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Structure and Characteristics of Fuelwood Supply Chain in Yobe, Nigeria

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Abstract

Fuelwood commercialization activities provide a source of livelihood in Nigeria. Despite its economic significance, the industry has been kept out of the formal economies due to a lack of supportive data on the structure and characteristics of the industry. This study investigates the structure of the supply chain and examines the chain actors' roles and functions to understand the issues within the supply chain activities. Data were collected through key informants' interviews and observations. The study found that fuelwood business activities were conducted formally by licensed actors and informally by non-licensed actors. Benefits received and issues experienced by actors were related to the formality of the business. Heavy reliance on natural forests for fuelwood production among chain actors can add pressure on the forest resources and ecosystem. Therefore, significant intervention is needed for the industry which includes policy and programs related to fuelwood plantation and management, government support, licensing education, and collaborations among all stakeholders to improve supply chain activities.

Keyword: *forest, fuelwood, livelihood, supply chain, characteristics*

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Introduction

Access to sustainable, affordable, and reliable energy is crucial to human well-being. According to the World Bank (2021), about 2.6 billion people worldwide live without access to clean cooking fuel in 2019. Additionally, electricity remains unaffordable to 759 million people worldwide, and 30 million people residing in Africa (World Bank, 2021). According to the World Bank (2021), Nigeria, the Democratic Republic of Congo, and Ethiopia had the largest deficit on access to electricity in 2019. The unaffordability of electricity has resulted in the use on various forms of biomass for cooking and heating, with 807 million people from Africa primarily relying on biomass energy such as fuelwood, charcoal, agricultural waste, an industrial by-product, and animal dungs (Cerutti et al., 2015; Sola et al., 2017). In many countries in Sub-Saharan Africa (SSA) including Nigeria, the primary energy for cooking is consumed in the form of fuelwood (firewood) or converted for use as charcoal (Ndiboi & Dare, 2020; Purwestri et al., 2020).

Nigeria is the third-largest fuelwood producer after Ethiopia and the Democratic Republic of Congo in Africa as more than 65 million m^3 of fuelwood is produced annually (FAO, 2016a). Fuelwood as the predominant source of energy for cooking and heating contributes to over 60% share of the total energy consumption in Nigeria (Energy Commission of Nigeria, 2018; Ndiboi & Dare, 2020). In Nigeria, fuelwood is not only consumed in the domestic sector for household cooking, but also used as the primary source of energy for cooking and heating in the commercial sector such as restaurants, bakeries, local groundnut oil milling, local breweries, local rice milling, fish smoking, beverage production and other industry such as brick production, and aluminum foundries, as well as in public institutions such as boarding secondary schools, correctional and rehabilitation centers, healthcare units/hospitals, training, and detention camps as fuel for cooking (Naibbi, 2015; Ndiboi & Dare, 2020). The prevalent use of fuelwood as energy for cooking in Nigeria is due to the unaffordability and unreliability of alternative modern energy such as liquefied petroleum gas (Ojo et al., 2012; Naibbi, 2015).

The high fuelwood demand in Nigeria has caused the production of fuelwood to increase over the years from 50.92 million m^3 in 1990 to 66.21 million m^3 in 2019, a 23% increase (FAO, 2016b; FAO, 2020). However, such high demand and production of fuelwood have contributed to the depletion of the country's forests. Previous studies show that

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the prevalence extraction of fuelwood has led to the depletion of 8.86 Mha (96%) of the total vegetation of Nigeria (Naibbi, 2015; Gbonegun, 2018; Goldman & Weisse, 2019), and caused other impacts that include erosion and deforestation (Naibbi, 2015; Ndiboi & Dare, 2020).

Nevertheless, fuelwood business activities play a vital role in the livelihood and development of the rural economy in Nigeria (Nelson et al., 2017; Ndiboi & Dare, 2020). The fuelwood industry has been reported to support the livelihood of about 2 million people in Nigeria (Larinde & Aiyeloja, 2015; Ndiboi & Dare, 2020). The fuelwood industry has also been reported to play an important role in aiding the development of the transport industry as fuelwood is mainly transported by road in Nigeria (Ojo, et al., 2012; Adewuyi & Olofin, 2014; Naibbi, 2015). Moreover, some households' implements such as chopping boards, handles of knives, pestle, mortar, as well as farms' tools (e.g. handles of a shovel, rakes, hoes, and diggers were reportedly produced from woods by sculptors in Nigeria (Larinde & Aiyeloja, 2015).

Given the positive and negative impacts of the commercial fuelwood activities in Nigeria, there is a need to understand the structure and characteristics of the fuelwood industry that include the channel from which fuelwood is supplied, understand the roles of the function of the key actors, and sources from which the fuelwood is obtained. Such information can help entrepreneurs (investors), government, and other relevant stakeholders to identify the strength, weaknesses, opportunities, and bottlenecks along the fuelwood supply chain to help for the development of a strategic action plan and programs for a more sustainable fuelwood industry in Nigeria. It is important to note the fuelwood industry in Nigeria failed to receive adequate attention from the government as it has been kept out of the formal economies due to a lack of supportive data and information along the fuelwood supply chain.

Thus, understanding the structure and characteristics of the supply chain is essential as characteristics have a direct connection to the economic performance of the industry (Lelissa & Kuhil, 2018). The previous studies on fuelwood in Nigeria often focused on a single value chain node or process. For example, Adeyemi and Ibe (2014) and Nelson et al. (2017) have focused on the vending node only, and examined the economic contribution of the fuelwood industry to livelihood. Audu (2013) focused on the extraction node and discussed the impact of the harvesting activity on the environment. This study, therefore, aims to bridge the knowledge gap by uncovering the structure and characteristics of the fuelwood supply chain in Nigeria using Yobe State as a case study. Specifically, the study investigates the structure of the supply chain and examines the chain actors' roles and functions to understand the issues within the supply chain activities. Results from this study can be useful to policy- and decision-makers, private investors, prospective investors, environmental bodies, and NGOs in developing policy, plans, and strategies to support sustainable fuelwood production and trade in Nigeria.

Method

Location of the study Yobe is a state located in Northeastern Nigeria (Figure 1A) and has 17 local government councils (Figure 1B). Yobe has a total land area of 4,660,900 ha characterized by Sahel savannah vegetation supporting open thorny short savannah trees of about 5 m to 10 m in height (Ali et al. 2019). The vegetation is dominated by xerophytic

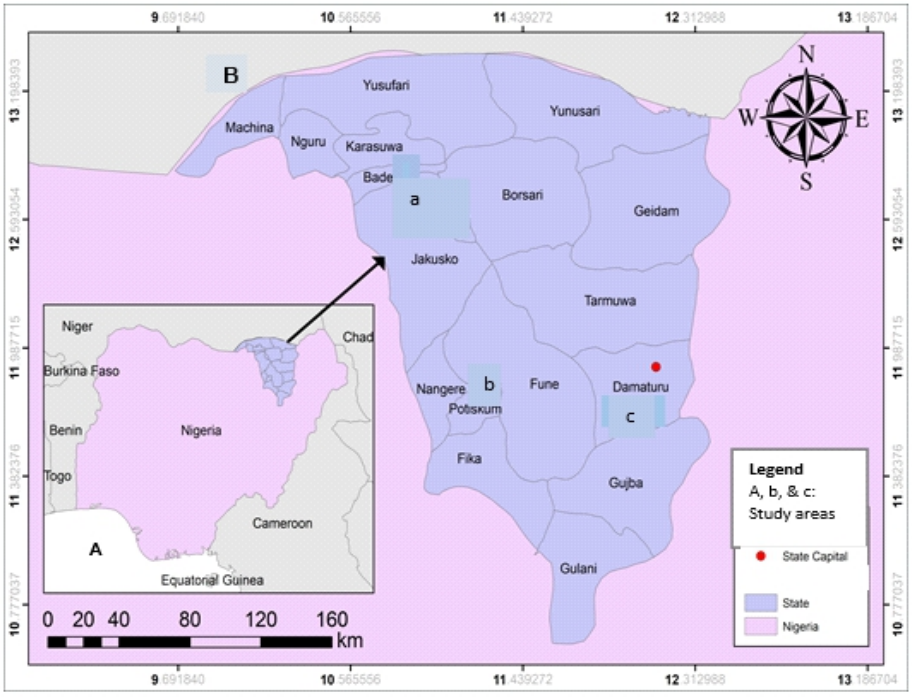

Figure 1 (A) Map of Nigeria showing Yobe State; (B) Yobe state showing the three study areas: (a) Bade, (b) Damaturu, and (c) Potiskum.

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trees such *Acassia polyacantha*, *Anogeissus leiocarpus*, *Bauhinia rufescens*, *Cassia arereh*, *Combretum molle*, *Croton amabili*, *Detarium microcarpum*, *Daniellia oliveri*, *Guiera senegalensis*, *Prosopis africana*, *Piliostigma recticulatum*, and *Securidaca longepedunculata* (Alao et al., 2016; WFP, 2018).

Yobe has a distinct wet and dry season, with annual rainfall as high as 700 mm in the southern parts of the state and as low as 275 mm in the northern parts (Ali et al., 2019; Zemba et al., 2018). Precipitation occurs between June and October, while the dry season extends from November to early May (Naibbi & Healey, 2013). Equally, the mean annual temperature in Yobe State is 34 ºC (Zemba et al., 2018). Yobe State has been described as economically fragile and extremely under-developed, with a low literacy level and high unemployment population (Ibrahim, 2012). Poverty in Yobe State is higher (69%) than the national average poverty of 61%, while the literacy level of the adult male and female population in the state is 24.2% (NBS, 2017). The primary source of livelihood in Yobe has been farming, livestock rearing, fishing, and trading of different commodities including fuelwood (Naibbi, 2015; WFP, 2018).

Three local governments councils namely Bade, Damaturu, and Potiskum (Figure 1B) were purposively selected for the study due to prevalence fuelwood business activities, and high involvement of the rural and urban population in fuelwood business activities (Naibbi, 2015; WFP, 2018). Thus, the criteria for the selection of the three areas was purposive. Most importantly, the results of the study represented an outcome of a preliminary survey aimed to find first-hand information on the characteristics of of fuelwood value chain that can be helped and ease the collection of data for an actual survey on sustainable fuelwood value chain management in Yobe Potiskum is the most populated area (Naibbi, 2015; Ali et al., 2019), followed by Damaturu and then Bade (WFP, 2018).

Data collection and analysis This study was conducted from June to September 2019, in which qualitative data were obtained through interviews and observation. The interviews method allows survey participants to be open in voicing both sensitive and non-sensitive opinions that may be difficult to articulate in a group dynamic (MSG, 1999). During the interviews conducted across three local government councils in Yobe, we learned that fuelwood business activities in the study area are either formal (business was conducted with license/permit) or informal (business was conducted without license/permit). Therefore, we employed the opportunistic sampling method to identify qualified informants along the fuelwood supply chain who provided relevant information that answered the research questions. Basic information gathered during the interviews includes the occupation of the participants, descriptions of commercial fuelwood activities along the supply chain, the sources of the respondents' fuelwood, and description of activities carried out along the supply chain.

A total of 30 respondents were interviewed at the three study locations comprised of both formal and informal fuelwood chain actors (Table 1). The selection of 30 participants as the sample of the study was based on the recommendations of Bernard (2000) that 30 people are enough participants in a qualitative study to avoid data saturation. The lack of an official registry of value chain actors in Yobe makes this study's systematic sampling difficult. Additionally, the fuelwood value chain activities in Yobe are sensitive to some extent as some value chain actors participate in fuelwood business activities informally. Thus, the percentage of respondents likely to respond/complete questionnaires for a study was recommended to be estimated (Mooi et al., 2018). We defined two broad categories of actors namely: formal (n = 24) and informal actors (n = 6). The formal actors were spread along 4 sub-groups comprising harvesters (n = 6), transporters (n = 6), wholesalers (n = 6), and retailers (n = 6) (Table 1). The informal actors (n = 6) were another independent group that carried out multiple value chain activities, as opposed to division of labor as observed amon the formal actors. Additionally, the sample comprised of 4 women and 26 men. The differences in the number of participants in terms of gender were the result of adopting opportunistic sampling, where participants were met opportunistically at their fuelwood operational business bases (markets and forests).

We conducted an open-ended interview with participants and field observation to confirm and gain a deeper understanding of how the fuelwood was extracted, transported, and traded by the respondents of the study area. The interview questions were designed with the consultation of stakeholders and were ground-tested in a pilot study before actual data collection. Moreover, observation activities during the study period were captured using a digital camera. The data were analyzed using descriptive statistics. Qualitative data was analyzed using content analysis as suggested by Miles et al. (2014).

Results and Discussion

Structure of fuelwood supply chain The identified structure of the fuelwood supply chain in Yobe is shown in Figure 2. The generic fuelwood supply chain starts with harvesting, transportation, wholesaling, and retailing (Figure 2A). Similar to Puentes-Rodriguez et al. (2017) in a fuelwood value chain study in Burkina-Faso, this study identified two channels of formality in the fuelwood supply chain, formal (licensed) and informal (non-licensed). The formal chain (Figure 2B-I) was steered by the licensed actors

Table 1 Number of respondent by location and fuelwood chain actor category

Location	Informal supply chain	Formal supply chain			
	Non-licensed actors	Harvester	Transporter	Wholesaler	Retailer
Bade	2	2	2	2	2
Damaturu	2	2	2	2	2
Potiskum	2	2	2	2	2
Total	6	6	6	6	6

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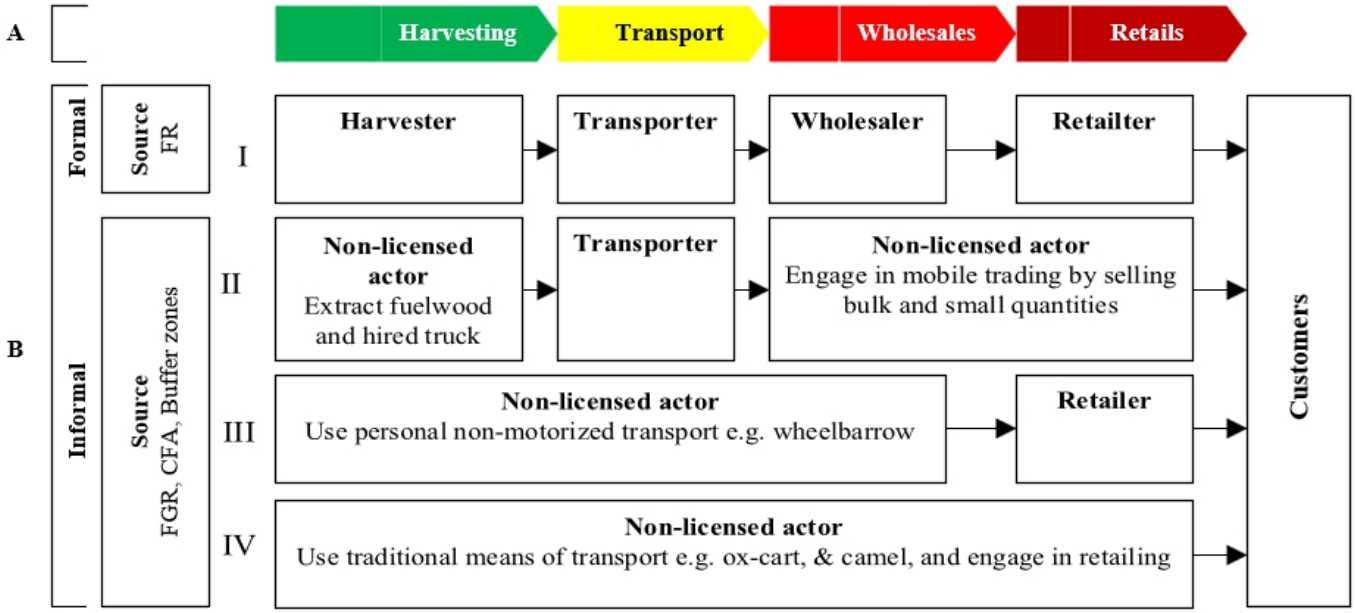

Figure 2 Map of fuelwood flow in Yobe; (A) Fuelwood generic chain; (B-I) Formal fuelwood supply chain; (B-II, B-III, & B-IV) Informal fuelwood supply chain; FR (forest reserve); FGR (federal grazing reserve); CFA (communal forest area).

who undertake legitimate supply chain activities at designated locations (i.e. forest reserves and fuelwood market) approved and supervised by the forestry officials. The licensed actors were organized and the actors engaged in separate supply chain nodes or activities either as harvesters, transporters, wholesalers, or retailers.

The informal supply chain consisted of non-license actors who carried out unregulated fuelwood value chain activities. We observed that non-licensed actors engaged in vertical integration or were involved in multiple supply chain activities and thus were grouped into three informal supply chains (Figure 2B-II, Figure 2B-III, Figure 2B-IV). The first informal chain (Figure 2B-II) represents a category of the non-licensed actors that undertake two value chain activities namely; harvesting trees for fuelwood, hiring transporters, and selling it (bulk and small quantities) directly to consumers. The second informal chain (Figure 2B-III) was occupied by non-licensed actors that carried out three value chain activities including fuelwood harvesting, hauling it using personal means of transportation (e.g. wheelbarrow), and selling it to the retailers. The third group of non-licensed actors (Figure 2B-IV) also engaged in three value chain activities: fuelwood harvesting, hauling it using traditional means of transportation (e.g. ox-cow and camel), and selling it in small or large quantities to both retailers and consumers.

Based on our interviews, all non-licensed actors (100%) were not affiliated with any association or trade union, and therefore their activities related to fuelwood harvest and trade were hard to control. For example, intrusion of protected forests and other lands for fuelwood harvest and unregulated fuelwood price that cause unequal distribution of profits across the supply chain (Puentes-Rodriguez et al., 2017; Guild & Shackleton, 2018). Furthermore, the weak enforcement of forest legislation, and forest governance in Nigeria need to be improved (Sambe et al., 2020) to effectively control and regulate non-licensed actors' activities.

Roles of fuelwood value chain actors Table 2 shows the list of the group of actors involved in different commercial fuelwood activities along the fuelwood supply chain. These groups consist of primary and supporting actors. The primary actors comprised of harvesters, transporters, wholesalers, retailers, and non-licensed actors. The supporting actors were only found in the formal supply chain and were responsible for providing special services to the primary actors. For instance, the transport aides provided support services to a trucker. The merchant assistants, on the other hand, provided support services to the wholesalers by sorting and assembling logs according to tree species types. The woodchoppers and porterage service providers at the retail node performed value-added services (e.g. chopping of logs, splitting of logs, bundling of cleaved fuelwood), and conveyed fuelwood purchased by customers using wheelbarrow and rickshaw (Table 2). The wide range of actors from primary activities to support activities across the supply chain, and the relationship between actors in the formal supply chain suggest that fuelwood business activities provide various employment opportunities, income sources, and livelihood and there was evidence of practicing cooperative contract system as noted in the previous study (Openshaw, 2011; Naibbi, 2015).

Fuelwood harvesting Fuelwood harvesting in the formal chain was observed to be a large-scale activity carried out mostly by men (harvesters). However, uses of traditional harvesting tools such as ax and diggers to harvest tress, cut the

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logs into desirable length and dig the stumps were apparent. Lack of modern machinery used such as chainsaws among harvesters observed in this study indicates low harvesting efficiency with subsequent low economic gains (Puentes-Rodriguez et al., 2017). Major reason why harvesters still rely on traditional tools as mentioned by respondents was due to poverty.

As can be seen in Table 3, methods of fuelwood extraction vary and depend on the harvesters' skills and physical ability since some of the methods were much more difficult than the others. For example, stump lifting requires both skills and physical ability to dig the soil and remove the whole-tree stump manually. This stump lifting method was commonly mentioned by licensed actors (67%). Other methods commonly employed by the licensed actors include coppicing (33%), selective felling and salvage operation (33%). Based on our interview of six non-licensed actors, the common methods employed were the collection of scrap wood (67%) and pruning activities (83%) (Table 3).

Table 2 List of primary and supporting actors across fuelwood supply chain

Actor	Formal supply chain	Roles	Informal supply chain	Roles
Primary actors	Harvesters	Harvesting fuelwood from source	Non-licensed actors	Multiple value chain activities
	Transporters	Hauling fuelwood from source to market	NA	NA
	Wholesalers	Bulk fuelwood sales	NA	NA
	Retailers	Petty fuelwood trading	NA	NA
Supporting actors	Transportation aides	Provide support services at the transport node (e.g. Driving, tire replacement)	NA	NA
	Merchant assistants	Provide support services at the wholesale node (e.g. Sorting and assembling of logs into stere)	NA	NA
	Wood-chopping and wood splitting service providers	Provide support services at the retail node by chopping and cleaving of logs and stumps	NA	NA
	Firewood bundling service providers	Provide support services at the retail node by bundling of cleaved logs	NA	NA
	Porterage service providers (wheelbarrow posters, rickshaw riders)	Provide support services by hauling fuelwood procured by consumers from retailers	NA	NA

Note: NA = not applicable

Table 3 Methods employed in harvesting (extraction) of fuelwood in Yobe

Methods of fuelwood extraction employed	Harvester n = 6 (%)	Non-licensed actors n = 6 (%)
Coppicing	33	NA
Scrap wood collection from stump	NA	67
Stump lifting (Whole stump)	67	NA
Pruning (branch and twigs removal)	NA	83
Selective felling (whole-tree marking and felling)	33	NA
Salvage	33	NA

Note: NA = not applicable; n = number of interviewees

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Based on our observation, regardless of formality status, harvesters have lack knowledge in sustainable harvest practices whereby trees were felled or pruned excessively for fuelwood. The unsustainable harvest practices of fuelwood in Nigeria have been cited to affect the future growth and composition of the forest (Naibbi, 2015) and linked to vegetation loss (Jenkwe & Iyeh, 2020). Although guidelines on fuelwood harvest are in place (FGN, 2014), the observed non-adherence by the actors to the regulation may be attributed to low knowledge and awareness among harvesters about sustainable harvest practices, lack of effective monitoring, and corruption by forestry officials.

Furthermore, the simultaneous transportation and selling of fuelwood by the non-license actors as opposed to the existing clear cut division of labor among the license actors in the formal supply chain indicates the absence of cooperation between the license actors (e.g. harvesters, transporters, wholesalers, retailers) and the non-license actors.

Fuelwood transportation Fuelwood transportation is the process of moving goods (i.e. fuelwood) from the source (forest) to formal market or residential areas. Based on our observation, men dominated the transportation activities across all supply chains. There were few actors involved in large-scale fuelwood transportation using heavy-duty trucks in the study area. Most of the heavy-duty transportation was owned by large fuelwood businesses or wholesalers. As mentioned by the licensed actors during the interview, the heavy-duty truck is expensive, and due to poverty and lack of access to an affordable financing rate for hire-purchase, the licensed actors find it difficult to own new and fairly used trucks. While at the informal chain, the same challenges of expensive truck had forced the use of available and cheaper means of transportation owned and operate by themselves including home-made means of transportation such as wheelbarrow and rickshaw (tricycle). Moreover, the transport-related cost is often costly and can vary greatly depending on the price of petroleum, the hauling distance of fuelwood to fuelwood market, as well as the frequency of service, maintenance, and spare parts needed especially for an old vehicle (Tan, 2011; Ojo et al., 2012). Thus, various means of fuelwood transportation were used in both formal and informal fuelwood supply chains in the study area. In the formal chain, there were independent licensed fuelwood transporters, hired by harvesters to transport fuelwood using small lorries and pick-up trucks. For the non-licensed actors, various types of transportation were used including pick-up trucks, rickshaws (tricycle), wheelbarrows, and in some areas, the fuelwood was carried as headload (hand carry). Other non-licensed actors also used traditional means of transportation such as carts pulled by animals (e.g. camel or ox).

Regardless of the method of transportation used (personal or hired), the non-licensed actors were not formally allowed to convey fuelwood into a formal fuelwood market in the study area since their activities are considered illegal. Therefore, the non-licensed actors have no access rights to trade fuelwood in the formal fuelwood market. This situation may cause urban traders in the formal market to reap more profits at the expense of the unlicensed producers in the rural areas (Puentes-Rodriguez et al., 2017).

Fuelwood trading Fuelwood trading is an act of selling fuelwood in bulk and small quantities in different market locations. In the study area, two types of sales locations were identified which include a formally designated fuelwood market, and informal off-market sales locations (depot, roadsides, and residential areas). This finding was in contrast with the situation in Enugu State (Adeyemi & Ibe, 2014) and Uyo city of Akwa Ibom State (Nelson et al., 2017) where all of the actors in their study traded their fuelwood in the fuelwood market since most of the traders did not belong to any association and hence were not regulated.

In this study, the formal market was patronized by licensed actors while the unlicensed actors sell their fuelwood through hawking methods at various locations such as roadside and residential areas using various modes of transportation such as the wheelbarrow, pickup truck, and animal cart (ox and camel). The licensed actors in the formal market, on the other hand, were much more organized and regulated. The fuelwood was traded either in large (wholesale) or small quantities (retail) by wholesalers and retailers, respectively. The wholesalers sold the fuelwood to retailers in the same form as supplied by the harvester. The retailers add value by chopping long and large logs and stumps and selling them as a measurable stere. Some of the chopped logs and stump were split (cleave) and sold as stere of cleaved fuelwood. The cleaved fuelwood was also bundled depending on the quantity demanded by consumers and even delivered directly to consumers' houses, similar to the situation in South Africa (Guild & Shackleton, 2018).

In the study area, fuelwood trade in the formal market follows the established official fuelwood rate or price based on quantity measures (i.e. truck, stere, and bundles) which is regulated or controlled by a registered trade union (fuelwood business association). The fuelwood price, however, can fluctuate due to seasonality. In the informal supply chain, the price of fuelwood sold by unlicensed actors in the market was not regulated and did not follow the official rates set by the trade association. The prices of fuelwood were typically fixed arbitrarily by the individual non-licensed actor. Interestingly, fuelwood business transactions by licensed actors in Yobe involved trade-credit transactions, a situation where wholesalers were supplied with fuelwood by harvesters with payment made after-sales. This suggests a positive working relationship among licensed value chain actors and has proven that the organization of actors does not only promote access to benefits from the government and other stakeholders but also promotes understanding among members of the organized group that led to supporting one another. Therefore, the government, financial institutions, and pro-environmental should exploit such opportunity of the presence of trade union to help in coordination and organizing all actors toward the equal distribution of profit.

Based on the finding of this study, non-formal traders were not allowed to trade in the formal market and thus need to adopt other means of trading or marketing strategies (off-market selling). Since there are various benefits of participating in the formal chain (i.e. access right to formal markets and ownership of market stall, fuelwood price

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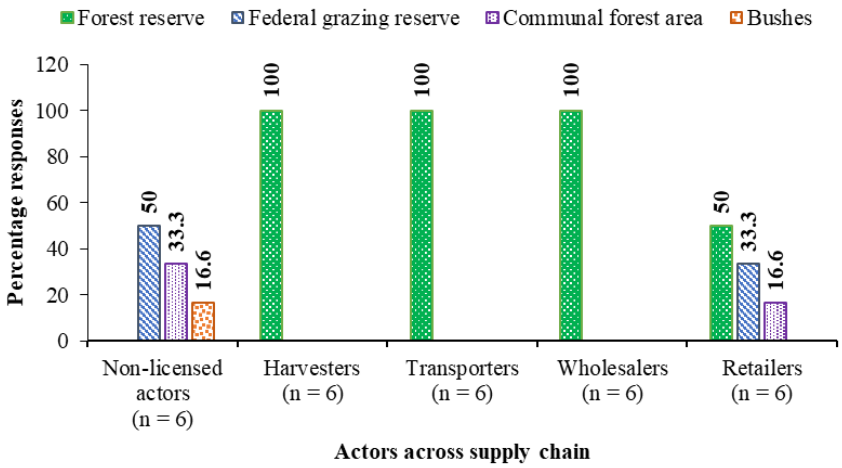

Figure 3 Sources of commercial fuelwood in Yobe.

stability, opportunities to receive fuelwood in the form of short term credit), non-licensed actors should be encouraged to participate in the formal supply chain through a more flexible license application system such as decentralizing the license application system to ward/village level and involving traditional authority (local leaders) such as village heads in the license issuance. The government and other stakeholders should, therefore, collaborate and communicate with all actors regardless of formality status to encourage participation in the formal supply chain.

Fuelwood supply sources Based on our interview with the supply chain actors, the majority of non-licensed actors (50%) sourced their fuelwood from federal grazing reserve (FGR), followed by communal forest area (CFA) (33%), and bushes (16.6%) (Figure 3). For licensed actors, all harvesters, transporters, and sellers mentioned that their fuelwood supply was sourced from forest reserves. The retailers, on the other hand, said that the fuelwood was obtained directly from forest reserve (50%), FGR (33%), and lastly CFA (17%). None of the actors mentioned fuelwood plantation or agroforestry as practiced in other African countries such as Burkina-Faso (Tanyi et al., 2018) and Kenya (Jepng'etich, 2020). Considering heavy reliance on natural forests for fuelwood production in the study area and given the high demand for fuelwood from consumers due to increase population and petroleum subsidy withdrawal, this situation should be taken seriously by all stakeholders (Nelson et al., 2017). It is important to note that heavy reliance on natural forests for fuelwood production will add more pressure on the forests and consequently contribute to the degradation of the forest or even deforestation (Onoja & Emodi, 2012; Audu, 2013). Therefore, a policy on sustainable fuelwood management such as farm-based fuelwood plantation and the designing of relevant program to support the implementation of the policy can reduce the dependency on the natural forest for commercial fuelwood.

Conclusion

This study uncovers the current structure and characteristics of the fuelwood supply chain in Nigeria using Yobe State as a case study. The study found that despite observed economic and employment opportunities and their potential in improving the livelihood of local communities, informal or unregulated fuelwood business activities are still prevalent in the study area which creates an unequal distribution of benefits across the supply chain. Measures such as an efficient licensing system, education, and collaboration with all stakeholders within the fuelwood supply chain should be considered in addressing this informality and unequal distribution of benefits issue across the supply chain. Furthermore, the reliance on natural forests by supply chain actors without significant intervention will cause enormous pressure on the forest resources and ecosystem. Policy and strategy that focus on large-scale fuelwood plantation management or agroforestry practices should be given greater emphasis to ensure sustainable production of fuelwood and consequently can help to protect the environment. Certainly, there are many other challenges and sustainability issues faced by the actors that need to be fully assessed and addressed. While this study only focuses on the supply chain characteristics, a thorough investigation using a value chain analysis approach can be conducted covering various sustainability issues at a larger scale.

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