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Sacrificing the savannah woodlands for energy and livelihoods? Charcoal production in Ghana

Austin Dziwornu Ablo [a,*], Lydia Osei [a], Francis Xavier Jarawura [b], Jospeh Awetori Yaro [a]

[a] Department of Geography and Resource Development, Box LG 59, University of Ghana, Ghana
[b] Department of Planning, Box 350, University of Business and Integrated Development Studies, Ghana

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ABSTRACT

The energy transition in many African countries involves the shift from firewood to charcoal and liquefied petroleum gas (LPG) as the primary domestic energy source. In Ghana, the demand for charcoal is on the rise, leading to diverse socio-economic and ecological outcomes in the Savannah woodland. Based on data produced through interviews, focus group discussions, observation, and a survey with 200 questionnaires administered, the paper examines the dynamics of charcoal livelihoods for energy and the ecological effects in the Savana woodland of Ghana. The article shows that charcoal production is critical to meeting household energy needs, supports the livelihood of different categories of people along the value chain and transforms local economies with unequal benefit streams to different actors. However, charcoal production results in loss of vegetation and ecological resilience with different levels of culpability on large migrant producers and small survivalist indigene producers. The paper shows that vegetation loss is highest in areas where indigenous charcoal producers continue to produce after the large-scale producers migrate when they exhaust matured trees. We recommend that stakeholders rethink governance strategies toward regulating the charcoal sector, considering its critical role in meeting domestic energy needs and supporting the livelihoods of many people.

Introduction

Energy resources play essential roles in societies and are linked to economic growth, poverty alleviation, social development, and environmental quality (Yiran, Ablo, & Asem, 2020). Energy availability and accessibility are critical to the structural transformation of sub-Saharan African (SSA) economies. In Ghana, energy resources providing power for domestic and industrial purposes consist of hydroelectricity (11 %), hydrocarbons (28 %), biomass (60 %), and solar (1 %) (Asumadu-Sarkodie & Owusu, 2016). About 90 % of Ghanaian households use firewood and charcoal for cooking (Yiran et al., 2020) because charcoal burns hotter, easy to transport and lasts longer in storage (Brobbey, Hansen, Kyereh, & Pouliot, 2019; Silva et al., 2019).

According to Yiran et al. (2020), the fluctuating prices of hydrocarbons on the international commodities market and the initial high cost of gas stoves compared to charcoal account for the increased reliance on charcoal by many households across SSA. Charcoal remains a vital energy source even in homes with gas stoves because food cooked on charcoal tastes better than food prepared on gas (Lokina & Mapunda, 2017). The extant literature on charcoal explored the ecological effects of charcoal production (Aabeyir, Adu-Bredu, Agyare, & Weir, 2016; Kiruki, van der Zanden, Gikuma-Njuru, & Verburg, 2017; Silva et al., 2019). Other studies have also explored the contribution of charcoal to rural livelihoods, employment, and poverty reduction (Agyei, Hansen, & Acheampong, 2018, 2020; Brobbey, Pouliot, Hansen, & Kyereh, 2019). This paper contributes to the growing body of research on energy dynamics and livelihoods in Africa. We examine the socio-ecological effects of charcoal production in the Gonja area of Ghana. Our analysis centres on the emergence and growth of charcoal livelihoods in response to increasing demand and how that affects the savanna woodland of Ghana. The central question addressed in this paper is, how does the organisation of charcoal livelihoods produce winners and losers and shape the industry's ecological effects?

The paper shows that charcoal production has become an important activity supporting the livelihood of different categories of people contributes to the local and the broader national economy. Although charcoal production destroys vegetation, we argue that tree composition in an area plays a significant role in the extent of devegetation. Areas with high densities of dawadawa (*Parkia biglobosa*) and shea (*Vitellaria paradoxa*) prohibited in charcoal production do not experience extensive tree loss. Areas with high densities of keche (*Khaya senegalensis*), kakali (*Anogaises leucopus*) and kawul (*Afrormosia laxiflora*) – the preferred species in charcoal production, are often depleted. Although

* Corresponding author.
E-mail address: aablo@ug.edu.gh (A.D. Ablo).

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charcoal production is an important livelihood activity meeting domestic energy needs in Ghana, there are no clear national policy guidelines that regulate charcoal production. Thus, though natural resources provide a vital asset for sustainable livelihoods and rural development, their exploitation needs careful strategies to ensure sustainability and local economic growth. The dilemma of environment preservation versus human development needs a nuanced debate with choices that society needs to negotiate carefully.

Significance of charcoal livelihoods in SSA

The increasing demand for charcoal has created the opportunity for non-farm employment for many rural and urban households in the charcoal value chain (Jagger & Jumbe, 2016; Jones, Ryan, & Fisher, 2016). The contribution of charcoal production to local and national economies is complex and often underestimated (Mwampamba, Ghilardi, Sander, & Chaix, 2013). Charcoal is not only accessible, affordable, and reliable energy to nearly 80 % of the SSAs population, it also contributes to national energy balances and reduces the dependency of poor households on energy imports (Sedano et al., 2016; Smith, Hudson, & Schreckenberg, 2017; Zulu & Richardson, 2013). Charcoal production and distribution contribute to economies through tax revenue, income for the poor, direct and indirect employment (Vos & Vis, 2010). In 2012, over 30.6 million tons of charcoal valued between US $9.2 billion and US$24.5 billion was produced in Africa (Neufeldt, Langford, Fuller, Iiyama, & Dobie, 2015).

In Tanzania, the charcoal industry in Dar es Salaam alone generates about US$ 650 million in revenue annually. In Malawi and Uganda, about UD$ 41 million and US$ 36 million, respectively is generated from charcoal production. Charcoal production again contributes US$ 77 million to the economy of Rwanda and about US$ 1.6 billion to Kenya's economy annually (Bank, 2010; Dam, 2017; Neufeldt et al., 2015). An estimated 12 million rural and urban dwellers in Africa will derive some parts of their income from charcoal by 2030 (Mwampamba et al., 2013).

Ghana ranks among the ten top global producers of charcoal (Aabeyir et al., 2016) and is the highest charcoal consuming country in West Africa (Anang, Akuriba, & Alerigesane, 2011). The bulk of the charcoal produced in Ghana is from the Savannah woodland ecology, with the Sissala ethnic group from the Upper West Region as the largest producers (Agyemnag, Amponsah, Braimah, & Lurumuah, 2012). Charcoal production is the second most crucial income source for rural households in the forest transition zone of Ghana (Brobbey, Hansen, et al., 2019). It is a critical seasonal income gap-filler and a safety net for people.

For many District Assemblies, particularly in the Savannah woodland of Ghana, levies and taxes on charcoal production are essential sources of internally generated revenue (Brobbey, Asante, Sampong, Kumeh, & Nketiah, 2015). More than 2.2 million families depend on charcoal for cooking and heating in Ghana, with an estimated 280,000 small-scale processing activities dependent on charcoal as the primary energy source (Brefo, Obiri, & Derkyi, 2012). Charcoal production is also linked to the sustainability of SMEs as about 600,000 SMEs, such as eateries, depend mainly on charcoal for energy (Brefo et al., 2012).

Zulu and Richardson (2013) identify six direct types of charcoal value chain jobs: large-scale commercial production, casual production, wholesale traders, packaging, transportation, and retail of charcoal. Indirect actors whose actions either help or hinder the production and marketing process of charcoal are also important in the value chain (Kambewa, 2007). The charcoal market provides seasonal and full-time employment for people in urban and rural areas. However, the differentiation of diverse actors is unclear because the same person can perform multiple functions in the value chain, such as the producer doing packaging themselves (Zulu & Richardson, 2013).

The environmental impacts of charcoal production are undoubted. However, the extent to which charcoal production has contributed to deforestation remains a contested issue (Mensah, Damnyag, & Kwabena, 2020; Montalván et al., 2019). Kiruki et al. (2017) found that charcoal production and agriculture decrease species diversity, tree density, and biomass in Kenya. The harvesting of vegetation for charcoal production is also linked to increased Co_2 emissions with implications for global climate (Ajibola, Raimi, Steve-Awogbami, Adeniji, & Adekunle, 2020; Alfaro & Jones, 2018).

A conceptual overview of charcoal livelihoods

The paper deploys the sustainable livelihoods framework (see Fig. 1) as a conceptual tool to explore the actor-oriented approaches in development discourses and shed light on the relevance and dynamics of charcoal livelihoods in rural communities. The livelihood framework emanates from Amartya Sen's entitlement approach analysing endowment, entitlement set and entitlement mapping in explaining famine. Sen argued that resources available to people, institutional frameworks and how they can be deployed is critical to livelihoods. Scholars (Bebbington, 1999; see Chambers & Conway, 1992; de Haan & Zoomers, 2005; Scoones, 1998); Scoones (2009) have expanded this approach with more emphasis on assets.

de Haan and Zoomers (2005) viewed livelihood as capabilities, assets – stores, resources, claims and access necessary for living.

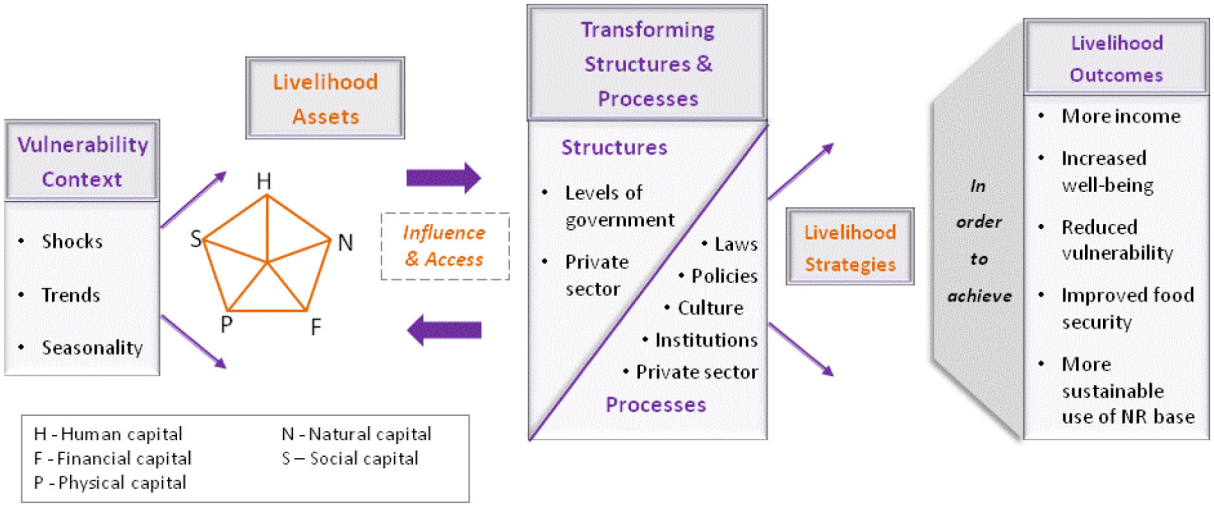

Fig. 1. The sustainable livelihood framework.
Source: DFID (1999)

Livelihoods can be sustained if people can cope with and recover from stress and shocks. The sustainable livelihood approach (SLA) utility in analysing charcoal livelihoods focuses on assets, institutions, organisation, and power relations. Deconstructing charcoal livelihoods thus requires a focus on the resources individuals and households deploy in the pursuit of their livelihood. Assets are both material and discursive in terms of relevance for rural livelihood sustainability (Carney, 1998; de Haan & Zoomers, 2005). In this paper, we examine the sustainability of rural livelihoods by exploring how people mobilise, combine and transform their physical, social, natural, financial, and human capital/assets (Carney, 1998; DFID, 1999).

Land (natural capital) not only signifies wealth (symbolic capital) but is critical to farming and non-farm livelihoods. In Ghana's savanna ecological zone, this paper shows how land access is vital to people's access to trees for charcoal production. Charcoal production and distribution we argue is intricately linked to rural people's embeddedness in various social relations or networks. Physical capital such as infrastructure (roads, schools, treated water) also enhances livelihoods (Poon, Thai, & Naybor, 2012; Scoones, 1998).

Bebbington (1999), Scoones (1998), Carney (1998) and Yaro (2013a) have argued that the sustainability of rural livelihoods is not entirely a function of various livelihood assets but how assets can be accessed. Thus, this paper explores how different actors in the charcoal value chain can access various resources which plays a crucial role in distributing benefits and costs from charcoal production. If asset portfolios are reduced, people can adopt agriculture intensification and extensification, livelihood diversification and migration (Scoones, 1998; Zulu & Richardson, 2013). In the context of dwindling agricultural output stemming from climate variability and change, charcoal production is emerging as a non-agricultural livelihood strategy. But as argued in this paper, though charcoal production supports rural livelihoods, it can degrade the environment further undermining agrarian livelihoods.

Institutions, both formal and informal, play critical roles in livelihood activities in rural communities (Scoones, 1998). In the charcoal value chain, we examine the role of traditional institutions like chieftaincy, cultural norms, and land tenure arrangements on land access for charcoal production. Additionally, we highlight the role of formal institutions at the national and sub-national levels like the district assembly and NGOs in regulating the charcoal businesses with complex outcomes often taken for granted in the policy space.

Study context and data collection

The study was conducted in the Gonja area, which covers 9700 km^2 in the Savannah Region of Ghana. The Gonja area is selected for this study because of its importance as a charcoal production hub in the savannah ecological zone of Ghana (Brobbey, Hansen, et al., 2019). Traditionally, the Gonjas is known as the Ngbanye, and they speak Ngbanyato. The overlord of the Gonjas is the Yagbonwura, supported by five sub-chiefs called *Bewura*. The Wasipe-wura, in whose

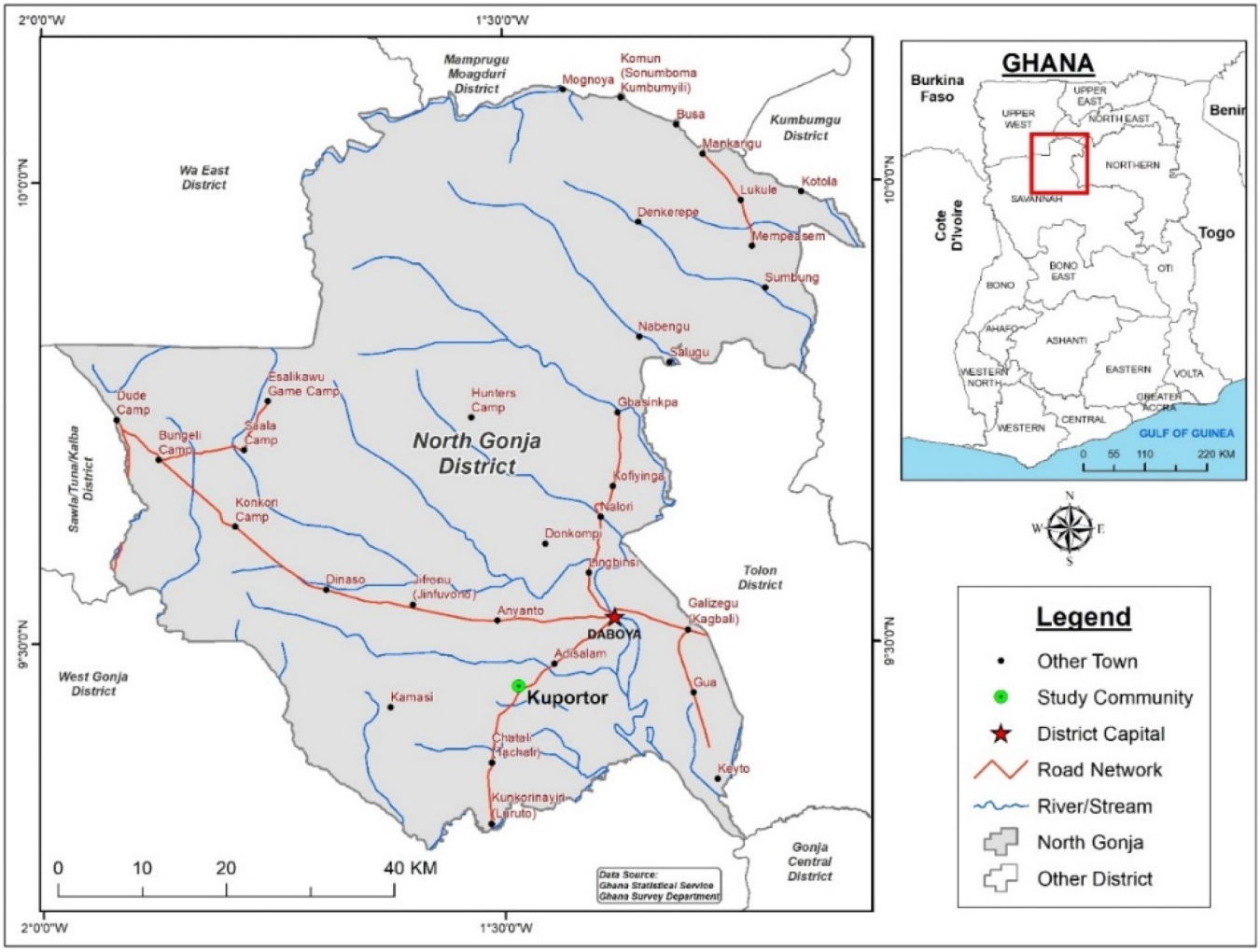

Fig. 2. North Gonja District Assembly.
Source: Prepared by RS/GIS Lab, Department of Geography, University of Ghana

jurisdiction this research took place, rules the Wasipe traditional area, with Daboya as both the traditional and administrative capital. The Wasipe traditional area is one of the five major divisional areas in the Gonja Kingdom, including Kpembi, Bole, Kusawgu and Tuluwe. Data collection was done in the North and West Gonja Districts (Figs. 2 and 3).

The vegetation of North and West Gonja Districts in Guinea Savannah has been greatly affected by human activities such as farming, lumbering, and charcoal production. The dominant tree species are the shea, baobab, dawadawa, neem, and ebony. Trees in the districts are generally dispersed; however, the valleys have dense trees and woodlands. Some crops cultivated are millet, sorghum, maise, Yam and groundnuts (GSS, 2014).

Agriculture is the main economic activity in the districts. The arable lands in the district foster crop farming, with the grasslands serving as feeding grounds for cattle. Smock weaving and trading is another economic activity in the districts. In the North Gonja District, the private informal sector employs 98 % of the economically active population (GSS, 2013) 60.5 % of the employed in the West Gonja District are engaged in agricultural activities.

Fieldwork was done in Langatire, Soaleppe (West Gonja District) and Kuporto (North Gonja District) between January and March 2020. These three communities are the charcoal production hotspots in the Gonja area. The study deployed a mixed-method approach (Creswell, 2013), triangulating qualitative and quantitative methods in data collection. The data collection methods are interviews, focus group discussion, observation, and surveys.

Table 1
Categories of respondents and issues discussed.

Categories of respondents	No	Focus
Charcoal producers	18	Acquisition of concession for tree harvesting charcoal production process, benefits, and challenges
Charcoal dealers	10	Business strategies, networks, challenges faced
Community leaders	5	Land tenure and charcoal production, agriculture and environmental change, socio-economic importance of charcoal production, regulation of charcoal activities
Environmental Protection Agency	1	Overview of charcoal production in the study communities, environmental impacts of charcoal production, regulation, and licensing regimes
District Coordinating Director	2	Overview of charcoal production in the study communities, environmental impacts of charcoal production, regulation, and licensing regimes
Environmental NGO	2	The focus of NGOs activities, advocacy, and training

The interviews explored the growing importance of charcoal, the environmental and health impacts, and the relationships between charcoal production, farming, and herding. A total of 38 key informants were interviewed and Table 1 below is a summary of category of informants and issues broached.

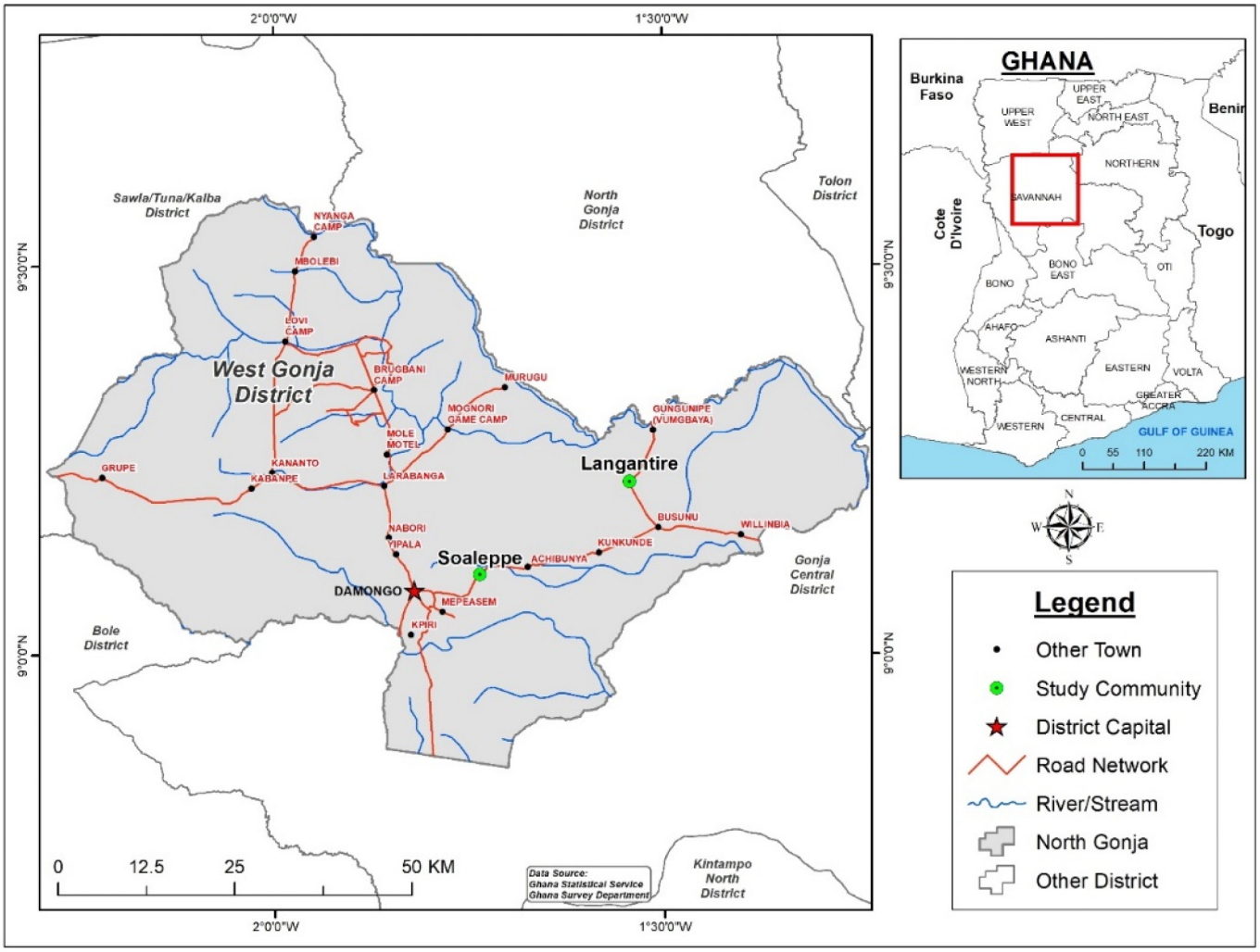

Fig. 3. West Gonja District Assembly.
Source: RS/GIS Lab, Department of Geography, University of Ghana

A structured interview guide guided the key informants' interviews. Informal interviews with community members and charcoal producers proved helpful in gaining an overview of the perceptions and experiences of community members on how charcoal production has shaped lives and social relations. The formal interviews were recorded using audio recorders with the permission of the interviewees, while the informal interviews were recorded in field notes. Four (4) focus group discussions (FGDs) for community leaders, men only, women only and mixed-gender charcoal producers comprising between eight to 10 participants were organised. The FGD allowed us to bring together the research participants to discuss critical issues regarding charcoal production. The audio recording from interviews and FGD were transcribed and based on the research goals; a table was designed with the various themes of the research in different columns. The researchers then read the interview transcripts and respondents' views placed under appropriate topics on the table. The research team visited charcoal production sites to observe the charcoal production process, charcoal-producing communities' state, and how charcoal production affects vegetation.

Two hundred (200) questionnaires were administered, with 71 in Kuportor, 58 in Soaleppe and 71 in Langatire, with 55.5 % of the respondents being male and 45.5 % being female. The sample distribution is proportional to the size of the number of households listed in the communities. A simple random sampling was used to select respondents, including charcoal producers and non-charcoal producers. A semi-structured questionnaire was used to collect the data on respondents' sociodemographic information, livelihood activities, experiences, expectations, and effects of the charcoal business in the communities. The questionnaire was inputted into the Computer Assisted Personal Interviewing (CAPI) software on tablets, used to record responses. The data recorded is synchronised daily and stored in the cloud. After the data collection, the responses were downloaded into SPSS, cleaned, and analysed. The survey data are presented as descriptive statistics such as tables, charts, and graphs. To ascertain how charcoal business influences welfare of households, we calculated the asset index of participants. Following Filmer and Pritchett (2001), we used the principal component technique to aggregate household assets including household durable assets (ownership of a cooking stove, radio, home theatre and television) and availability of electricity. The main limitation of asset index as a measure of welfare is that changes in well-being may not manifest immediately through changes in asset accumulation. However, the asset index was a good basis to estimate the welfare of households because of charcoal production.

Results and discussion

In this section, we present the study results and analysis. The main themes discussed are the role of migrants in the diffusion of the charcoal, the charcoal production process, technology and its related impacts on wellbeing of people. The sections also explored the reciprocal relationship between charcoal production and agriculture as well as the challenges confronting charcoal producers. Additionally, we examined the systemic barriers to women's participation in the charcoal value chain. The last part of this section delves into the debate on if and the extent to which charcoal livelihoods are degrading the savannah ecology of Ghana.

Sissala migrants and the introduction of charcoal production in Gonjaland

According to Obiri, Nunoo, Obeng, Owusu, and Marfo (2014), Sissalas are Ghana's most efficient charcoal producers. The Sissala, a Gur-speaking people and part of the Grune/Grunshi ethnic group in the Upper West Region of Ghana. They introduced charcoal production to Gonjaland, and they continue to be the largest producer. The Sissala hail from Tumu and Gwollu areas of the Upper West Region. A largely agrarian society, the Sissala ethnic group is Ghana's leading charcoal producer (Agyemnag et al., 2012).

Sissala men dominate the large-scale charcoal production sector in the forest, forest transition, and Ghana's woodland ecology. Charcoal production makes up 80 % of the Sissala livelihood (Lurimuah, 2011; Obiri et al., 2014). Described as 'nomadic' charcoal producers (Agyei et al., 2020), the Sissalas migrate and settle in small communities to access vegetation for charcoal production. Once the trees are exhausted, they migrate to new production centres.

The migrant Sissala producers work in teams ranging from four (4) to fifty (50), consisting of family and friends, usually led by the eldest, the most experienced. As a 25-year-old, Sissala charcoal producer notes:

> 'I learnt the charcoal job from my father. I used to follow him in the Ashanti Region, where we produced charcoal. Once I learned the trade, I formed my gang [team], and now we are operating here [in the Gonja area].'

Knowledge of the charcoal business is acquired through an apprenticeship where younger Sissala follow experienced members of the ethnic group across the country, producing charcoal. Social capital/assets (Fuller & Tian, 2006; Poon et al., 2012) constituting the social relations in the production teams provide the means through which relevant knowledge (human capital) on the dynamics of the charcoal trade. These social relations are also crucial for negotiating access, conflict management, and developing appropriate networks transmitted to Sissala youths.

Before the arrival of Sissala charcoal producers, communities in the Gonja area produced charcoal on a small scale from wood gathered after clearing the land for farms. According to respondents, the Sissala producers transformed and commodified charcoal production in the communities. As a female charcoal producer noted,

> 'For the charcoal, it is the Sissala who used to engage in it, so after they have packed it into sacks and left, we go there to search if at least we can get something small for the house and sometimes we do get enough and sell.'

After gaining a better understanding of the economic value of charcoal production, many indigenes also venture into it. As Yaro (2006), Scoones (2009), and Trang and Loc (2021) have argued, the value of assets rests on access to them and their transmutability. Although the Gonja people have always had vegetation (natural capital), it took the presence of Sisalla producers to impact the necessary human capital (charcoal production skills) and the social networks that grant them access to relevant market urban markets.

The movement of Sissala charcoal producers is embedded in complex systems of relations that facilitate their entry into communities and access to wood for charcoal. The charcoal livelihoods are embedded in political, kinship and religious institutions in the Gonja area. The organisation of the charcoal business by the Sissala in the Gonja area can be explained using the three systems of exchange, i.e. reciprocity, redistribution and market exchange (Polanyi & MacIver, 1944). These systems of exchange entail rules, conventions, and discourses on the species of trees that can be harvested, the prohibition on dawadawa and shea and areas where charcoal production is permitted.

Granovetter (2005) argues that social networks affect economic outcomes by influencing the quality and flow of information, providing a source of reward and punishment and trust-building in any economic relation. Many of the Sissala in the Gonja area draw on social capital (Scoones, 2009) embedded in their social networks to identify lush woodlands and negotiate access to produce charcoal. Here social networks provide natural capital (Blanco & Grier, 2012) (wood) for charcoal production.

People's network branches out from them to their close associates, society, and beyond (Prell, 2012). The Sissalas rely on social networks such as kin, work associates and members of their ethnic group in the charcoal business. The structure of social networks, i.e. the nature and

content of links in social networks, is essential for successful charcoal value chain participation (Ihalainen, Schure, & Sola, 2020). The charcoal production process and distribution harness and depend upon existing social relations patterns in Ghana's woodland ecology.

The Sissala charcoal producers rely on their strong and weak ties in navigating the labyrinth of the charcoal business. The weak links entail people's acquaintances or low-density network where they are less likely to be socially involved than close ties such as family which constitutes their strong ties/high-density network' (Granovetter, 1983, 1985). The charcoal production teams are composed of strong ties such as family members and close relatives and friends from Sissala village. Working together for an extended period has fostered trust between them and clearly defines each member's roles, making the production process efficient. However, as migrants, the Sissalas rely on weak ties, non-Sissala friends and acquaintances such as the community liaison person, to secure entry into a village and negotiate access to wood for production. The weak ties provide an essential conduit for Sissala charcoal producers to gain access and cope with the complexities of land tenure and cultural differences.

> 'Before we came here, my brother contacted someone he knew in the village. This man introduced us to the chief to get the trees for charcoal. Whenever we have any problem in the bush, my brother tells him, so he informs the chief for us' (Sissala migrant, Kuportor).

Understanding the dynamics of rural livelihoods and energy production thus requires a focus on the transmutability of various assets (Dam, 2017). In the Ghanaian context, social capital is critical for accessing wood and conflict management and transferring knowledge and team-building skills from migrant charcoal producers and indigenes of production communities.

The Charcoal production process and technology

Following the concession acquisition, the trees are harvested, packed, covered with grass and soil to trap the smoke, and ensure proper carbonisation. They then lit a small opening exposed to the wood and later covered it with grass and soil once the wood was adequately lit. The charcoal production technology has not changed substantially over the years except for chainsaws instead of axes in harvesting the trees (Plate 1).

The charcoal producers pitch camp in the bush to monitor the kiln around the clock. Small kilns burn in a few days, while larger kilns can take two or more weeks to burn completely. When the wood is entirely carbonised, producers poke holes into the kiln, which allow the sand to enter the kiln and start putting out the fire. The charcoal is spread to cool and divided into grids so that in cases the charcoal catches fire, it will destroy only the quadrant that caught fire. The charcoal is then packed into sacks and is ready for transportation to the market.

Table 2
Improvements in the community because of charcoal production.

Variable	Kuportor	Soaleppe	Langatire	Overall
Has the income of your household increased in real terms? (%)				
Improved	77.5	63.8	71.8	71.5
Stayed the same	11.3	10.3	15.5	12.5
Got worse	11.3	25.9	12.7	16.0
Can you afford to spend or invest more? (%)				
Improved	80.3	62.1	60.6	68.0
Stayed the same	8.5	12.1	26.8	16.0
Got worse	11.3	25.9	12.7	16.0
Have the incomes of your neighbours in this village increased in real terms? (%)				
Improved	64.8	51.7	69.0	62.5
Stayed the same	7.0	5.2	7.0	6.5
Got worse	4.2	13.8	8.5	8.5
Don't Know	23.9	29.3	15.5	22.5
N	71	58	71	200

Charcoal production, employment, and wellbeing

From Table 2 below, 71.5 % of respondents reported improved income due to charcoal production. Respondents praised charcoal production as a lucrative venture that enabled them to make a meaningful living. As a 30-year-old producer noted, '*Charcoal production has helped me purchase land in the Ashanti Region. I have sand on the land, and I intend to build on it.*' Natural capital (vegetation) is thus essential for acquiring assets like a home. Therefore, the significance of charcoal production cannot be limited to meeting Ghana's energy needs but is critical for overall societal development.

Indeed 68 % of respondents said they could now afford to spend more or invest more due to increased income from charcoal. According to a teacher who is an indigene and a charcoal producer:

> 'You know very well that as teachers, our income is meagre. If you are not engaged in other alternatives, you will find it challenging to take care of your wife and children. Farming is an alternative,

Plate 1. Charcoal kiln and charcoal spread to cool.
Source: Fieldwork 2020

but there are too many challenges [with farming]. Charcoal gives us a better income, so I produce it.'

Charcoal production enables them to invest in modern farming, improved homes, and household expenditure in these rural communities. Climate change has threatened agricultural livelihoods in Africa (Dam, 2017; Yaro, 2013b), and charcoal production has become a vital livelihood diversification activity (Dam, 2017; Ihalainen et al., 2020). As Leach, Mearns, and Scoones (1999), Scoones (2009), and Jones et al. (2016) have all argued, various strategies are deployed in response to shocks. Charcoal production offers rural communities a more stable source of income when compared to farming. Migrant charcoal producers invest revenue from the charcoal business in their hometowns and cities. These investments can be the purchase of farming inputs to invest in agriculture in their hometowns, housing, and non-farm activities.

From Table 3 below, the average income from charcoal is about GH₵13,481 (US$1497) compared to GH₵ 3251.2 (US$361) from other sources, including farming. The respondents confirmed that income from charcoal is higher than from agriculture and other off-farm livelihood activities and has improved access to food. As shown in Table 2 below, 46.5 % of families never cut nor skipped a meal due to income from charcoal. The value of charcoal production as a livelihood activity is linked to its potential role in attaining the UN SDGs 1 (no poverty) and 2 (zero hunger). The figure is even higher for Kuportor, where 60.6 % of respondents never had to cut or skip meals, which they attribute to income from the sale of charcoal. 68 % of respondents said they could now afford to spend more or invest more due to increased revenue from charcoal.

Also, charcoal production and related activities create a service economy in rural communities (Dam, 2017; Ihalainen et al., 2020), including food vendors, drinking bar operators and retail shops. In the Gonja area, the charcoal support service is dominated by women, which is not a departure from the overall structure of the Ghanaian economy, where women dominate the informal service sector (Forkuor, Buari, & Aheto, 2020). Some youth sell fuel to charcoal producers, and motorbike repair shops abound to service the numerous motorbikes purchased with charcoal money. Though many large-scale producers own chainsaws, many independent chainsaw operators provide charcoal producers and farmers with tree harvesting services. Unsurprisingly, 62.5 % of respondents perceive their neighbours to have an improved income due to charcoal-related livelihood activities. The general perception of improvements in revenue at the community level is due to the linkages between charcoal production and the broader local economy. Charcoal producers contribute toward community development projects such as water provision and maintenance of the community borehole. In Kuportor, for example, charcoal producers pay an amount of GH₵250 (US$28) each time a charcoal truck is loaded for the market as a contribution to development projects.

Overall, 53.7 % of the respondents classified among the richest in the communities are engaged in charcoal related activities, while the poorest are those involved in trading (60 %) and 66.7 % in other livelihood activities. Concerning the scale of charcoal production, those classified as the wealthiest asset holders in the community (71.64 %) are small-scale producers who are usually indigenes who invest in the communities. However, the large-scale producers are the poorest asset holders (54.55 %) since most of them are migrants who live in small shacks in the bush, without facilities and suitable housing. Thus, large-scale producers' assets are situated in their hometowns and major cities where their families reside. One of the Sissala large-scale producers, for instance, lives in a shack in the bush where he produces the charcoal with no assets in the village but owns a house in the capital city, Accra, where his family lives.

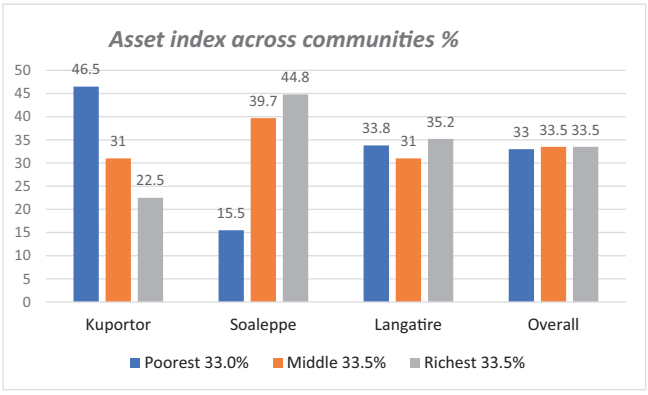

Fig. 4. Asset index across communities.

Fig. 4 shows the wealth distribution across study communities. In Kuportor, the current charcoal frontier, there are new entrants, hence the high percentage of the poorest (46.5 %). Soaleppe, one of the older and depleted charcoal production zones, has a high proportion of the wealthiest people (44.8 %) because accumulation was done in the past. With charcoal production estimated to have peaked five years ago, many people accumulated assets and reinvested in other businesses through diversification and expanded farming. Thus, the proportion of wealthy people in Kuportor may increase over time while the poor reduce. The economic impacts of charcoal activities should not be limited to short-term analysis but rather observed over time as the investment of charcoal income in assets and diversified activities create improved livelihoods in subsequent years.

When the asset index is compared across gender (Fig. 5), more than 61 % of men are among the richest compared to 38.8 % of women. Most women have much more diversified livelihood activities compared to men. In addition to charcoal production and farming, women also engage in petty trading, picking, and processing shea nuts, giving them a more diversified income source, with a little over 50 % classified within the middle-level asset index. Many scholars have argued that the

Table 3
Income from charcoal.

Variable	Kuportor	Soaleppe	Langatire	Overall
Average income from charcoal in 2019 (US$)	2599.3	1146.2	681.3	1497
Average income from other sources (US $)	644.5	206	204	361
% households who cut the size of the meals or skip meals because it did not have enough food in the last 12 months				
All the time	1.4	0.0	0.0	0.5
Almost always	5.6	6.9	9.9	7.5
Some of the time	26.8	41.4	40.9	36.0
Seldom/rarely	5.6	12.1	11.3	9.5
Never	60.6	39.7	38.0	46.5
N	71	58	71	200

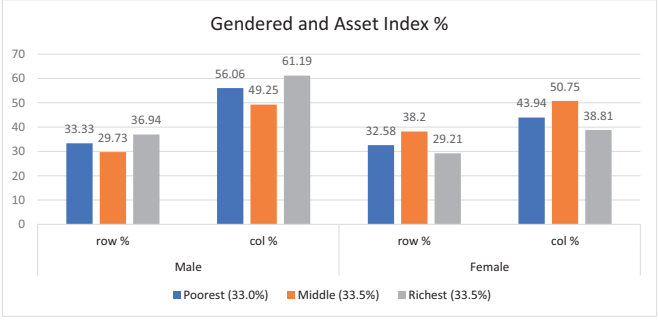

Fig. 5. Gender and wealth distribution.

diversity of livelihood activities is critical to long term sustainability (Bebbington, 1999; de Haan & Zoomers, 2005; Scoones, 2009; Zulu & Richardson, 2013).

The average income from the charcoal business is over 91 % higher than income from farming. Charcoal production provides an essential income source to rural communities and urban retailers and is intricately linked to diverse sectors, not least agriculture.

The charcoal production process has created direct casual employment for women, the youth, and society's very poor. The charcoal producers mainly employ women to fill sacks with charcoal for a daily wage range of 10 to 15 GHC (1 to 1.7 US$). In addition, the women can pick rejected pieces of charcoal to fill their sacks for household use or sale at much lower prices due to its poor quality. At the height of production, charcoal provides a regular source of employment for women for almost half the year. However, the employment effect reduces as the tree densities reduce and the Sissala migrates further inland.

The youth in the area have also enjoyed both direct and indirect employment. First, they are employed to carry felled logs, dig depressions to make kilns, and load trucks. Indirectly, charcoal production has created a demand for transport services (tricycles) that convey logs, charcoal and people into the woodlands following footpaths. The poor road network in this inaccessible part of Ghana accounts for the increasing investments in tricycles with multiple incomes and employment effects. The three primary beneficiaries are tricycle owners, operators, fuel vendors, and mechanics. Some tractor owners have also cashed in by transporting charcoal on narrow farm trails, allowing tractors to work all year round. In the rainy season, the tractors plough the fields while they haul charcoal in the dry season. There is an intensification of economic activity and the disappearance of the seasonality of income for many people.

Chainsaw operation has become an essential source of employment for the youth. Though initially this was mainly done by the Sissala, as they worked with indigenes and impacted this skill, youths have purchased chainsaws commonly called 'dorman' or employed by people with these machines to work for them. Linked to charcoal was the harvesting of rosewood, which helped the youth build skills in operating chain saws that are now employed in charcoal production. A respondent in Kuporto reported learning how to operate a chainsaw when rosewood buyers came to the district many years ago. However, when the ban on rosewood took effect, he became unemployed but soon bounced back to business when the charcoal producers replaced the rosewood harvesters. This is an essential process as skills learnt for one activity are transferred to other activities.

This chain of multiplier employment effects also goes for food vendors who have taken advantage of the emerging monetised economy to open 'chop bars' (mini restaurants) providing food to indigenes, charcoal aggregators and visitors. The level of commercial activity in these charcoal producing communities is so high as to sustain so many other micro-businesses, which serve as employment and wealth accumulation avenues. Charcoal revenues have become vital for diversification into a sustained non-agricultural economy.

The reciprocal relations between charcoal production and agriculture

Dwindling farm yields have characterised northern Ghana due to structural adjustment and climate change (Apuri, Peprah, & Achana, 2018; Yaro, 2013a). The introduction of charcoal production has resulted in a synergistic relationship between farming and charcoal production. Due to the low population densities and, therefore, availability of land for extensification of the agricultural output, capital from charcoal for investing in farming is vital. For many Gonjas, charcoal production is done in addition to agriculture. At the end of the farming season, farmers focus on charcoal production, particularly during the dry season when there are no farming activities. Thus, though charcoal production is on the rise, it is not replacing farming as an essential livelihood for indigenes. This relationship takes several forms.

Firstly, farm expansions require clearing vegetation to make it easy to plough the land. As farmers move further away from their villages into new areas to farm, they rely on charcoal producers to clear the trees on the land. Therefore, the charcoal producers have access to abundant raw material from these savannah groves, converted into farmlands. Many charcoal producers consider this arrangement convenient, as they do not need to negotiate for trees from higher chiefs. According to a farmer,

> "There is a positive relationship [between charcoal production and farming] because if a dry tree is found on the farmland, we call a charcoal burner and sell it to them and invest the money on our farm".

By allowing charcoal producers to harvest trees on their land, farmers reduce their production cost when clearing the land and may receive a portion of the income from the producer. Women often take charge of the charcoal produced from the farm. This income is saved in informal savings institutions known as 'susu' and withdrawn when needed. Many farmers first clear the woodlands for charcoal and invest the proceeds on the farms, which they would not have been able to do due to lack of credit facilities. These we can call woodland rents, which are gotten ones in a lifetime.

The challenges associated with charcoal livelihoods

The major challenge charcoal producers face is reducing available woodlands for production, which necessitates rapid relocation outwards further into the hinterlands with less infrastructure. It is a challenge emanating from the increasing number of people engaged in charcoal production to meet the growing demand (Aabeyir et al., 2016; Yiran et al., 2020). The demand for charcoal in Ghanaian cities has increased the number of producers. This resulted in the rapid depletion of vegetation, forcing producers to travel further to access wood.

Even though we found tree densities high in most communities, the commercial producers only harvested preferred trees. The availability of preferred trees is the major problem rather than the availability of woodlands. Like any other African resource, access rights to woodlands are complex and often conflict-ridden (Kweyu, Thenya, Kiemo, & Emborg, 2020). Traditional leaders usually lead negotiations in common access areas with the family heads. While these negotiations may be legitimate, not all community actors support charcoal production resulting in conflicts. Some drastic actions against charcoal producers include burning packed wood and the campsites. In some communities, the conflict is related to the lack of youth involvement in the charcoal business and the share of benefit streams. A male youth respondent describes one of these situations:

> 'There was a time we had a group of Sissala people dominating charcoal burning in this community. The youth of this community became aggrieved, sort permission from authorities and expelled them from this community. They moved to Yazori, a community in North Gonja.'

Some Sissala producers did not secure an appropriate permit from the traditional leaders in the case above. The chief supported the community youth to sack the Sissala producers. The further away charcoal production camps are from the villages; the more likely producers will not have the appropriate authorisation to harvest wood. In all instances, these conflicts are sources of shock (de Haan & Zoomers, 2005) in the sustainability of livelihoods (Plate 2).

The current approach of state agencies such as the Forestry Commission, the Environmental Protection Agency (EPA), and the District Assemblies is that charcoal production is detrimental to the environment; hence, it must be banned. Paradoxically, while the district assemblies have been unsuccessful in enforcing the ban on charcoal production, their officials instead use the threat of arrest to extort

Plate 2. Destruction of Sissala campsite and packed wood for charcoal.
Source: Fieldwork 2020.

money from charcoal producers. Thus, some district assemblies tax the charcoal producers while others issue punitive fines to curtail their activities and extortion by the assembly officials. Whether viewed as taxes or fines, the assemblies generate revenue from the charcoal business.

Systemic barriers to women's participation in the charcoal business

Women charcoal producers face systematic barriers to their entry into the charcoal business. The differential access to resources and gender roles practised over the years has resulted in women having low capital and labour to invest much into the production process (Brobbey, Hansen, et al., 2019; Brobbey, Pouliot, et al., 2019; Ihalainen et al., 2020). There are consequently no women in all study communities in large-scale charcoal production. According to a small-scale charcoal producer, *'today charcoal burning is the preserve of females in this community with few males involved.'* The view above relates to the fact that women only gained access to the woodland for charcoal after the large-scale producers had exhausted the concessions and moved on to new areas. Institutions in the form of norms, values and practices mediate access to livelihood assets (Scoones, 2009). The patrilineal inheritance practised in the study communities with its inherent patriarchal practices limited women's access to land vis-a-vis capacity to produce charcoal on a large scale. Thus, during the peak period of charcoal production, women were mainly labourers working for large-scale producers and learning skills. However, once the large-scale producers are no longer there, women forage the remaining woodland for trees considered unfit for profitable production or less desired species. Unlike the men, women are usually not granted concessions for charcoal production, limiting female ownership of large production units. The entrenchment of male access routes to natural resources, especially when seeing chiefs, is a major patriarchal hurdle restricting women's access to productive resources. The socio-culturally embedded practices mediate access to vital livelihood resources and their transmutability (Brobbey, Pouliot, et al., 2019; Ihalainen et al., 2020; Yiran et al., 2020).

Are charcoal livelihoods degrading the northern savannah?

Many actors, including governments, NGOs and local authorities, oppose charcoal production, citing damaging environmental impacts (Aabeyir et al., 2016). In Fig. 6 54 % of respondents believe preferred tree species for charcoal production have become scarce. All respondents agree these trees are no longer found closer to their villages as in the past. The evidence that charcoal production causes massive devegetation is not entirely true as there is selectivity in harvesting only preferred trees. There are possibly over 50 tree species, but only four species are preferred by large producers, while indigenes who join add four less preferred species to make eight harvested species.

Across the Savannah woodland, certain tree species such as dawadawa, shea and mango are not harvested for charcoal; hence areas dominated by these species do not suffer substantial vegetation loss. Places with a broader tree diversity do not experience severe degradation except for the extinction of the preferred tree species for charcoal. However, where the preferred species for charcoal production dominate the landscape, considerable deforestation results. In places where preferred species such as *keche (Khaya senegalensis), kakali (Anogaises leucopus) and kawul (Afrormosia laxiflora)* used for charcoal production dominate, these areas will experience significant devegetation. The FDG shows that one-third of all trees in Kuportor and many communities are suitable for charcoal. In effect, charcoal production could lead to the extinction of the three main tree species in the Gonja area.

As the Sissala commercial producers harvest the preferred species and move on to more lush woodlands, the indigenes harvest less favourite species and smaller preferred tree species, exacerbating environmental degradation. It was observed that in Langatire and Soaleppe, smaller trees are being harvested for charcoal production. These small producers prevent the regeneration of the environment. The possibility of revegetation is lower with the indigene invasion of the charcoal

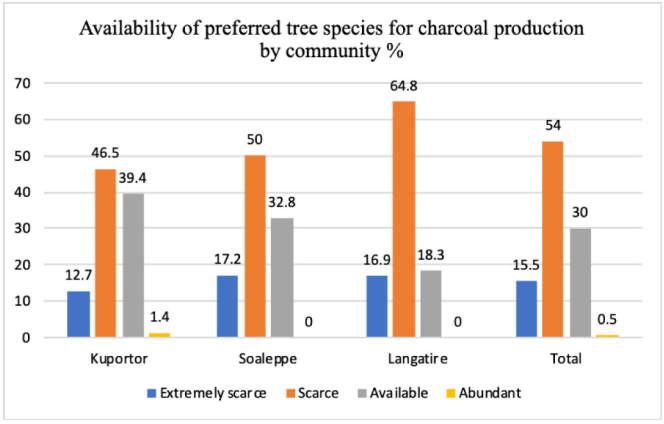

Fig. 6. Availability of preferred tree species for charcoal production.

business. However, the Sissalas are the primary cause of reducing the Savannah woodlands and the depletion of older trees and, therefore, carbon sinks. All over the northern savannah, hitherto thick woodlands in the 1960s have become open woodlands with scattered trees resulting from fuelwood harvesting, charcoal burning and agriculture.

The nexus between charcoal production and agriculture is the deadly alliance that causes devegetation. Poor farmers unable to clear thick woodlands piggyback on charcoal producers who thin the woodlands, enabling easy colonisation. Therefore, even though charcoal production does not directly remove most vegetation, it indirectly helps farmers open up the woodlands. Farmers, in turn, only allow shea and dawadawa trees with a few known fruit trees to stand on their fields. It is not fair to criminalise charcoal producers without a critical analysis of their operations (Montalván et al., 2019). Disentangling their effects from other land uses is vital for good policy formulation since charcoal as an energy source remains vital in Ghana and Africa (Brobbey et al., 2015; Dam, 2017; Ihalainen et al., 2020; Yiran et al., 2020).

A major annual environmental event in northern Savannah is bushfires which critics often link to charcoal livelihoods. Our data shows that only 35 % of respondents believe charcoal production contributes to bush fires. The charcoal production process is organised to reduce its potential to cause bush fires, as confirmed by interviews with producers, farmers, and traditional leaders. It is in the interest of charcoal producers to prevent bushfires because they need grass for the charcoal carbonisation process (Alfaro & Jones, 2018). Thus, charcoal processing cannot occur when grass to line kiln is unavailable. Fire can destroy charcoal and harvested wood leading to colossal damage and cost to producers. This is the reason why many Sissala producers pitch a tent in the bush and keep a close watch on the charcoal kilns to ensure the fire is quenched; the charcoal is packed and bagged before they return home. Even where the charcoal is packed, producers face the threat of uncontrolled bush fire mainly caused by other land users such as herdsmen, farmers, and arsonists. Therefore, charcoal producers must ensure that their activities do not result in bush fires.

Conclusion

The role and impacts of charcoal in African economies are complex and embedded in socio-cultural systems and economics (Montalván et al., 2019; Mwampamba et al., 2013). In many African cities, rapid urbanisation driven by rural-urban migration has also set energy transitions at the household level (Silva et al., 2019; Yiran et al., 2020). While the current debate on energy transition, particularly in Europe, focuses on decarbonising society, the transition is a shift from one form of biomass to another in Africa. Although many African governments are encouraging the use of liquefied petroleum gas (LPG) (Perros, Büttner, Leary, & Parikh, 2021), its uptake is low and mostly occurs in urban areas (Yiran et al., 2020). Thus charcoal remains an essential source of biomass energy (Brobbey, Pouliot, et al., 2019; Mwampamba et al., 2013) and, therefore, an avenue for people living in wood abundant rural areas to make a livelihood (Agyei et al., 2018, 2020).

The limitations of this paper are that it focuses on a few charcoal producing communities, it has not captured the diversity and nature of woodland, as well as population density which can translate into different outcomes of charcoal production. Nonetheless, the paper has shown that the organisation of charcoal livelihoods produces winners and losers based on the dynamics of power and the positionality of actors in the value chain. The income distribution from charcoal production follows the traditional set-up at the community level – the village chiefs receive payment directly from the producers based on the agreed-upon terms. The activities of migrant charcoal producers create a service economy of retailers, transport operators, repairers, many of whom are indigenes. Charcoal transporters pay tax to every paramount Gonja chief through whose jurisdiction the charcoal passes. Charcoal dealers also pay monies to the public officials whose duty is to regulate and enforce rules of harvesting and transporting the commodity. Some local governments benefit from the charcoal business through penalties and taxes imposed on charcoal producers.

Community members benefit directly by engaging in charcoal livelihoods as producers or labourers or indirectly from the taxes paid for community development projects. Community members employed directly in the charcoal business invest in housing, health care, education, and agriculture. There is a mutually beneficial relationship between charcoal production and agriculture. Income from charcoal is being invested in farm size expansion while clearing vegetation for farms increases the availability of wood for charcoal production.

A critical assessment of the benefit distribution shows a huge extraction of charcoal rents by migrants as they use up the best wood producing thousands of tonnes of charcoal with minor investments in the extraction zones. This is like multinational companies harvesting timber resources for export who do not invest in the resource regions but their countries. Our findings show that depending on tree composition in a particular place; minimal devegetation may result from charcoal production. However, the lethal synergy between charcoal production, farming and herding can collectively adequately explain the degradation of the ecology of the savannah, which affects tree densities and leads to the loss of habitats for wildlife. Thus, vegetation loss should not be narrowly blamed on charcoal, as this undermines policy nuances needed to tackle environmental degradation.

There is a need for a comprehensive national policy and dialogue on sustainable charcoal production taking cognisance of local differences and nuances. Managing major producers of charcoal and restricting small survivalist charcoal production seems a vital pathway to ensure sustainability. Strengthening local economic linkages and partnerships between experienced, well-resourced migrants and the local population is needed to provide meaningful benefits from charcoal production. Considering the large number of people involved in charcoal production and its significance to local economies and meeting domestic energy needs, an outright ban on charcoal production will be counterproductive. Also, since other land users will ultimately convert the woodlands involving tree removals, a win-win focus by policy strategies with broader community buy-ins is needed.

Declaration of competing interest

The authors declare no conflict of interest

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