoal to satisfy the rising need for inexpensive cooking fuel, especially in big cities.

The availability of natural resources, technological developments, socioeconomic factors, institutional frameworks, and market dynamics are some of the factors that affect the dynamics of charcoal production and marketing in the chosen communities of the Mankranso Forest District [2]. In order to develop effective policies and strategies to support the sustainability and profitability of the charcoal sector while addressing environmental and social issues, it is essential to understand these drivers.

Environmental issues related to charcoal production and marketing include the loss of forest resources, unsustainable production methods, and deforestation. Assessing these activities' impacts on the neighbourhood ecology and identifying sustainable techniques that might lessen their detrimental environmental consequences are the goals of studies like Owusu et al. (2018) and Antwi et al. (2017).

According to Asuming-Brempong et al. (2020) and Nketiah-Amponsah et al. (2016), the socioeconomic factors affecting charcoal production and marketing also have an impact on local livelihoods, revenue creation, and potential for employment. Finding possible bottlenecks and restrictions that can impede the industry's expansion and development is made easier by being aware of these variables.

The production of charcoal is a significant source of income, primarily in rural areas, and an essential energy source, particularly in developing nations (Kebede et al., 2010; Njenga et al., 2013). Therefore, in many nations, especially those of Sub-Saharan Africa (SSA), the usage of wood to create heat energy, notably for cooking and heating, continues to be extremely significant (Erakhrumen, 2008). According to Kemausuor et al. (2011), wood fuels account for 60–80 % of all wood consumed globally and between 50 and 90 % of all energy used in poor nations. Additionally, Abbas et al. (2016) calculated that 52 million tonnes of wood charcoal were produced worldwide in 2015. Africa generated more than half (62.1 %), followed by the Americas (19.6 %) and Asia (17 %), while Europe and Oceania contributed just a little amount (1.2 %) and 0.1 %, respectively [3]. Global charcoal output climbed by 19 % between 2005 and 2015, according to statistics from the FAO, and by 46 % over the previous 20 years, according to Abbas et al. (2016); the majority of the rise occurred in Africa. The top 10 producers of charcoal in the world in 2015 were Brazil, Nigeria, Ethiopia, India, Ghana, the
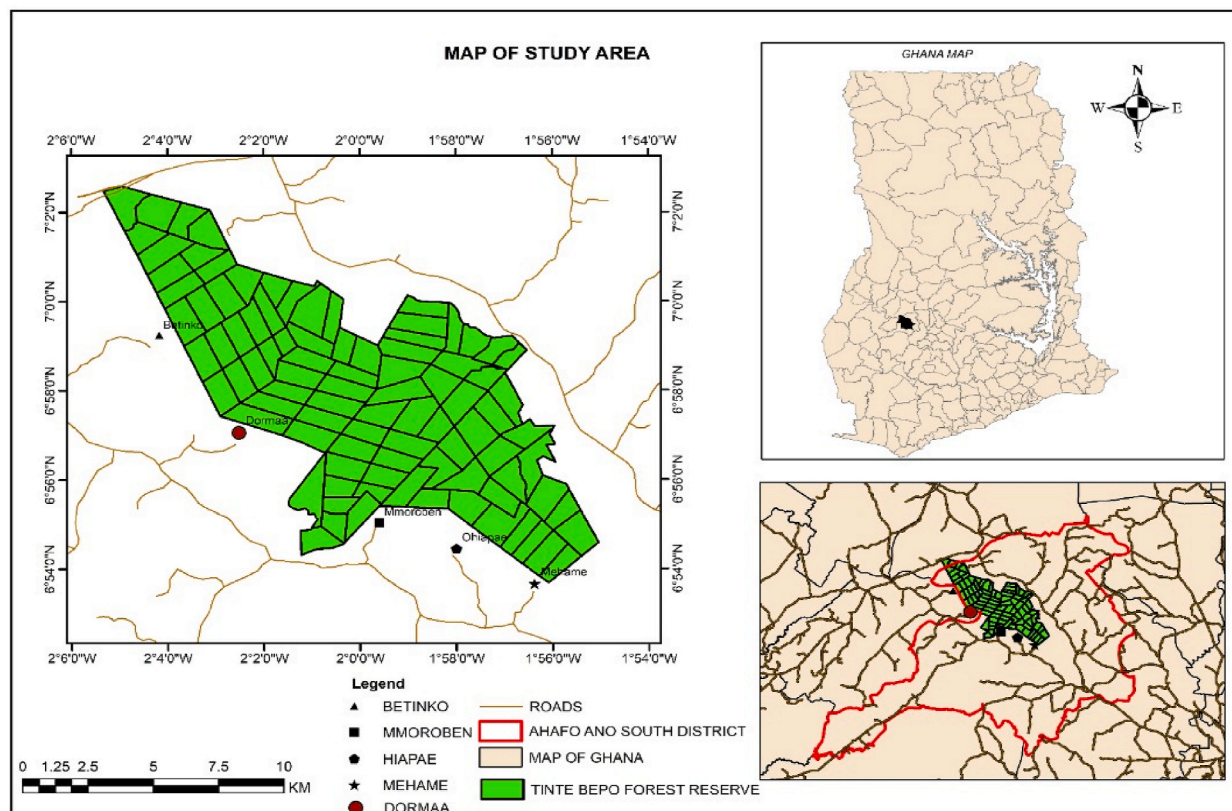

Fig. 2. Map of the study area.
Source: Author's design

United Republic of Tanzania, China, Madagascar, and Thailand.

More than 90 % of Africans use either firewood or charcoal for cooking and other heating purposes (Erakhrumen et al., 2010), which has led to a rise in the continent's fuel wood consumption, which is predicted to reach 544.8 million for firewood and 46.1 million tons for charcoal by 2030. (Arnold & Persson, 2003). This is due to the recent huge increase in the energy demand for charcoal on the African continent, of which Ghana has witnessed a massive increase in demand as a result of population growth and urbanization. However, the use of wood fuel, especially wood charcoal, is more prominent, adding to the growing demand [4]; Duku et al., 2011). Ghana is one of the top West African nations for charcoal consumption, and it also has one of the highest per capita wood demands in the subregion, demonstrating the significance of wood energy for the nation's socioeconomic growth (Yevich & Logan, 2003).

Comprehending the factors that impact the production and marketing of charcoal in Ghana is imperative for formulating effective policies and strategies that foster sustainable practices and augment the socioeconomic welfare of industry participants. Gender is a major factor in charcoal production and marketing in Ghana. Research indicates that men are mostly involved in the production of charcoal because of the physically hard nature of the task [5]. According to [5], families headed by men are more likely to produce charcoal, which has been connected to the necessity for labour that is done outside the home (Schaafsma et al., 2012). However, male merchants are less impacted since they may follow up with producers on the production site, where they occasionally need to spend several days with producers to collect their charcoal. Female merchants are unable to spend days away from home since they have domestic responsibilities to attend to, in addition to the fact that their cultures forbid them from doing so and staying with producers [6]; Owusu-Adjei, 2017).

Another factor is marital status. Due to the ability to hire family members as farmhands, married farmers are more likely to make charcoal [1,5]. However, according to other research, marital status could not have a significant impact on the amount of charcoal produced [7].

In Ghana, the marketing and production of charcoal are heavily influenced by ethnicity. Some ethnic groups are more likely to engage in the production of charcoal since they are known for doing so traditionally—for example, the Sissala tribe hails from northern areas ; [1]. This is frequently associated with livelihood strategies and cultural behaviours.

The likelihood that someone may produce charcoal seems to decrease with education level. Those with higher levels of education are more inclined to look for different, less labour-intensive jobs because they believe that producing charcoal is a lower-class profession (Brobbey et al., 2018; Kiruki et al., 2019).

One important factor is the land's availability. Due to their potential lack of access to other agricultural options, households with smaller land holdings may be more inclined to produce charcoal[8]. Production of charcoal is frequently carried out on common lands in places where property ownership is uncommon [9].

The type and availability of raw materials have a big impact on how much charcoal is produced. Wood for the production of charcoal comes from a variety of geographical regions, such as forests, shrublands, savannahs, and agricultural lands [4]. Charcoal producers frequently receive free wood from farms and forests, which adds to the supply of raw materials.

Ghana has several laws and rules about licenses for the production of charcoal, land acquisition, and admission into forests that may have an impact on business. Farmers who are aware that licenses are required to produce charcoal could be more likely to do so, whereas farmers who live in distant places might be less likely to follow the rules (Kiruki et al., 2019). It has also been shown that paying customary charcoal taxes as required by law encourages participation in the charcoal-making process (Brobbey et al., 2019). The high demand for charcoal in the urban areas of the country motivated a lot of people especially men both young and old in the rural areas into the business of charcoal production. However, despite its benefits, charcoal production has adverse effects such as desertification, environmental degradation, global warming and climate change.

The existing literature on the charcoal sector predominantly focuses on the adverse environmental and health impacts of charcoal production, with limited attention to production and marketing aspects. For instance, studies have highlighted the detrimental effects of traditional charcoal production on environmental issues and health problems among labourers and nearby residents[10,11]. Furthermore, the use of outdated methods in charcoal production has been identified as a significant contributor to environmental pollution and ozone layer depletion [12]. Additionally, the formalization of charcoal value chains has been explored about livelihood outcomes in Central- and West Africa, emphasizing the need to assess the relations between formalization and socio-economic outcomes [13].

While the negative impacts of charcoal production are well-documented, there is a scarcity of rigorous studies on the production and marketing dimensions. However, a study in Mozambique has shed light on the flexible role of charcoal production in the livelihoods of smallholders, emphasizing the varied role of production in their livelihoods[14]. Similarly, a study in Nepal has explored the impact of improved charcoal production technology on conserving the environment and promoting sustainable livelihoods in rural areas [15–17]. These studies provide valuable insights into the multifaceted role of charcoal production in livelihoods and environmental conservation.

Moreover, the potential usage of charcoal as an energy carrier or reducing agent in iron and steel making has been examined, highlighting the need for a comprehensive understanding of charcoal production with alternative materials and its potential applications. Additionally, life cycle assessment methodologies have been utilized to estimate the greenhouse gas footprint of charcoal production from biomass, emphasizing the importance of considering different environmental impact categories in the assessment of charcoal production.

While the existing literature has extensively addressed the detrimental effects of charcoal production, there is a notable gap in rigorous studies focusing on the production and marketing aspects. The limited studies available emphasize the need to explore the multifaceted role of charcoal production in livelihoods, environmental conservation, and potential alternative applications. Therefore,

further research is warranted to comprehensively understand the production and marketing dynamics of the charcoal sector. Also, there is a limited understanding of the factors that influence Charcoal production and marketing in the extant literature. Though the forest within the study area is protected, charcoal production is still peaking and no study has investigated the determinants of charcoal production and marketing by farmers in the study area.

Therefore, this study attempts to evaluate the factors that affect charcoal production and marketing in certain communities in the Mankranso Forest District in the Ashanti Region of Ghana. Specifically, we sought to; 1) determine factors that influence Charcoal production and marketing, 2) study the marketing strategies, and 3) identify the challenges facing charcoal production and marketing in the study area. The researchers aim to enlighten policymakers, stakeholders, and community members about the challenges and potential in the charcoal business by looking at the natural, technical, socioeconomic, institutional, and market-related variables. Promoting sustainable practices and enhancing the socioeconomic well-being of the affected people are the ultimate goals, along with assuring the preservation of the area's forest resources.

2. Materials and methods

2.1. Description of study area

The study was conducted in the Ahafo Ano South district particularly Mankranso and its surrounding environs of the Ashanti region. The district is located at Latitude 6°42 N and longitude 4°5 N and 2° 20 W (GSS, 2012). The district is located within the forest belt of Ghana. The area experienced two seasons in a year, thus rainy and dry seasons.

The Mankranso Forest District is located in the study area which takes charge of the Tente Bepo Forest reserve [18]. The Tente Bepo forest reserve covers a land area of 300 km^2. Specifically, the Dormaa, Betinko, Mmoroben, Hiapae and Mehame communities were selected from the district for this study. These communities lie along forest reserves with limited farmlands (MoFA, 2022). Hence, farmers in these communities encroach on the forest reserves and utilise them for farming and other related activities such as charcoal production due to the presence of trees.

3. Research design

The study adopted descriptive and causal designs. This design allowed researchers to keep track of the research activities and helped to ensure that the ultimate research objectives were achieved. [19,20] recommended a descriptive survey to ascertain and be able to describe the characteristics of the variable of interest in a situation. Thus, the descriptive approach enabled the researcher to describe key marketing strategies used by charcoal producers, whereas the causal design enabled the researchers to conclude on the drivers of charcoal production and marketing outlet choice. Accordingly, this design was justified by[21] that causal designs enable researchers to identify relationships between variables.

3.1. Sources of data

Both primary and secondary data were used for this study. Primary data was obtained through the administration of a structured questionnaire. Five communities in the Ahafo Ano South district were selected namely; Dormaa, Betinko, Mmoroben, Hiapae and Mehame. In this research study, secondary data was gathered from a comprehensive review of scholarly articles and books relevant to the research topic. These were collected from different published and unpublished sources, government institutions, district forest offices and websites. The utilization of secondary data from these academic sources provides a robust foundation for the study, as it leverages the expertise and findings of established scholars in the field. By critically examining and synthesizing existing knowledge and insights, this approach ensures the research is grounded in a well-informed and up-to-date theoretical framework, allowing for a comprehensive analysis and interpretation of the subject matter.

3.1.1. Population of the study
Based on data obtained from the district forest office, [22] approach for sample size determination was used to estimate approximately 100 respondents for the study. The Central Limit Theorem justifies that a sample size greater than or equal to 30 is adequate for standard normal deviation [2,18]. However, the number of respondents interviewed increased to 120 in the study to substantiate the generalization of the findings.

3.2. Sampling technique and sample size

The study communities and respondents were selected via a purposive and snowball sampling approach. the purposive approach was used to select five communities for the study (Dormaa, Betinko, Mmoroben, Hiapae and Meham). These communities were chosen due to the intense charcoal production and marketing activities currently peaking in the area. However, there has been an upsurge in interest in commercial charcoal production in the communities along the fringes of the said forest. The snowball sampling approach was used to interview 24 respondents from each of the five communities, totalling 120 respondents in the five communities. Structured questionnaires were used to gather data from the respondents. They were administered to the respondents by the researcher personally. Before the administration of the questionnaire, the researcher thoroughly explained the details of the questionnaire to the respondents so that they were informed about the purpose of the research. Conforming to the ethics of scientific research, respondents

were not forced to answer questions. This approach improved the understanding of the respondents on the content of the questionnaire and did away with ambiguities, suspicions, partiality and being able to provide independent opinions and views.

4. Methods of data analysis

Descriptive statistics such as mean, frequencies and percentages in the process of examining and describing demographic outputs and marketing functions were applied. A 5-point Likert scale was also employed to measure participants' responses to challenges facing charcoal production and marketing, ranging from Strongly Disagree (represented by 1) to Strongly Agree (represented by 5).

An econometric model was employed to analyze the impact of one-unit changes in explanatory variables on dependent variables i. e. determinates of charcoal production and marketing in the study area. The response variable, in this case, is binary: thus, if the respondent produces and trades charcoal (=1) or otherwise (=0). In situations where the dependent variables are binary, the binary probit or binary logit models are considered appropriate. The choice of binary probit or binary logit is subjective because they produce almost the same estimates. Thus, whether to produce/sell charcoal or not are mutually exclusive and each gives respondents a certain level of utility. In that regard, rational producers/traders would choose the option that provides the highest payoff (Greene & Hensher, 2010). However, it is worth noting that the expected satisfaction to be obtained from producing or selling charcoal is heterogeneous and can be determined by individual farmers' socioeconomic characteristics as well as their farm-level and institutional variables. The binary probit model was used in this study.

5. Model Specification

Specify the probit model with the binary response variable and the selected independent variables. The general form of the probit model for a single binary response variable Y and multiple predictors X1, X2, …, Xn is as follows:

$$Pr(Y = 1) = \Phi(\beta 0 + \beta 1 X1 + \beta 2 X2 + \ldots + \beta n Xn)$$

Where:

Pr(Y = 1) is the probability of engaging in the activity (binary outcome: 1 for engaging, 0 for not engaging).

$\Phi()$ is the cumulative distribution function of the standard normal distribution.

β0 is the intercept term.

β1, β2, …, βn are the coefficients of the independent variables (X1, X2, …, Xn) representing various factors that may influence the

Table 1
Descriptive statistics of variables.

Continuous Variable	Mean	Min	Max
Age	45	24	68
Level of education	4	0	12
Household size	7	1	16
Experience	9	1	25
Annual charcoal production(bags)	89	0	500
Distance to the production site (km)	3	1	8
Selling price (GH')	23.33	0	90
Weight of Charcoal bag (kg)	62	45	100
Binary Variable		**N**	**%**
Gender	Male	71	59.2
	Female	49	40.8
Marital Status	Single	54	45
	Married	66	55
Tribe	Akan	64	53.3
	Northerner	56	46.7
Religion	Christian	73	60.8
	Muslim	45	37.5
	Traditionalist	2	1.7
Forest protected	Yes	96	80
	No	24	20
Charcoal production regulated	Yes	80	66.7
	No	40	33.3
Own a tricycle	Yes	13	10.8
	No	107	89.2
	Credit access		
	Yes	28	23.3
	No	92	76.6
Warehouse	Yes	35	29.2
	No	85	70.8
Ready market	Yes	30	25
	No	30	25

Source: Author's own computation based on field data, (2022).

decision.

6. Results and discussion

6.1. Summary statistics of the data

This section presents the summary statistics of the data gathered. The summary statistics of the continuous various and dichotomous variables are presented separately.

Inferring to Table 1, the average age of the respondents is 45 years. This means the charcoal actors are still at their youthful age and hence have the energy to undertake physical activities involved in the charcoal business. Similarly, Asare et al. (2022) disclosed that charcoal producers are between the age bracket of 15–47 years. Further, the highest years of formal education of the respondents is 12 years or senior high school while the average years of formal education is 4 years (primary school).

There is an average of seven people in a household. Similarly, [1] found an average of seven people in the household of charcoal producers. The average farming experience of producers is eight years which indicates that the producers have the

adequate farming experience to make them informed of strategies to manoeuvre their way through their endeavours. On average, the producers produce 89 bags of charcoal annually. The average distance to their production sites is 3 km. This means that farmers cover a considerable distance to reach their production sites.

Moreover, Table 1 indicated that the majority (59 %) of the respondents are males while the remaining 41 % are females. It is not surprising because the charcoal business is ascribed as physically intensive. Thus, production, marketing and other aspects require some level of physical strength that females usually cannot withstand [6]. Likewise, Asare et al. (2022) found that males dominate the charcoal venture in Ghana. Further, the majority of the actors are married with just 45 % of them who are single. In a related study, [23] and[24] reported that the majority of charcoal producers are married.

The most dominant tribe among the respondents is the Akan. Thus, the Akan tribes represent 53 % of the total respondents while the remaining 47 % are of the Northern tribes including Dagaare, Sissala, Dagomba, Gonja etc. Further, the majority of the respondents, thus around 61 % are Christians while the remaining 38 % and 2 % are Muslims and Traditionalists respectively. The majority of the respondents indicate that the forest is protected by the Forestry Commission. Around 67 % of the actors are aware that charcoal production is regulated. Thus, the charcoal business including trading and production is regulated. There are some tree species that producers are not allowed to use to produce charcoal. Also, the marketers are supposed to pay a charcoal license fee between GH' 0.5 and GH' 1 per bag to the forestry commission and district assemblies respectively.

Further, around 89 % of the charcoal producers claim that they do not own a tricycle. The majority of the actors (77 %) indicated that they did not take credit for their charcoal business. The results also demonstrate that 85 of the respondents do not own a warehouse for keeping charcoals. Also, the results show that an equal proportion (25 %) of farmers claim there is a ready market for charcoals in the study area.

Table 2
Probit regression on the determinants of charcoal production.

Variables	Coefficient	Robust Std. errs.	P-value	Marginal effects
Socio-economic characteristics				
Gender	−0.131	0.367	0.722	−0.052
Age	−0.025	0.028	0.373	−0.010
Education	−0.113	0.044	0.010***	−0.045
Household size	−0.136	0.063	0.032**	−0.054
Marital status	2.055	0.333	0.000***	0.820
Farm experience	0.010	0.049	0.840	0.004
Ethnicity	0.996	0.425	0.019**	0.397
Religion	−0.456	0.352	0.195	−0.182
Farm level characteristics				
Farm size	−0.115	0.055	0.036**	−0.046
Land tenure	−0.105	0.202	0.602	−0.042
Proximity to a production site	0.286	0.100	0.004***	0.114
Institutional characteristics				
Charcoal production training	−0.032	0.332	0.924	−0.013
Protected forest	−0.126	0.447	0.778	−0.050
Charcoal production regulated	0.678	0.366	0.064*	0.270
Credit access	−0.066	0.394	0.867	−0.026
Own tricycle	−0.612	0.534	0.252	−0.244
Constant	1.012	0.83	0.406	
Wald Chi^2 [20]	70.03			
Prob > Chi^2	0.000			
Pseudo R^2	0.456			
Log pseudo-likelihood	−45.277			

Note: ***, **, and * represent significance levels at 1 %, 5 %, and 10 % respectively.
Source: Author's own computation based on field data, (2022).

6.2. Determinants of charcoal production

Table 2 presents the analysis of factors influencing charcoal production. The model diagnostic which determines the fitness of the analytical approach via the probability of chi and pseudo R^2 indicates that the model is fit. Thus, the probability of Chi is statistically significant which infers that the model used suits the data perfectly. Also, the pseudo R^2 is 0.456 which explains that the variables used to ascertain the determinants of charcoal production explain around 46 % of producers' decisions to participate in charcoal production. From the table, it can be inferred that education, household size, marital status, ethnicity, farm size, proximity to the production site and regulations on charcoal production are the significant determinants of charcoal production in the study area. However, marital status, ethnicity, distance to the production site and regulations on charcoal production positively affect charcoal production while education, household size and farm size are negative predictors of charcoal production.

Individually, the results demonstrate that farmers who are married are more likely to engage in charcoal production than those who are single by 82 %. Probably married couples serve as a source of farm hands to help in undertaking some activities involved in charcoal production. Contrary, Tassie et al. (2021) disclosed that marital status has no significant influence on charcoal production in Ethiopia. Also, northerners are more likely to be engaged in charcoal production than Akans at a significance level of 5 %. Thus, being a Northerner increases the probability of engaging in charcoal production by 39.7 %. The Northerners especially the Sissala tribe are known as the traditional charcoal-producing group in Ghana [6,25,26]. It is iterated that the Sissala tribe and other Northern tribes move from one community to the other to engage in charcoal production. The charcoal business serves as a major source of livelihood for this tribal group. This result is congruent with the findings of [1] who disclosed that being a Sissala tribe increases the likelihood of participating in charcoal production.

Moreover, an increase in the distance from the house to the charcoal production site increases the probability of engaging in charcoal production by 11.4 %. Probably, because charcoal production is regulated in the study area, farmers who are located in hinterlands are unlikely to be caught when engaged in charcoal production. Likewise, regulation on charcoal production increases the probability of engaging in charcoal production by 27 %. Thus, farmers who are aware that they need a permit before they can engage in charcoal production increases the chances of them engaging in the same. For instance, [1] found that payment of the traditional charcoal levy, which is a section of the regulation on charcoal production increases participation in charcoal production.

On the other hand, education decreases farmers' likelihood of engaging in charcoal production by 4.5 %. Thus, as a farmer's level of education increases, the probability of participating in charcoal production decreases. Educated farmers can find themselves other types of work which is relatively better and less tedious compared with charcoal production which makes them shy away from charcoal production. Nonetheless, Tassie et al. (2021) found an insignificant relationship between charcoal production and education. A unit increase in household membership decreases the probability of engaging in charcoal production by 5.4 %. A reasonable explanation could be that maybe the producers engage the household members in other activities such as cocoa farm work, plantain and other relatively attractive work. Contrary, [8] and Bekele & Kemal (2022) reported that an increase in household size augments participation in charcoal production. However, Tassie et al. (2021) and [1] found that household size is not an important factor in the decision to

Table 3
Probit regression on the determinants of charcoal marketing.

Variables	Coefficient	Robust Std. errs.	P-value	Marginal effects
Socio-economic characteristics				
Gender	−5.027	1.446	0.001***	−0.002
Age	−0.094	0.076	0.216	−0.000
Education	0.420	0.112	0.000***	0.000
Household size	−0.134	0.129	0.302	−0.000
Marital status	3.044	1.041	0.003***	0.000
Ethnicity	2.091	1.008	0.038**	0.001
Religion	0.336	1.149	0.770	0.000
Farm level characteristics				
Quantity per annum	0.015	0.009	0.095*	−0.000
Cost of bagging material	−0.127	0.062	0.041**	−0.000
Institutional characteristics				
Association membership	−3.447	1.485	0.020**	−0.001
Storeroom	2.689	1.352	0.047**	0.001
Charcoal production regulated	2.951	1.006	0.003***	0.016
Credit access	0.866	0.876	0.323	0.000
Ready market	1.996	0.881	0.023**	0.001
Taxes/levies	−0.986	1.124	0.381	−0.000
Constant	2.372	3.212	0.460	
Wald Chi^2 [19]	37.19			
Prob > Chi^2	0.001			
Pseudo R^2	0.545			
Log pseudo-likelihood	−10.716			

Note: ***, **, and * represent significance levels at 1 %, 5 %, and 10 % respectively.
Source: Author's own computation based on field data, (2022).

participate in charcoal production.

Again, as farm size increases, the probability of engaging in charcoal production decreases by 4.6 % and this is significant at the 5 % level. Thus, an increased farm size means that farmers have enough land available for the cultivation of crops and the rearing of animals. Given this, farmers channel all their effort including time, resources and labour into farm work and overlook charcoal production. However, this finding contradicts the assertion of Bekele & Kemal (2022) that an increase in farm size increases the probability of participating in charcoal production.

7. Determinants of charcoal marketing

Table 3 presents the analysis of factors influencing charcoal marketing. The model diagnostic which determines the fitness of the analytical approach via the probability of chi and pseudo R^2 indicates that the model is fit. Thus, the probability of Chi is statistically significant which infers that the model used suits the data perfectly. Also, the pseudo R^2 is 0.545 which explains that the variables used to ascertain the determinants of charcoal marketing explain around 55 % of traders' decisions to participate in charcoal marketing.

According to the table, gender, education, marital status, ethnicity, the quantity of charcoal produced, cost of packaging material, FBO membership, availability of storeroom, regulation of charcoal production, and ready market are the statistically significant factors that drive participation in charcoal marketing. However, marital status, ethnicity, distance to the production site and regulations on charcoal production positively affect charcoal marketing while education, household size and farm size are negative predictors of charcoal marketing.

Individually, the results demonstrate that males are less likely to engage in charcoal marketing, unlike females by 0.2 %. Trading has always been a thing of females in Ghanaian society and particularly in the charcoal trade. Hence, females are more likely engage in marketing, unlike their male counterparts. [6] pointed out that it is customary in Ghanaian society for men to refrain from participating in tasks that are traditionally done by women, such as selling home cooking supplies like charcoal. This generally protects men from taking part in the wholesale and retail trades in charcoal, which are dominated by women, particularly in retail.

Also, an increase in the cost of the bagging material decreases the probability of marketing charcoal at a 5 % significant level. This is plausible because when the prices of bagging materials increase, it becomes costly for actors to afford these materials and hence decreases their intention to engage in marketing. Actors who cannot afford to buy the bagging materials will not worry to engage in marketing. Also, being a member of a farmer association decreases the probability of marketing charcoal by 0.1 %. Group has mostly been a place for sharing market and production information among farmers hence it was expected to increase the likelihood of trading charcoals. A plausible reason for the finding is that the study did not specify the type of group joined by respondents. Hence, it is likely that the groups joined by the respondents have no interest in the charcoal trade. Therefore, the ability of the group to promote other businesses aside charcoal trade negatively impacts their decision to partake in the charcoal trade. However, this study contradicts the findings of [1] who posited that being a member of a charcoal association positively affects the decision to participate in the charcoal trade.

On the one hand, education increases the likelihood of trading charcoal which is significant at a 1 % level. Thus, an increase in farmers' years of education increases their marketing skills including the ability to create market linkages with farmers. This induces them to sell their charcoal after production. Also, education increases the awareness of charcoal producers that the charcoal business could serve as an alternative source of income and hence the decision to engage in the charcoal trade after production. Similarly, Worku et al. (2021) unravelled that educational attainment significantly increases the supply of charcoal to the market. In tandem, [1] reported that education positively influences the decision to participate in the charcoal trade.

Also, those who are married are more likely to engage in charcoal marketing, unlike single charcoal producers. Probably the availability of a wife to help in the marketing of the charcoal informs charcoal producers to produce for sale. Also, northerners are more likely to be engaged in charcoal marketing than Akans by 0.1 %. Northerners, especially Sissala are well-known in the charcoal business. Their major source of livelihood has been charcoal production and trade. Since they depend chiefly on charcoal production and trade for a living, they are likely to sell the charcoal for income to cater for household expenditure. Consistently, [1] reported that being a Northerner, particularly the Sissala tribe positively augments the decision to participate in the charcoal trade. Again, [6] asserted that the Sissala tribe dominate charcoal production and trade in Ghana.

Moreover, a unit increase in the quantity of charcoal produced per annum increases farmers' likelihood to participate in the market. Thus, when the quantity of charcoal produced is high, it is possible that the producer's household cannot utilise it alone and hence the decision to sell some becomes laudable. Consistently, [27] disclosed that the quantity of farm output positively predicts producers' decision to participate in the market. Likewise, producers who have storerooms are more likely to sell their charcoal than those without storerooms by 0.1 %. Thus, having a storeroom means farmers can store their charcoal and sell them later when buyers come by or when the prices are good. Also, having a place to keep the charcoal prevents them from getting damaged or stolen which encourages the producer to continue production for sale.

Lastly, having access to a ready market increases the chances of selling charcoal by 0.1 %. This is justified because having access to a ready market gives an assurance that when the charcoal is produced, it can easily be disposed of which increases the likelihood of selling charcoal among the producers. Similarly, [28] acknowledged the significance of market access on the market outlet participation decision of farmers. It is reported that farmers who have access to the market are more likely to sell their produce.

7.1. Distribution channels

The charcoal industry involves a plethora of actors performing different roles along the charcoal value chain. A typical charcoal

marketing chain identified in the study area involves producers, wholesalers, retailers and end-users. Likewise, Worku et al. (2021) underlined that the wholesalers, retailers, producers and consumers are major participants in the charcoal value chain. Also, there are actors such as transporters, forestry commission, district assembly and security services that play a supporting role in the proper conduct of activities along the chain.

Given this considerable number of actors along the chain, the charcoal moves from the producing areas (mostly rural areas) to the cities through these agents. Mostly, wholesalers aggregate the charcoal at the farm gate from the producers in large quantities and transport it to the cities. Transportation is facilitated by transporters. Mostly cargo and KIA rhinos are used to transport charcoals to the urban areas. In the cities, retailers and end-users purchase charcoals from wholesalers. However, in rural areas, most retailers purchase their charcoal from the producers because of their immediate proximity to the producers. The retailers further sell the charcoals in smaller quantities either in bags, polythene sheets or *olonka* to end-users such as households, restaurants and food joints. One trader noted that *"I have market women in Kumasi whom I sell to after aggregating from the farm gate. These women are able to buy in large quantities, sometimes 20 or 30 bags each and sell to the end-users"*. She added further that *"end-users such as restaurants or food joints are also my key customers. Most often they give orders of the quantity they will need so that I buy from the village and transport it to them"*.

When asked about the perceived profit margin between the various actors, one producer insisted that the petty traders and retailers reap the majority of the profit. The producer posited that *"the number of olonka or polybags the petty traders and retailers are able to get* per *bag of the charcoal is amazing. After selling a bag of* charcoal*, they are able to make a reasonable amount of money"*. This opinion is in tandem with the findings of [29] and Worku et al. (2021) who reported that significant profits are derived by traders while producers obtain lower levels of profit.

After the series of interrogations and discussions with the various stakeholders, the researcher organised a typical distribution channel for the charcoal value chain as mapped below.

8. Estimation of marketing cost and margins for charcoal trade

Given that the 50 kg bag was the predominantly traded weight on the market and grounding on the value chain mapping, the various cost and margins per the 50 kg bag of charcoal were estimated for the various actors. From Table 4 the average price received by farmers on all the channels is GH' 60.00. The qualitative interrogation also revealed the same. The results further reveal that the total margins accrued on channel I was GH' 23.20 while channel II and channel III have total margins of GH' 18.20 and 28.20. The results indicate that channel III has the highest margin accrued. A possible reason is that the channel is shorter compared with channel I and also retailers sell at higher prices to end-users. In terms of total costs incurred on the three channels, channel II and III was the lowest with total marketing costs of GH' 11.80 each.

Table 4
Average marketing costs and margins of the various channels per 50 kg bag.

Details	Channel I (GH')	Channel II (GH')	Channel III (GH')
a. Producers			
•**Marketing cost**	0.00	0.00	0.00
•**Selling price**	60.00	60.00	60.00
b. Wholesalers			
•**Transport cost (vehicle)**	3.00	3.00	
•**Tricycle (internal transport)**	2.00	2.00	
•**Loading and offloading**	2.00	2.00	
•**Bagging material**	3.00	3.00	
•**District Assembly levy (Waybill)**	1.00	1.00	
•**Conveyance bill (Forestry Commission)**	0.80	0.80	
•**Total Marketing Cost (I)**	*11.80*	*11.80*	
•**Selling price**	*85.00*	*90.00*	
•**Marketing margin (A)**	*13.20*	*18.20*	
c. Retailers			
•**Transport cost (vehicle)**	2.00		2.00
•**Tricycle (internal transport)**	3.00		3.00
•**Loading and offloading**			2.00
•**Bagging material**			3.00
•**District Assembly levy (Waybill)**			1.00
•**Conveyance bill (Forestry Commission)**			0.8
•**Total Marketing Cost (II)**	*5.00*		*11..80*
•**Selling price**	100.00		100.00
•**Marketing** margin (B)	**10.00**		*28.20*
d. End-users			
•**Purchase price**	100.00	90	100.00
Total Marketing Costs (I + II)	**15.80**	**11.80**	**11.80**
Total marketing margin (A + B)	**23.20**	**18.20**	**28.20**

Source: Author's own computation based on field data, (2022). NB: $ 1 = GH' 11.17

9. Challenges associated with charcoal production and marketing

Table 5 presents charcoal producers' agreement on constraints confronting charcoal production. Rankings of constraints were used to analyze the challenges confronting charcoal producers. To measure the level of agreement of the responses given by the producers, Kendall's coefficient of concordance was used. The researcher presented charcoal producers with four items and they were asked to indicate their level of agreement with these challenges on a five-point Likert scale, ranging from strongly agree to strongly disagree. Their level of agreement shows the most pressing and least pressing challenge. The most significant and pressing constraint received a lower value in the ranking. Therefore, the challenge with the lowest overall mean score represents the most pressing challenge in producing charcoal. Table 5 shows that the analysis is significant at a 1 % level. Also, there is a 17.5 % agreement in the responses given by the charcoal producers.

Inferring from Table 5, the most pressing constraint ranked by charcoal producers is the difficulty involved in charcoal production. This has a mean rank of 2.07. [6] underline those activities such as charcoal production demand physical strength and energy. This is even the reason behind the low participation of women in charcoal production. Therefore, it is not amazing that farmers agree that charcoal production is tedious. Also, lack of government support was ranked as the second most pressing challenge with a mean rank of 2.33. Perhaps, the central government and local government do not provide producers the needed support like training, regulations or social amenities like road to improve charcoal business.

Also, limited access to credit was the 3rd ranked constraint according to charcoal producers. Generally, farmers access to credit is very challenging in Ghana. The lack of collateral and limited knowledge about credit requirements has been blamed for this limited access to credit in the sector. Consistently,[30,31] acknowledge the lack of credit access by farmers in Ghana. Lastly, the least pressing constraint reported by producers is poor market linkage and information among actors along the charcoal value chain.

Table 6 highlights the constraints hindering charcoal marketers. Rankings of constraints were used to analyze the challenges confronting traders. To measure the level of agreement of the responses given by the traders, Kendall's coefficient of concordance was used. The researcher presented charcoal marketers with five challenges and they were asked to indicate their level of agreement with these challenges on a five-point Likert scale, ranging from strongly agree to strongly disagree. Their level of agreement shows the most pressing and least pressing challenge. The most significant and pressing constraint received a lower value in the ranking. Therefore, the challenge with the lowest overall mean score represents the most pressing challenge in charcoal marketing. Table 6 shows that the analysis is significant at the 10 % level. Also, the level of agreement among the responses by the marketers is 3.6 %.

The marketers indicated that the most pressing constraint is the lack of government support to improve their capacity. Thus, this challenge was ranked 1st with a mean of 2.75. As elaborated earlier, probably, the government does not provide charcoal marketing training for marketers to improve their marketing abilities. Further, the 2nd most pressing constraint is limited access to credit with a mean rank of 2.82. In every aspect of agriculture be it trading or production, credit access by the players in the sector is generally limited. This could contribute to why it was ranked as the second most pressing constraint. Likewise,[32] have noted limited access among small and medium agribusinesses in Ghana.

Further, levies paid by marketers are the third most ranked constraint with a mean rank of 2.94. It was disclosed in the previous sections that the forestry commission charges around GH' 0.8 per bag of charcoal and the district assembly charges GH' 1. Aside from that security agents such as the police usually take tokens from them when crossing barriers. In some instances, before the consignment gets to its final destination, the traders spend a huge amount of money on just the levies. Likewise, [33] reported that charcoal traders are liable to payment of levies including district assembly levies, forestry commission certificate levies and sometimes payment of levies to the traditional authorities. It is therefore not surprising that these respondents indicate that levies/taxes/tolls are their third most pressing challenge.

Moreover, limited means of transport were identified by marketers as their fourth most pressing challenge with a mean rank of 3.21. Generally, lack of transport is a major problem in rural areas dominated by farmers. The inability to obtain means of transport to move produce from the farm gate to the nearest market has been a long-standing challenge in Ghana. For instance, [34,35] reported that the lack of a proper transportation system cripples the poultry business in Ghana. Lastly, poor market linkage and information sharing among the various actors was ranked as the least pressing challenge with a mean rank of 3.29. Information sharing like prices and establishing good rapport with customers is inevitable in business such as charcoal trading. Hence, the ranking is the least constraint by traders.

Table 5
Challenges confronting charcoal producers.

Challenges	Rank	Mean rank
Charcoal production is difficult, time-consuming and labour intensive	1	2.07
There is a lack of government support and training to improve stakeholders' capacity in charcoal production and marketing	2	2.33
There is limited access to credit by charcoal producers and marketers	3	2.50
There are poor market linkages and information among producers, traders, and buyers	4	3.10
Kendall's W[a]	0.175	
Chi-square	35.622	
Significance	0.000***	

Note: *** represent significance levels at 1 %. **Source: Author's own computation based on field data, (2022).**

Table 6
Constraints confronting charcoal marketers.

Challenges	Rank	Mean rank
There is a lack of government support and training to improve stakeholders' capacity in charcoal production and marketing	1	2.75
There is limited access to credit by charcoal producers and marketers	2	2.82
The levy paid (police bribe and tolls) by charcoal producers and marketers is very huge	3	2.94
There are limited means of transporting charcoal	4	3.21
There are poor market linkages and information among producers, traders, and buyers	5	3.29
Kendall's W[a]	0.036	
Chi-square	8.71	
Significance	0.069*	

Note: * represent significance levels at 10 %. **Source: Author's own computation based on field data, (2022).**

10. Conclusion and policy RECOMMENDATION

10.1. Conclusion

The production of charcoal is a significant source of income, primarily in rural areas, and an essential energy source, particularly in developing nations. Therefore, in many nations, especially those of Sub-Saharan Africa, the use of wood to produce heat energy, notably for cooking and heating, is still very much relevant. Due to this, the number of people engaged in charcoal production and trade keeps increasing. The charcoal business has therefore received attention in this regard.

The regression analysis revealed that education, household size, marital status, ethnicity, farm size, proximity to the production site and regulations on charcoal production are the significant determinants of charcoal production in the study area. However, marital status, ethnicity, distance to the production site and regulations on charcoal production positively affect charcoal production while education, household size and farm size are negative predictors of charcoal production. Also, gender, education, marital status, ethnicity, the quantity of charcoal produced, cost of packaging material, FBO membership, availability of storeroom, regulation of charcoal production, and ready market are the statistically significant drivers of charcoal marketing. However, marital status, ethnicity, distance to the production site and regulations on charcoal production positively affect charcoal marketing while education, household size and farm size are negative predictors of charcoal marketing.

The interview revealed that charcoal producers and traders utilise a couple of marketing strategies. Thus, pricing strategies such as pan seasonal, pan territorial, cost plus pricing and competitive pricing are all used by the respondents. Also, charcoal is packaged into different sizes and weight which ranges from mini bag, maxi bag and jumbo bags. The charcoal market is a typical spot market where the transaction is usually termed *"cash and carry"* but with few instances where there are contractual arrangements between producers and traders. The market margin analysis indicates that retailers make good fortune in terms of margins accrued from charcoal trading when they engage directly with the producers. Thus, it shortens the middlemen in the channel and hence they tend to make substantial margins from the trade. The marketing margin analysis is supported by the qualitative revelation that retailers make more margins than the other actors in the charcoal value chain.

The most pressing challenges faced by the respondents are levies paid, the tedious nature of charcoal production and trade, limited access to credit, lack of government support, limited transport system and lack of storage facilities.

10.2. Policy recommendation

It is therefore recommended that.

a) Charcoal production is directly related to the loss and degradation of forests. To reduce the environmental effect of charcoal production and to guarantee sustainable resource management, government action is essential.
b) Policies in rural regions with a high concentration of charcoal production should work to increase income generation. By assisting this industry, poverty may be reduced and economic growth can be promoted.
c) The Forestry Commission should make the levies charged affordable to charcoal producers and traders. Also, they can lease with the local authorities to make arrangements on the amount the local authorities charge charcoal producers per bag.
d) Since charcoal production is currently a tribally oriented venture, thus, northerners are more likely to be engaged in production, there is a need for education to other tribes on the fortunes that can be made from the charcoal venture. This education needs to be concentrated on where charcoal production is legalized so that indigenes who are not northerners can also make fortunes from the venture.
e) The availability of a ready market facilitates charcoal marketing, it is therefore recommended that investment should be channelled towards developing charcoal markets and also improving accessibility by improving road networks and making available means of transport to the producing areas. Also, private businesses and transport firms should allocate some of their vehicles for charcoal transport to improve the ease of market access among both producers and traders.
f) It was disclosed that perception of regulation influences charcoal production and marketing. Hence, it is prudent that regulatory bodies such as district assemblies and forestry commissions intensify their education on sustainable charcoal production and

marketing to make both producers and marketers aware of the modalities involved in the venture. This can be done through farmer organisations.

g) Ensuring a steady supply of affordable and clean energy is a priority for any government. Policies should address the efficient production and distribution of charcoal to meet the energy needs of the population.

h) d. The government has a responsibility to protect biodiversity and the environment. Effective policies can balance the economic benefits of charcoal production with environmental conservation efforts.

i) Policymakers should promote inclusive policies that consider the socio-economic variables influencing the amount of charcoal produced. This can help reduce disparities within the industry.

11. Future recommendation

Evaluating the effectiveness of policies and interventions aimed at promoting sustainable charcoal production and marketing can guide future policy development.

12. Limitations of the study

The study may be limited by data availability and data reliability, potentially impacting the depth and comprehensiveness of the analysis. Additionally, logistical challenges, such as limited access to cash (liquid assets) and transportation options, posed obstacles to the research process. Moreover, gathering a substantial number of respondents (charcoal producers) for interviews proved to be a challenging endeavour. The findings may be specific to the Mankranso Forest District and may not be entirely representative of other regions in Ghana.

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Data availability statement

The dataset used is available upon reasonable request from the corresponding author.

CRediT authorship contribution statement

Nicholas Oppong Mensah: Writing - original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Solomon Addo:** Writing - review & editing, Writing - original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation. **Stanley Dickson Sumbayi:** Writing - original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Augustine Prosper Osei-Gyabaah:** Writing - review & editing, Visualization, Validation, Software, Resources, Methodology, Formal analysis, Data curation. **Tekuni Nakuja:** Writing - review & editing, Validation, Software, Resources, Investigation. **Samuel Afotey Anang:** Writing - review & editing, Visualization, Validation, Software, Resources.

Declaration of Competing interest

The authors declare no conflict of interest.

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References

[1] L.K. Brobbey, C.P. Hansen, B. Kyereh, M. Pouliot, (2019). The economic importance of charcoal to rural livelihoods: evidence from a key charcoal-producing area in Ghana Forest, Policy and Economics 101 (2019) 19, 3.

[2] E.P. Mensah, R.K. Bannor, H. Oppong-Kyeremeh, S.K.C. Kyire, An assessment of postharvest losses to support innovation in the egg value chain in Ghana, African Journal of Science, Technology, Innovation and Development (2021) 1–13.

[3] S. Rossi, F.N. Tubiello, P. Prosperi, M. Salvatore, H. Jacobs, R. Biancalani, L. Boschetti, FAOSTAT estimates of greenhouse gas emissions from biomass and peat fires, Climatic Change 135 (2016) 699–711.

[4] B.T. Anang, M.A. Akuriba, A. Alerigesane, Charcoal production in Gushegu District, Northern Region, Ghana: lessons for sustainable forest management, Int. J. Environ. Sci. 1 (7) (2011) 1944–1953.

[5] H.M. Kiruki, H.E. Zanden, P. Kariuki, H.P. Verburg, The contribution of charcoal production to rural livelihoods in a semi-arid area in Kenya, Journal of Environment, Development and Sustainability (2019) 1–30.

[6] K.F. Agyei, C.P. Hansen, E. Acheampong, Profit and profit distribution along Ghana's charcoal commodity chain, Energy for Sustainable Development 47 (2018) 62–74, https://doi.org/10.1016/j.esd.2018.09.002.

[7] K. Tassie, B. Misganaw, S. Addisu, E. Tesfaye, Socioeconomic and environmental impacts of charcoal production activities of rural households in Mecha district, Ethiopia, Adv. Agric. (2021) 1–16.

[8] C.J. Gardner, F.U. Gabriel, F.A.S. John, Z.G. Davies, Changing livelihoods and protected area management: a case study of charcoal production in south-west Madagascar, Oryx 50 (3) (2016) 495–505.

[9] M. Belay, A. Abegaz, W. Bewket, Livelihood options of landless households and land contracts in north-west Ethiopia, Environ. Dev. Sustain. (2015), https://doi.org/10.1007/s10668-015-9727-x.

[10] P. Eniola, Menace and Mitigation of Health and Environmental Hazards of Charcoal Production in nigeria, 2021, pp. 2293–2310, https://doi.org/10.1007/978-3-030-45106-6_238.

[11] D. Jones, C. Ryan, J. Fisher, Charcoal as a diversification strategy: the flexible role of charcoal production in the livelihoods of smallholders in central Mozambique, Energy for Sustainable Development 32 (2016) 14–21, https://doi.org/10.1016/j.esd.2016.02.009.

[12] R. Kattel, Improved charcoal production for environment and economics of blacksmiths: evidence from Nepal, J. Agric. Sci. Technol. B 5 (3) (2015), https://doi.org/10.17265/2161-6264/2015.03b.006.

[13] S. Kusch-Brandt, Charcoal from Alternative Materials for Use as Energy Carrier or Reducing Agent: a Review of Key Findings in Europe and the Americas, 2018, https://doi.org/10.5593/sgem2018/4.1/s17.027.

[14] T. Norgate, N. Haque, M. Somerville, S. Jahanshahi, Biomass as a source of renewable carbon for iron and steelmaking, ISIJ Int. 52 (8) (2012) 1472–1481, https://doi.org/10.2355/isijinternational.52.1472.

[15] J. Songsore, Regional Development in Ghana: the Reality and the Theory, Woeli Publishing Services, Accra, Ghana, 2003.

[16] StataCorp, Stata: Release 14. Statistical Software. College Station, TX, StataCorp LP, Texas, USA, 2015.

[17] G. Surup, A. Trubetskaya, M. Tangstad, Life cycle assessment of renewable reductants in the ferromanganese alloy production: a review, Processes 9 (1) (2021) 185, https://doi.org/10.3390/pr9010185.

[18] R.K. Bannor, H. Oppong-Kyeremeh, S. Abele, F.O. Tutu, S.K.C. Kyire, D. Agyina, Seedling production and choice among cashew farmers in Ghana: a profitability analysis, World Journal of Entrepreneurship, Management and Sustainable Development 16 (2) (2020) 109–129.

[19] A.C. Harvey, Estimating regression models with multiplicative heteroscedasticity, Econometrica 44 (3) (1976) 461–465, https://doi.org/10.2307/1913974.

[20] M.R.M. Hussin, M.H.A.H. Asaari, N. Karia, A.J. Ali, Small farmers and factors that motivate them towards agricultural entrepreneurship activities, Journal of Agribusiness Marketing 5 (2012) 47–60.

[21] Zikmund, Business Research Methodology, seventh ed., United States: South Western, 2003.

[22] E. Slovin, Slovin's Formula for Sampling Technique, 1960. Retrieved. (Accessed 21 July 2021).

[23] O.A. Adeniji, O.S. Zaccheaus, B.S. Ojo, A.S. Adedeji, Charcoal production and producers' tree species preference in Borgu local government area of Niger State, Nigeria, J. Energy Technol. Pol. 5 (11) (2015) 1–8.

[24] E.A. Salamatu, O.C. Emmanuel, A.T. Ogah, Examining the Relationship between Commercial Charcoal Production and Socioeconomic Variables in Nasarawa State, North-Central Nigeria, 2020.

[25] Ghana Statistical Service, District Analytical report. 2010 Population and Housing Census. Ahafo Ano South District, 2012 available at:.

[26] D. Gujarati, Basic Econometrics, International Edition, McGraw Hill Book, New York, NY, 2015.

[27] R.K. Bannor, M. Sharma, Determinants of the choice of marketing outlet among kinnow farmers in Rajasthan state of India, Indian Journal of Economics and Development 13 (1) (2017) 11–22.

[28] F. Adams, C.A. Wongnaa, E. Coleman, Profitability and choice of marketing outlets: evidence from Ghana's tomato production, J. Agribus. Dev. Emerg. Econ. 11 (3) (2020) 296–312, https://doi.org/10.1108/JADEE-06-2019-0090.

[29] F.K. Agyei, C.P. Hansen, E. Acheampong, Forestry officials don't have any land or rights here: Authority of politicolegal institutions along Ghana's charcoal commodity chain, J Rur Stud 72 (2019) 264–272, https://doi.org/10.1016/j.jrurstud.2019.10.043.

[30] P.K. Nkegbe, Credit access and technical efficiency of smallholder farmers in Northern Ghana: Double bootstrap DEA approach, Agric. Finan. Rev. 78 (5) (2018) 626–639.

[31] S. Sekyi, B.M. Abu, P.K. Nkegbe, Farm credit access, credit constraint and productivity in Ghana: Empirical evidence from Northern Savannah ecological zone, Agric. Finan. Rev. 77 (4) (2017) 446–462.

[32] E.B. Ntiamoah, D. Li, M. Kwamega, Impact of government and other institutions' support on performance of small and medium enterprises in the agribusiness sector in Ghana, Am. J. Ind. Bus. Manag. 6 (5) (2016) 558–567.

[33] L.K. Brobbey, C.P. Hansen, B. Kyereh, The dynamics of property and other mechanisms of access: the case of charcoal production and trade in Ghana, Land Use Pol. 101 (2021), 105152.

[34] N.O. Mensah, E.C. Amrago, J.K. Asare, F.O. Tutu, A. Donkor, Poultry farmer's willingness to pay for agricultural tax: evidence from the Bono region, Ghana, World Journal of Entrepreneurship, Management and Sustainable Development 17 (2) (2020) 290–306.

[35] Z. Nigussie, A. Tsunekawa, N. Haregeweyn, M. Tsubo, E. Adgo, Z. Ayalew, S. Abele, Small-scale Woodlot Growers' interest in participating in Bioenergy market in rural Ethiopia, Environ. Manag. 68 (4) (2021) 553–565.