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Fuelwood Value Chain in Northern Nigeria: Economic, Environment, and Social Sustainability Concerns

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Abstract: The increased fuelwood demand and commercialization activities in Nigeria over the years have incurred various sustainability issues and concerns along the fuelwood value chain. This study employed value chain analysis to examine the sustainability of the fuelwood value chain in Yobe, Nigeria, in relation to economic, environmental, and social aspects. From the analysis, it was found that fuelwood business activities were conducted by registered licensed actors (formally) and informally by non-licensed actors who do not register with the government agency that controls forest-related activities. Profit was not equally distributed along the value chain, whereby 65% of the total profits were reaped by the transporters. Natural forests were the main source of fuelwood, with 18 tree species being preferred and commonly traded by both formal and informal chain actors. Women's participation in the formal fuelwood value chain was limited and mainly concentrated in the informal chain. The findings of this study can inform policymakers to enhance the sustainability of fuelwood production and trade along the value chain, especially in terms of profit sharing, exploitation of forest resources, and gender equality.

Keywords: fuelwood; gender equality; profit equality; sustainability; value chain

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1. Introduction

Fuelwood or firewood is an important energy source in Nigeria, accounting for about 60% of its total energy consumption [1]. In Nigeria, fuelwood is not only commonly used by rural and urban households for cooking and heating purposes but is also widely utilized in the cottage and small-scale industries (e.g., bakeries, tea shops, fish smoking, cassava processing, and palm oil processing industries) as well as in public institutions such as correctional centres, hospitals, and secondary boarding schools [2,3]. This widespread consumption of fuelwood is attributed to various factors, including poverty, inadequate infrastructure (i.e., poor road network), inefficient cooking methods, and the absence of good political will and governance [1,4]. With population growth exceeding 400 million people in 2050, fuelwood consumption is expected to increase and worsen in the future [5].

In 2020, forests in Nigeria accounted for less than 8% of the total 923,763 km^2 of land area (about 21.63 million hectares) and growing stock of 2166.16 million m3 [6]. The total forest land area includes more than 1000 Gazetted Reserves, seven (7) National Parks, 32 Game Reserves, and one (1) Strict Natural Reserve, which is spread out throughout

the five primary biological zones of freshwater/mangrove, lowland rainforest, derived savannah, Sudan, and Sahel savannah [6]. Under the National Forest Policy of 2006, the state is responsible for managing the state forest reserves, reserves owned by indigenous authorities, and community forest areas. However, the local government has the autonomy to collect forest revenues, including fuelwood harvest. The Nigerian forest supports the production of various forest products, including sawn wood, panel products, furniture, fuelwood, and non-wood forest products (e.g., fruits, bark, honey, medicinal plants, etc.). Nonetheless, the country's largest user of wood is the fuelwood sector, accounting for about 87% of total wood removals in 2015 [7]. Between 1990 and 2019, fuelwood production in Nigeria grew by 23% from 50.92 million m^3 in 1990–66.21 million m^3 in 2019 [8]. The increased production of fuelwood and other activities, including logging activities, urbanization, and agricultural extension, has caused the depletion of Nigerian forest resources. Deforestation in Nigeria is estimated at a rate of 3.5% per annum (about 350,000 ha to 400,000 ha) [9].

The use of fuelwood is substantially higher in the northern states of Nigeria than in the southern states, mostly because there is a lack of modern cooking fuel in the north due to the scarcity of fossil fuel [10]. In Yobe, a rural state in Northern Nigeria, about 80% of households rely on fuelwood as a source of energy, especially for cooking [11]. Fuelwood is not only used for self-consumption, but it also provides local communities with an income and livelihood. Due to the range of activities and job possibilities it generates, the current position of fuelwood extraction in Yobe has shifted from livelihood to commercial activity [12]. The forest reserve in Yobe covers an area of 386,710 ha [11]. Around 90% of the state's total fuelwood supply has been reported to come from natural forests [13]. From 2001 to 2020, Yobe lost about 95.1% of its tree cover [14]. Deforestation and plant loss have been linked to fuelwood collecting, overgrazing, and agricultural land removal [13,15]. Yobe, like other northern states, is situated in the savannah region, and due to unsustainable human activity, certain areas of the land are undergoing the process of desertification [16,17].

The high consumption of fuelwood has caused worrying concerns, especially in terms of its sustainability along the value chain, starting from harvesting, transporting, and selling activities by wholesalers and traders (retailers) in the market, and finally, the never-ending demands from end-users, such as households or businesses [18]. Certainly, issues surrounding fuelwood sustainability are occurring not only in Nigeria but also in other countries in Sub-Saharan Africa (SSA), where fuelwood remains the primary energy [18]. Accordingly, a multitude of sustainability issues has been reported in previous studies, which include prices that are often not regulated or controlled hence causing some actors to reap more profits than others, inequality of gender participation, inefficient control of the value chain activities, disproportionate work burden, poor tenure or access rights, non-implementation of large-scale woodlot/plantation for preferred wood tree species, involvement of a large number of low-income actors in small scale production, illegal trade, the low market value of wood, high costs of transportation and multiple regulatory bodies [18–20]. Similarly, excessive exploitation of forest resources for fuelwood is very apparent in these countries, which has caused deforestation and degradation of their forests [18,21,22].

A sustainable fuelwood value chain via effective sustainable fuelwood management can play an important role in the nation's socioeconomic development such as the alleviation of poverty, the promotion of gender equality (empowerment of women), and the reduction of deforestation and degradation of the forests [3,23,24]. In this context, the economic, environmental, and social aspects of the fuelwood value chain need to be examined to help policymakers and practitioners to better understand the issue and target specific interventions that can help to protect and conserve the forest resources in order to meet its current and future generation's needs. Value chain analysis has been used in previous studies to understand the activities and addressed sustainability issues along the value chain of various commodities and products such as coffee [25], medicinal plants [26], mushrooms [27], charcoal [28], and dairy products [29]. For the fuelwood sector, Schure et al. [18]

utilized the value chain analysis and identified key issues that affected the sustainable utilization of fuelwood in the SSA countries. In Burkina Faso, Puentes-Rodriguez et al. [19] applied the value chain analysis to address sustainability issues, including economic (quantities and prices), social (educational level of actors), and environmental (the preference and use of tree species for fuelwood) aspects. Unfortunately, limited research has been performed in Nigeria to analyze the fuelwood value chain that addresses the sustainability issues employing the value chain analysis framework. The available literature on fuelwood often focused on aspects of sustainable development at specific value chain activities [30]. Hence, this study aims to analyze the sustainability of the fuelwood value chain in Yobe, a rural Northern Nigerian state. It focuses especially on three pillars of sustainability, namely, economy, environment, and social, as mentioned in the Brundtland report in 1987 [31]. These three principles serve as the foundation for sustainable development and can only be achieved when environmental protection, economic growth, and social inclusion function as a whole.

For the economic aspect, the equal distribution of profit along the fuelwood value chain was assessed to understand whether the distribution of economic benefit is inclusive along the value chain [23]. As stressed by Agyei et al. [28], information on profit distribution is an important sustainability aspect to improve the equity and well-being of the chain actors. In this respect, the distribution of profit along the fuelwood value chain in this study was assessed to determine whether the economic growth is inclusive and benefits distributed fairly across society [23,32]. For environmental sustainability, the potential damage of the value chain activities to resource depletion can be used as an indicator [23]. While forest resource depletion assessment typically entailed data from forest inventory and spatial analysis, according to Puentes-Rodriguez et al. [19], potential resource depletion can be assessed using views or knowledge of the local community. Thus, following Rodriguez et al. [19], the most preferred species by chain actors was assessed as an indication of potential damage to natural resources. In addition, the source of fuelwood and chain actor's view on scarce tree species were included in the analysis. The social sustainability aspect, on the other hand, was assessed based on gender equality along the value chain. Gender equality is one of the core concerns outlined under sustainable development goal number 5: to achieve equality between men and women and empower women and girls [24]. Faster economic growth is experienced in societies where there is greater gender equality, and encouraging women to engage in certain professions will lead to a more inclusive economy [24]. Ihalainen [33] asserts that addressing gender equality is necessary to increase the efficacy and sustainability of a particular value chain. In Nigeria, gender equality has been a great issue of concern, whereby women continue to suffer injustices and marginalization [34]. Thus, to better enable women to participate in the fuelwood value chain, the factors affecting women's participation in different levels of the fuelwood value chain were also assessed through stakeholders' engagement to empower women.

This study specifically employs the value chain analysis framework devised by Sepp [35], who outlined four basic steps, i.e., value chain mapping, quantification, economic analysis, and in-depth analysis of the environmental and social issues.

2. Methodology

2.1. Study Area

This study was carried out in three local government areas in Yobe state located in North-Eastern Nigeria, namely (a)-Bade, (b)-Potiskum, and (c)-Damaturu (Figure 1A). Yobe lies within the Sahel savannah, where the vegetation there is made up of thorny, open, and short trees between 5 m and 10 m in height. Rainfall across the state is variable, with about 700 mm recorded as the average annual rainfall in the Southern parts of Yobe, while in the Northern parts, it is as low as 275 mm. Low rainfalls in the Northern parts of the state occur especially during the four months of the year [36]. The mean annual temperature is 34 °C, ranging between 39 °C and 42 °C [13,37]. Yobe has a total land area of 4.67 million ha or 46,609.0 km^2 and a population of 3,294,137 as of 2016 [38,39]. The main livelihood of the

population is farming, livestock rearing, and fishing [40]. Alarmingly, the Human Poverty Index (HPI) in Yobe is very high, i.e., 76.3% and the unemployment rate has reached 26.2% [38]. The literacy level of the adult population in Yobe is only about 39.6% [38].

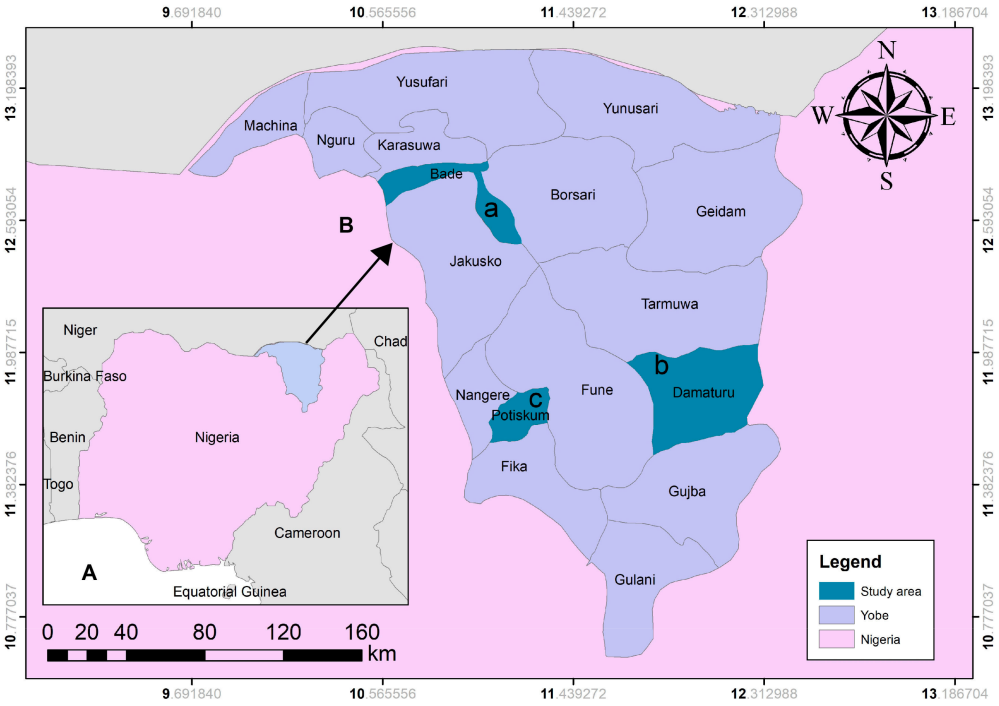

Figure 1. (A) Map of Nigeria showing Yobe State; (B) Yobe State showing the location of study areas (a) Bade, (b) Potiskum, and (c) Damaturu.

The selection of the three study areas (indicated as (a)-Bade, (b)-Potiskum, and (c)-Damaturu) in Figure 1 within Yobe of Nigeria is based on the population's reliance on nature such as commercialization of fuelwood and other forest products in addition to agricultural activities [39]. Among the three selected areas, Potiskum is the most popular local government council in terms of its fuelwood collection, transportation, and marketing activities. This is evidenced by the presence of four popular fuelwood markets there, namely, *Kampala, NPN-Kuwait, Nahuta*, and *Tashan-Aduwa* [37]. In Bade, the second study area, there is only one formal fuelwood market called *Zangon ice*. However, there are several other illegal fuelwood depots in operation, usually by the roadside. In Damaturu, there are also several roadside fuelwood depots, but there is no formal fuelwood market [36,37]. Overall, there are twelve (12) natural forests used as sources of commercial fuelwood across the three study areas, with five (5) located in Damaturu (i.e., Damaturu Forest Reserve, Dusuwa Forest Reserve, Gundulwa Forest Reserve, Galamo Forest, Kalalawa Forest Reserve), four (4) located in Postikum (Burai Forest Reserve, Maale Federal Grazing Reserve, Zayi-Chana Federal Grazing Reserve, Babale Communal Forest Area), and three (3) located in Bade (i.e., Damaturu Reserve, Bam-Bautukum Communal Forest Area, and Kukuri Communal Forest Area [36]). Yobe is mainly savannah, and the vegetation is characterized by shrubs, trees, and grasses. A total of 4889 trees and shrubs inhibited Yobe with predominant species of *Calatropis procera* (sodom apple), *Acacia nilotica* (Thorn Acacia), *Guiera senegalensis* (Guiera), *Hyphaene thebaica* (Doum palm), *Combretum glutinosum* (Combretum), *Balanites aegyptiaca* (Desert date), and *Acacia seyel* (Whistling thorn) [11]. Most of the tree species belong to the family *Fabacae* with poor representation of other families [11].

2.2. Data Collection

Data for this study were collected in the following two stages: a preliminary study and the main study. The preliminary study was conducted to create a value chain chart for the study area, which considers the various value chain stages, nature of business (formal or informal), roles of chain actors, and their source to obtain fuelwood. Observation and unstructured interviews with 30 value chain actors, six for each group of fuelwood value chain actors (i.e., harvesters (6), transporters (6), wholesalers (6), retailers (6), and roadside non-licensed traders (6)) were conducted between June and September 2018. Opportunistic sampling was used to select the respondents.

For the second stage (i.e., the main study), we employed the mixed methods approach whereby data were collected using a face-to-face questionnaire survey, focus group discussion (FGD), and field observation. The main study was conducted between July and October 2019. Both quantitative and qualitative data were collected through the use of two different methods, namely, face-to-face interviews using survey questionnaires and a focus group discussion (FGD).

For the questionnaire surveys, value chain information was collected from fuelwood harvesters, transporters, retailers, wholesalers, and non-licensed actors. The questionnaires contained both open-ended and close-ended questions that sought information on the following: (i) socio-demographic characteristics of the respondents, (ii) cost and sales information, (iii) preferred fuelwood tree species, (iv) scarcely tree species for fuelwood, (v) average monthly quantity of fuelwood handled, (vi) means of transporting fuelwood, (vii), method of sales of fuelwood and (viii) forms of fuelwood handled (e.g., logs, stumps cleaved, twigs, and scrap wood). The questionnaires were developed based on adapted questions from the previous study [40], with some added information gathered during the preliminary study carried out in 2018. The draft of the questionnaires was first sent to three experts for content validation. Then, a pilot study was conducted to test the questionnaire to check for the clarity and sensitivity of the questions. After the pilot study, ambiguous words, phrases, and statements were removed and amended. In addition, the questionnaire was reviewed and endorsed by the Universiti Putra Malaysia's Research Ethics Committee in terms of ethical standards. The questionnaires used in this study are provided in the supplementary materials of this article.

A purposive sampling strategy was used to select the respondents that represent each of the value chain activities in the study area. With the lack of a reliable official registry of people involved in the fuelwood business in Yobe, the nature of the questionnaires that contain qualitative questions (open-ended), and the sensitivity of the fuelwood business, a total of 30 respondents for each value chain activity were selected opportunistically at their operation base [12,41].

The selection of the operation base or study location within the three study areas was based on information from the preliminary studies. Although there are 12 forests located within the three study areas, information from the preliminary study revealed that Burai forest is the only forest reserve where licensed harvesters are legally permitted by the government (the regulating body) to harvest fuelwood. Therefore, in this study, Burai was chosen as the study location to collect data from licensed harvesters. It is important to note that non-licensed actors are not allowed to harvest/collect fuelwood in the forest reserve. Thus, the non-licensed actors usually source their fuelwood from federal grazing reserves (FGR) and communal forest areas (CFA) such as in Zayi, Gada, and Maale. Licensed transporters mostly convey the fuelwood of licensed actors from the Burai forest reserve to different formal fuelwood markets, namely, Kampala, NPN-Kuwait market, Tashan-Aduwa, and Nahuta. Although the study employs purposive and opportunistic sampling, attempts were made to choose samples equally throughout the study location, except for the Burai forest. Respondents were selected based on their availability and willingness to participate during the visit at their operational base.

The distribution of sampled respondents within the study areas is shown in Table 1. They comprised licensed harvesters (n = 30), which were mainly from the Burai forest. For

non-licensed actors, the location of respondents was from grazing reserves and communal forest areas, including Zayi (n = 15), Gada (n = 5), and Maale (10). The sample size for licensed transporters, wholesalers, and retailers within Kampala, NPN-Kuwait market, Tashan-Aduwa, and Nahuta was as shown in Table 1.

Table 1. Sampled respondents by location of the value chain activities.

Study Area	Location	Non-Licensed Actors	Licensed Actors			
			Harvester	Transporter	Wholesaler	Retailer
B	Burai forest	Na	30	Na	Na	Na
B	Zayi-Chana federal grazing reserve,	15	Na	Na	Na	Na
A	Gada Forest (Gada village)	5	Na	Na	Na	Na
B	Maale forest	10	Na	Na	Na	Na
B	Kampala market	Na	Na	8	8	8
B	NPN-Kuwait market	Na	Na	8	8	8
B	Tashan Aduwa (Yindiski) market	Na	Na	7	7	7
C	Nahuta market	Na	Na	7	7	7
	Total	30	30	30	30	30

Note (A) Bade, (B) Potiskum, and (C) Damaturu.

Table 2 describes the sample where the licensed actors (harvesters, transporters, wholesalers, and retailers) constitute about 80% of the respondents, while the non-licensed actors make up only 20%. Most of the licensed actors (97%) were male, and only 3% were female respondents. Of the 30 non-licensed actors interviewed, 93% were females, and only 7% were males. In terms of the relationship between gender and value chain activities, harvesting, and transportation activities were 100% dominated by males. Even though the wholesale and retail activities were carried out by both genders; nevertheless, 90% were male wholesalers and 80% were male retailers. On the other hand, in the informal supply chain, 93% of the women carried out more than one value chain activity. Regarding the respondents' age distribution, the youngest group was the non-licensed actors, with an average age of 22 years old. The ages of licensed actors (harvesters, transporters, wholesalers, and retailers) were between 45 and 56 years old. The average working experience of the licensed male actors was 16 years, and for females, it was five (5) years. All respondents were self-employed.

Table 2. Respondents' profile.

Categories of Actors	Location of Value Chain Activities	Actors' Formal Status (%)		Gender (%)		Mean of Age (Years)		Mean Working Experience (Years)	
		Yes	No	Men	Women	Men	Women	Men	Women
Non-licensed actors (n = 30)	GR, CFA, BZ, RSS, ID, RAS	0	100	7	93	45	22	2	1
Harvesters (n = 30)	FR and FM	100	0	100	0	45	nil	18	nil
Transporters (n = 30)	FM	100	0	100	0	56	nil	12	nil
Wholesalers (n = 30)	FM	100	0	90	10	50	53	17	5
Retailers (n = 30)	FR and RAS	100	0	80	20	50	45	17	5

n: number of respondents in each value chain activities; GR: grazing reserve; CFA: communal forest area; BZ: buffer zone; RSS: roadside sales; ID: illegal depot; RAS: residential area sales; FR: forest reserve; FM: fuelwood market.

A focus group discussion (FGD) was organized to discuss the participation of women in the formal fuelwood value chain. A total of 11 participants comprising representatives from the regulatory/licensing authority (Zonal forestry and wildlife service division)

from the formal fuelwood markets, namely, Kampala market, NPN market, Tasha-Aduwa market, Zangon Icce, and Nahuta market, and the non-licensed actors attended the FGD. Out of the 11 participants of the FGD, 5 were women, and 6 were men. The FGD was held on 7 August 2019 at the conference hall of a guest house owned by the Federal College of Education (Technical) Potiskum, Yobe, Nigeria. During the FGD, responses from different gender were duly sought. Participants were allowed to brainstorm before reaching a consensus on the agreed themes/questions.

2.3. Fuelwood Value Chain Analysis

We employed the fuelwood value chain analysis framework from Sepp [35], which recommends four basic steps of analysis. The steps involved were as follows: (i) reconstructing the value chain (mapping the value chain), (ii) quantifying the value chain (measuring the volume of fuelwood handled by the value chain actors), and estimating the costs and income received as revenue from sales of the fuelwood supply chain, (iii) analyzing the profit and profit margin, and finally, (iv) conducting an in-depth analysis of the critical issues affecting the environment and the social aspects.

3. Data Analysis

3.1. Economic Sustainability Aspect

We used the equal distribution of profit along the fuelwood value chain as an indicator to assess whether the distribution of benefit along the fuelwood value chain is inclusive [23]. The profitability analysis was used to analyze profits (gross and net) and the profit margin of the value chain as devised by Shively [42]. The Gross Profit (P) received by each value chain actor is calculated as the total monthly revenue for each actor (R) minus the actor's total variable costs (C) reported for the same month, which is calculated using the following Equation (1):

$$P = R - C \quad (1)$$

where P is the profit, R is the revenue, and C is the variable cost.

Variable costs refer to the costs incurred on goods or services whose prices are not constant but fluctuate with the quantity of fuelwood produced, the volume of hauled fuelwood, the frequency of trips, and the frequency of sales. Variable costs incurred in the fuelwood value chain include the cost of fuelwood, taxes, cost of transportation, wage payable to transport aides, and special service providers such as wood sorters, wood pyramid development service providers, bundling service providers, chopping, and cleaving service providers, cost of bundling wire, cost of diesel, cost of maintenance of the truck, and illegal charges incurred by the value chain actors.

Net profit (NP) was calculated using Equation (2) which is defined by Datar and Dajan [43] as the differences between monthly total revenue/sales (TR) and total cost (TC),

$$NP = TR - TC \quad (2)$$

where NP is the net profit, TR is the total revenue, and TC is the total cost.

The total cost (TC) is defined as the sum of the total fixed costs (TFC) and total variable costs (TVC) [43], as shown in Equation (3).

$$TC = TFC - TVC \quad (3)$$

Fixed costs refer to all expenses incurred on materials or services whose price does not fluctuate with changes in the volume of production of fuelwood, transportation, or sales of fuelwood, e.g., rent, license fees, permit fees, vehicle lease, and maintenance.

Profit margin (PM) was calculated using Equation (4) [43].

$$Profit\ Margin\ (PM) = \frac{R - C}{R} \times 100 \quad (4)$$

It is to be noted that all monetary information presented in this study was obtained in Nigeria's currency (Naira), symbolized by ₦, and was converted to USD ($) at a conversion rate of 1.0 USD = 365 Naira. This is based on the average exchange rate at the time of data collection (2019).

3.2. Environmental Sustainability Aspect

For environmental sustainability concerns, the analysis focused on several aspects related to natural resource conservation. First is based on the current sources of fuelwood supply by the value chain actors to indicate whether fuelwood sourcing depends primarily on the natural forest, which can affect the sustainability of the natural resources given the apparent problems on the unavailability of energy alternatives, high reliance on fuelwood, and population increase in Nigeria and other African countries [8,15]. This analysis was based on qualitative data findings from the first stage of data collection to develop the value chain chart. The second aspect used to assess environmental sustainability was based on the preference of tree species by the value chain actors. As mentioned by Puentes-Rodriguez et al. [19], potential resource depletion can be assessed using views or knowledge of the local community. Besides species preference, we also asked the respondents to mention species that they thought as scarcely available. Data on species preference and views on scarcely available tree species were collected during the questionnaire survey. The triangulation method was used to analyze the data.

3.3. Social Sustainability Aspect

The social sustainability aspect was addressed based on gender equality as outlined under sustainable development goal 5, which is to achieve gender equality and women empowerment [24]. Data on gender equality were based on the profile of respondents collected during the questionnaire survey. In addition, given the fact that gender equality is a great issue of concern in Nigeria [44], a focus group discussion was conducted to identify the factors affecting women's participation in the fuelwood value chain to understand the underlying factors that can prevent women empowerment initiatives. Qualitative data from the FGD were thematically analyzed using the ATLAS.ti 8 software version 12, following the method performed by Jalam et al. [44]. In general, the steps used in the thematic analysis include (1) transcription (typing the data into a textual format in a Microsoft document); (2) data importation (sending the word document file to ATLAS.ti [8] software); (3) coding (iterative coding process to determine themes using constant comparative method of grounded theory), (4) theme development (organization of related identified codes to develop specific sub-themes), and (5) networking, (presenting the sub-themes in a manner that addressed the research question or main theme (e.g., factors affecting women's participation).

4. Results

4.1. Structure of the Fuelwood Value Chain

Data collected during the preliminary survey were used to build the structure of the fuelwood value chain in Yobe. This encompasses matters such as sources of fuelwood, the number of the process along the value chain activities, the type of actors, and their roles, as shown in Figure 2. The fuelwood value chain activities begin with harvest, followed by transport, then wholesale, and lastly, retail (Figure 2A). Two (2) market channels were identified, namely, the formal and the informal supply chains (Figure 2B). In the formal chain (Figure 2B-i), the flow of activities followed the generic fuelwood value chain activities or functions and is made up of harvesters, transporters, wholesalers, and retailers who have been licensed, obtained permits to operate, and registered with the fuelwood association. The source of fuelwood was mainly from the forest reserves, and the wholesaler and retailer traded in the formally recognized fuelwood marketplace.

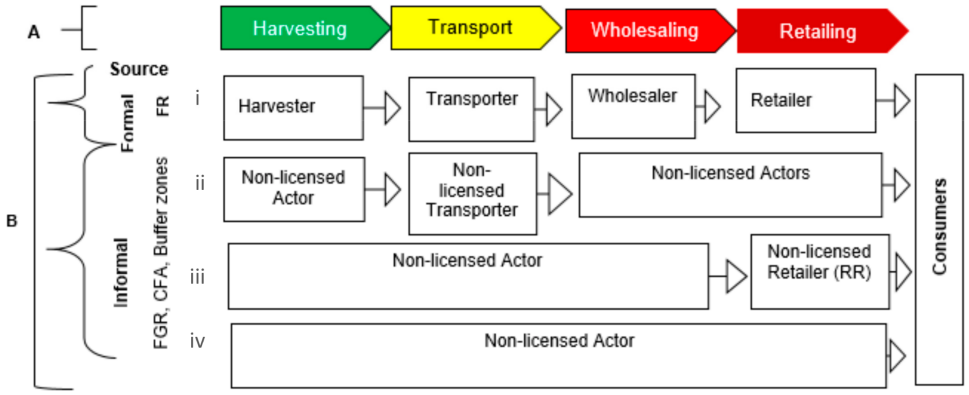

Figure 2. Fuelwood value chain chart in Yobe; (A): fuelwood generic components; (B) (i): formal supply chain; (B) (ii–iv): informal supply chain. Note: FR: forest reserve; FGR: federal grazing reserves; CFA: communal forest area; RR: residential retailers.

The informal chain has three sub-chains (Figure 2B-ii–iv), whereby each of the sub-chains is manned by a group of non-licensed actors that participate in more than one value chain function (vertical integration). All informal actors (non-licensed actors) carry out their fuelwood harvesting activities in communal forest areas, federal grazing reserves, or buffer zones (homestead forests, farmlands, and degraded forests). However, these areas are not recognized formally as sources of commercial fuelwood but are more intended for conservation, grazing, and collection of non-timber forest products and small-scale fuelwood for household cooking only.

In the first informal sub-chain (Figure 2B-ii), the non-licensed actors harvest the fuelwood, hire illegal truckers to haul their harvested fuelwood to towns and then sell them to end consumers such as household and restaurant owners either in bulk or in small quantities. The second sub-chain (Figure 2B-iii) is also manned by a group of non-licensed actors. They harvest their fuelwood, usually in the forms of twigs or cleaved wood, and transport those using personal trucks or non-motorized carriers such as wheelbarrows to urban areas. They are normally sold directly to residential retailers (non-licensed retailers). In the third informal sub-chain (Figure 2B-iv), the non-licensed actors harvest their fuelwood and transport them using personal trucks and traditional means of transport such as oxcarts to town. Generally, sales of fuelwood at the informal sub-chains are carried out along the streets of residential areas.

4.2. Economic Aspects of the Fuelwood Value Chain

4.2.1. Quantity, Cost Incurred, and Revenue

Table 3 shows the monthly quantity of fuelwood, revenue, and costs incurred along the value chain. The non-licensed actors handled the least average monthly quantity of fuelwood (1040 kg), which represents 0.6% of the total mean monthly quantity of fuelwood handled by the respondents. Among the licensed actors, the transporters handled the largest (58%) mean monthly quantity of fuelwood, followed by the harvesters (16.3%). Meanwhile, the wholesalers and the retailers handled a mean monthly quantity of fuelwood at 12.8% and 12%, respectively.

Table 3. Monthly quantity of fuelwood, revenue, and cost along value chain.

Variable	Unit	Non-Licensed	Licensed			
			Harvesters	Transporters	Wholesalers	Retailers
Monthly quantity	Minimum (kg)	39	1000	28,000	8000	900
	Maximum (kg)	156	4000	200,000	120,000	80,000
	Average (kg)	1040	26,800	96,000	21,100	19,600
Monthly revenue (Sales)	Minimum ₦	8400	4800	60,000	32,000	30,000
	Maximum, ₦	33,600	192,000	625,000	480,000	500,000
	Average ₦ ($)	18,620 (51)	95,960 (263)	251,158 (688)	64,929 (178)	114,997 (315)
Monthly cost	Minimum, ₦	6384	63,218	53,500	8617	2600
	Maximum, ₦	10,134	99,218	481,000	120,617	160,000
	Average, ₦ ($)	7912 (22)	67,812 (186)	92,627 (254)	54,611 (150)	80,623 (2201)

The mean monthly cost incurred by the transporters was the highest, i.e., estimated at ₦90,227 (USD 247.2). This was then followed by the retailers with ₦80,623 (USD 221), harvesters with ₦66,195 (USD 181.4), wholesalers with ₦54,610.7 (USD 150), and lastly, the non-licensed actors with ₦7912 (USD 22). In terms of revenue from the sale of fuelwood and service rendered along the value chain, the transporters churned the highest average monthly revenue of ₦251,158 (USD 688), followed by the retailers, who made ₦14,997 (USD 315.1), and then the harvesters with ₦95,959.4 (USD 263) while the wholesalers reaped an average monthly sale of ₦64,929 (USD 178). As expected, the non-licensed actors managed to obtain a low monthly revenue of ₦18,620 or USD 51.

4.2.2. Profit Distribution

In terms of profit distribution, the transporters reaped the highest average monthly profit of ₦158,531 (USD 434) (Table 4). This amounts to 65.5% of the share of the total profit. The share of profits was then followed by the retailers at 14.2%, the harvesters at 11.6%, the wholesalers at 4.3%, and lastly, the non-licensed actors at 4.4%. In terms of profit margin, all categories of actors who are involved in the fuelwood business activities obtained a margin of more than 15% (Table 4). Specifically, the transporters earned the highest profit margin (63.1%), followed by the non-licensed actors (57.5%), the retailers (29.9%), the harvesters (29.3%), and lastly, the wholesalers (16%). However, the average monthly profit for all the actors, regardless of their formal status, was ₦48,416 (USD 132).

Table 4. Average monthly profit of actors in the value chain.

Cost, Revenue, and Profit	Non-Licensed Actors	Licensed Actors			
		Harvesters	Transporters	Wholesalers	Retailers
Average monthly revenue ₦ ($)	18,620 (51)	95,959 (263)	251,157.7 (688)	64,929 (178)	114,99 (315)
Average monthly cost ₦ ($)	7912 (21.7)	67,812 (185.8)	92,627 (253.8)	54,611 (149.6)	80,623 (220.9)
Average monthly profit ₦ ($)	10,708 (29.3)	28,147 (77.1)	158,531 (434.3)	10,318 (28.3)	34,374 (94)
Profit share (%)	4.4	11.6	65.5	4.3	14.2
Profit margin (%)	57.5	29.3	63.1	16	29.9

Based on the value chain map provided in this study (Figure 2) that shows certain actors (non-licensed) were vertically integrated but still could not earn significant profit compared to the licensed actors that carried out one activity in a specific value chain node. However, the vertical integration strategy of the non-licensed actors would have

been very significant to profitability if not for their characteristic of reliance on traditional transportation means or hiring small-medium trucks due to inadequate working capital to buy trucks. Thereby limiting the ability of the non-license actors to harvest and transport a large quantity of fuelwood. For the licensed actors, despite their strict adherence to the division of labor, in addition to the characterized inadequate working capital by some of these license actors (e.g., harvesters and wholesalers), as revealed in Table 3, the licensed actors earned more profits than the non-licensed actors.

4.3. Environmental Aspects of the Fuelwood Value Chain

Preferred Tree Species for Fuelwood

Respondents were asked to state their preference regarding the tree species for fuelwood and the scarcely available tree species within the study area. A total of 120 respondents responded to the question, except for transporters, since they declared that they have no particular choice or preferences for fuelwood and thought that the question was not relevant to their fuelwood business activity. Table 5 shows eighteen (18) identified preferred fuelwood tree species that were made up of 10 taxonomic families, of which the members of the Fabaceae family surpassed five other species. This is then followed by Combretaceae, with three (3) species, and the rest had one species each. All the 18 identified tree species were indigenous trees, whereby *Balanites aegyptiaca*, *Acacia senegal*, *Acacia nilotica*, and *Borassus aethiopum* were identified by 75% of the respondents as the most preferred tree species. Furthermore, eleven (11) of the eighteen (18) identified preferred fuelwood tree species were asserted by the respondents to be widely distributed and found abundant in the farmlands.

Table 5. Most preferred tree species for fuelwood.

Tree Species	Family Name	Per Cent (%)
Acacia nilotica	*Fabaceae*	75
Acacia senegal	*Fabaceae*	75
Balanites aegyptiaca	*Zygophyllaceae*	75
Borassus aethiopum	*Arecaceae*	75
Guiera senegalensis	*Combretaceae*	73
Combretum molle	*Combretaceae*	50
Piliostigma recticulatum	*Leguminosae-caesalpinioideae*	50
Anogeissus leiocarpus	*Combretaceae*	49
Securidaca longepedunculata	*Polygalaceae*	47
Ximenia americana	*Olacaceae*	47
Prosopis africana	*Fabaceae*	42
Daniellia oliveri	*Fabaceae*	37
Detarium microcarpum	*Fabaceae*	37
Cassia arereh	*Leguminosae-caesalpinioideae*	25
Croton amabilis	*Euphorbiaceae*	23
Cassia sieberana	*Fabaceae*	21
Parinari curatellifolia	*Chrysobalanaceae*	17
Acassia polyacantha	*Leguminosae-Mimosoideae*	15

Of the 18 preferred tree species, the respondents further identified seven (7) tree species as scarcely available, namely, the following: *Acassia polyacantha*, *Anogeissus leiocarpus*, *Balanite aegyptiaca*, *Combretum molle*, *Daniellia oliveri*, *Detarium microcarpum*, and *Prosopis africana* (Table 6). According to the respondents, these seven tree species, even though they

were preferred, their availability have reduced greatly over the years and are available in smaller quantities in selected forest reserves.

Table 6. Perceived tree species scarcely available.

Tree Species	Family Name
Balanites aegyptiaca	*Zygophyllaceae*
Combretum molle	*Combretaceae*
Anogeissus leiocarpus	*Combretaceae*
Prosopis africana	*Fabaceae*
Daniellia oliveri	*Fabaceae*
Detarium microcarpum	*Fabaceae*
Acassia polyacantha	*Leguminosae-Mimosoideae*

4.4. Social Aspects of the Fuelwood Value Chain

4.4.1. Gender Equality along Fuelwood Value Chain

As presented in the profile of the respondent section (Table 2), the informal chain was dominated by females and mostly concentrated on cutting and picking smaller/younger trees, and fallen dead woods compared to their male counterparts. In the formal chain, men dominated all nodes of the formal value chain and women's participation was limited to wholesale and retail activity, and their proportions were insignificant, at 10% and 20%, respectively.

4.4.2. Factors Affecting Women's Participation in the Fuelwood Value Chain

Based on the FGD, factors affecting women's participation in the formal value chain are shown in Table 7. A total of six factors or themes were identified, namely, cultural norms, lack of entrepreneurial skills and support, gender stereotypes, lack of financial resources, information gap, and insecurity. Factors related to gender stereotypes were the most commonly mentioned factors, as shown by the code density count/scores. Economic-related factors such as lack of financial resources and lack of entrepreneurial skill and support were also among of commonly mentioned factors that affect women's participation.

Table 7. Factors affecting women's participation in the fuelwood value chain in Yobe.

Factors Affecting Women's Participation in the Fuelwood Value Chain	Contextual Meaning	Building Block of Sub-Theme
Cultural norms	This comprised all factors associated with tradition and religion that influence social habits, behaviors, and practices of the people (it also includes a set of rules that guide the behaviors of people).	• Gender segregation (5); • Norms and Tradition (4); • Religion and beliefs (2).
Lack of entrepreneurial skills and support	This refers to the presence or absence of motivations or encouragement in terms of information, skills, or capital that help one develop confidence and desire to achieve financial independence.	• Lack of entrepreneurial education (4); • Family economic background (2); • Entrepreneurial knowledge and skills received from work experience (1).
Gender stereotype	This refers to the preconception about attributes or characteristics that ought to be possessed or performed by women and men	• Discrimination (2); • Women's powerlessness (5); • Gender characterization (2).
Lack of financial resources	This refers to the lack of funds to be used as capital and renders an entrepreneur to afford all costs involved in a business.	• Lack of financial assistance and support (7); • Poverty (11).
Information and communication gap	This includes a lack of verbal, gestural, and written communication between the beneficiaries and the benefactors.	• Illiteracy (2); • Lack of awareness of laws and guidelines (2); • Bureaucracy and complex licensing system (3).
Insecurity	This refers to the absence of safety and the presence of threats to life, assets, and wealth that prevent one to undertake lawful business activities.	• Assault/threats from bandits and gangs in the forest (1); • Threats from pastoralists or Fulani herders (4); • Threats from terrorists (e.g., *Boko haram*) (2); • Harassment from local vigilantes/local forest protectors (4).

5. Discussion

The discussion of this study is sorted into three separate sustainability viewpoints, specifically on the economic, environmental, and social dimensions. The economic aspect focuses on the profit distribution along the value chain. For the environmental aspect, the discussion centered on the source of fuelwood, preferred tree species, and view on scarcely available tree species by value chain actors. Finally, the social aspects focused on gender equality and the factors affecting the low participation of women in formal value chain activities.

5.1. Economic Aspects of the Fuelwood Value Chain

Results from this study show that the average monthly profit for all actors was ₦48,416 (USD 132) (Table 4), which is comparatively higher than the international monthly poverty threshold (USD 57/month). This is obtained by multiplying the UNs daily poverty threshold of USD 1.9 by the 30 days of the month [40]. However, profit was found unequally distributed where transporters reaped the highest profit share (65.5%) followed by retailers (14%), harvesters (11.6%), non-licensed actors (4.4%), and lastly, wholesalers (4.3%). The unequal distribution of profits implies that fuelwood production in Yobe is not inclusive and therefore does not promote sustainable economic growth whereby the economic benefit is not distributed fairly across society. In our case, the non-licensed actors and wholesalers were the impacted groups that received the least economic benefits. As income disparity has an impact on the rate of poverty reduction [45]; therefore, proactive measures are needed to enhance proportionate profit sharing along the fuelwood value chain.

The high profit earned by transporters was due to the large fuelwood quantity or volume handled by them. In the study area, transporters can make frequent and overloaded trips due to the low number of available trucks that provide fuelwood haulage services and the high demand from the harvesters for fuelwood. A study by Kwerteng [46] in Ghana revealed similar results, especially relating to the frequent transport services rendered by the transporters due to the inadequate number of trucks. In the case of Yobe, the use of huge heavy-duty trucks for the fuelwood sector is relatively limited, partially attributed to affordability issues, poverty, and a lack of access to financing at an acceptable hire-purchase rate [47]. Pickup trucks, rickshaws, wheelbarrows, and in certain places, headload (hand carry) or carts drawn by animals are some of the small and less expensive methods commonly utilized to transport fuelwood from the forest to the fuelwood market [47]. Therefore, to increase participation in fuelwood transportation services, there is a need for a formal national credit policy and financial institutions such as banks to provide more flexible credit facilities so that more people can afford to buy trucks. In Nigeria, the lack of formal national credit policy and credit institutions in Nigeria has been noted as a barrier to all business ventures while limiting the contribution of micro, small, and medium enterprises to the nation's economy [28,48].

A slightly higher profit received by the retailer was attributed to the presence of many value-added tasks, such as splitting and bundling, which were also reported to be the contributory factors influencing profitability [30]. This value-adding activity creates more employment opportunities in the fuelwood industry of Nigeria [2,30].

On the contrary, the harvesters' low profit (11.6%) may be caused by the influx of cheap fuelwood due to unregulated fuelwood harvesting, especially by the non-licensed actors. In other words, lack of adherence to harvesting quantity of fuelwood and uncontrolled supply by the non-licensed actors had resulted in lower revenue due to lower prices. The results of this study also coincide with previous studies that described fuelwood harvesting as one of the low-profit business activities [42].

Similarly, the lowest profit earned by wholesalers represented only 4.3% of the total profit share in the value chain may be explained by the practice of sales of fuelwood in bulk without adding value. Another reason responsible for the very low profit at the wholesale function may be due to inadequate working capital to procure a large quantity of fuelwood, thereby limiting the wholesalers' fuelwood procuring power. As observed in the study, inadequate capital could have been the reason that forced most wholesalers to rely on and practice trade-credit business transactions, which involved wholesalers receiving fixed-price supplies of fuelwood as a short-term credit from harvesters. The result of a very low profit reaped by the wholesalers in this study is in contrast with previous studies where wholesalers earned the highest profits in the fuelwood value chain in Burkina Faso [18]. According to Schure et al. [18], wholesalers were able to reap higher profits because they doubled up as transporters as opposed to the finding of this study, where wholesalers participated in fixed roles of selling fuelwood in large quantities. This backward integration strategy practices found in Schure [18] demonstrate the advantage of vertical integration in the fuelwood supply chain, which increases profits. According to Buzzel [49], vertical integration in the supply chain can help to increase efficiency, reduce cost, and ultimately increase profit. Hence, this vertical integration strategy (forward or backward) can offer practical solutions to chains actor in Yobe who wishes to increase their profit. Yet, the downside to vertical integration strategy and the greatest would be a higher capital investment [49], which can be a major obstacle to local fuelwood business communities in rural areas, especially in the rural northern states of Nigeria.

The non-licensed actors received a low monthly profit share of 4.4%, even though this group of non-licensed actors carried out more than one value chain function. The low profits revealed in the study are attributed to several factors, namely, lower quantity of fuelwood produced and lower revenue due to lower selling price. Generally, the non-licensed actors are the marginalized community and typically not able to engage in the formal market that requires additional costs such as payment of forest administrative

charges, including license fees, taxes, and employing helpers or workers [18]. Furthermore, fuelwood price in the informal market is not regulated compared to the formal market that is controlled by the trade association. Thus, unlicensed actors typically receive a lower price than licensed actors and this situation is pretty much similar in Burkina Faso, as reported by Puentes-Rodriguez et al. [19].

In terms of net profit margin (NPM), the fuelwood chain actors earned a good profit margin, especially transporters (63.1%) and non-licensed actors (57.5%). However, the high NPM at the informal supply chain steered by non-licensed actors can be a cause of concern since it can attract new entrants in the informal market, thereby putting more pressure on forest resources.

5.2. Environmental Aspects of the Fuelwood Value Chain

Based on the value chain chart developed in this study, the source of fuelwood for both formal and informal chains concentrated on natural forests such as forest reserves and special purpose forested areas (e.g., federal grazing reserves, communal forest areas, and homestead forests) (see Figure 2). The dependency on the natural forest as the primary source of fuelwood can be cause for concern because it would affect the sustainability of the forest resources given the high demand for fuelwood [5] and the lack of policies and programs that promote sustainable fuelwood management, especially in Yobe [11,37]. A study made by Naibbi [15] using Landsat satellite images found that vegetation cover in Yobe, Nigeria, has reduced drastically since the 1970s, and uncontrolled fuelwood collection activities were mentioned among the main causes. Therefore, our finding indicated a need for the development of alternative and sustainable fuelwood production systems, including dedicated energy plantations that use short-rotation coppice systems and agroforestry models, which have been found in the previous study to reduce local community's reliance on natural forests for fuelwood [50,51].

In terms of tree species for fuelwood, the study identified eighteen (18) tree species from ten (10) taxonomic families being preferred by chain actors, with *Balanites aegyptiaca, Acacia senegal*, *Acacia nilotica*, and *Borassus aethiopum* as the most preferred tree species (see Table 5). The preferences of these five species as fuelwood trees are based on several wood quality criteria, including easy splitting, easy ignition, fast moisture loss, high combustion capacity (hot flame), long burning duration, quality charcoal production, release no or low glows (sparks) and emit little smoke [52–54]. A study conducted by Dadile and Sotannde [53] found that local communities in Damaturu, Yobe, have good knowledge of which tree species possess good fuel quality, which affects their preference. In addition to fuel quality, Dadile and Sotannde [53] further noted that preference is also affected based on availability and easy access. Our findings demonstrated that the majority of the tree species preferred by chain actors belonged to the Fabaceae family. Given the fact that Fabacae dominates Yobe's vegetation [11], this helps to explain our finding.

A total of seven (7) tree species were reported by value chain actors as scarcely available, namely, *Acassia polyacantha*, *Anogeissus leiocarpus*, *Balanite aegyptiaca, Combretum molle, Daniellia oliveri, Detarium microcarpum, and Prosopis Africana*) (Table 6). Of the listed species, *Balanite aegyptiaca* was among the top preferred species for fuelwood by chain actors. A conservation assessment study carried out by Danjuma and Mafara [55] in North-western Nigeria confirmed some of the chain actors claimed whereby *Balanite aegyptiaca* is reported as threatened species while *Proposis africana* is categorized as a critically endangered as found in the IUCN Red lists version 3.1. Therefore, our finding indicates that chain actors' preference and knowledge of trees can play a role in the identification of threatened species and ecosystems. Hence, their knowledge and opinion can be incorporated into fuelwood management plans and natural resource conservation activities, as has been suggested by Puentes-Rodriguez et al. [19]. It is important to note that local views may lack ecological accuracy when examined closely in terms of the dwindling forest resources, yet their significance in guiding sustainable forest management should not be understated. Our finding also implies a more aggressive outreach program to raise awareness among all

actors on their responsibilities towards conservation efforts, for example, reforestation or tree planting programs that are being practised in other SSA countries [15,46].

5.3. Social Aspects of the Fuelwood Value Chain

Based on our survey and observation findings, women's participation in the formal fuelwood value chain is limited and tends to constitute a minority in wholesaling and retailing parts of the value chain (Table 2). Women were mostly involved in the informal chain as fuelwood collectors that relied on scrap wood and twigs from decaying stumps, branches of dead trees, and cutting from shoots of young trees. A total of six (6) themes were identified as the factors affecting women's participation in the formal value chain, namely, cultural and religion-related factors, gender stereotypes, lack of financial resources, less access to entrepreneurial skills and training, communication gap, and insecurity. Ewang [34] made a similar observation, noting that gender stereotypes, cultural and religious traditions, and low levels of education are some of the challenges that Nigerian women confront in order to succeed in society.

The influence of culture and religion on women's involvement in entrepreneurship was considered an obstacle to rural economic development [56]. Bowles [56] maintains that society's norms are the products of culture, religion, and beliefs that shape the behaviours of the SSA population. Generally, in many SSA societies, it is a common belief that women are supposed to be good housewives, take care of children, and cannot work or engage as entrepreneurs [57]. Therefore, job characterization is seen as a product of cultural norms, and in a community such as Yobe, Nigeria, the failure of individuals to respect such norms will get them isolated, become the subject of ridicule or gossip, and be rejected by their immediate and extended family. Therefore, the government should implement policies to ensure gender-equal opportunities and to further prevent gender discrimination [56–58].

Lack of financial resources contributed to the low women's participation in the fuelwood value chain activities. Previous studies also identified finance and less access to resources as the major constraint for women's involvement in the oil palm and fish value chain in Nigeria [59,60]. In Nigeria, specific financial support, or programs for women to involve actively in business, are very limited. Bowles [56] discloses that access to business loans from financial institutions for small-scale business owners, especially uneducated women in many developing countries is difficult because they do not understand the processes involved in the banking system. Ihalainen et al. [33] also highlighted that government regimes, especially tax enforcement and formal licensing systems, influence women's participation, given that women in SSA countries tend to have less control over finances. Complex guidelines and requirements for securing loans and licensing systems also prevent women's participation in the formal fuelwood value chain. This is closely tied to poor financial literacy and education level among women in Nigeria, especially in rural communities [57].

Another factor is insecurity in terms of workplaces (forests). It has been found that forested areas were infiltrated with the presence and activities of armed bandits, religious fanatics, and criminal gangs [27,56]. This situation may put women in a vulnerable position whereby some may succumb to sexual blackmail, kidnapping, and killings.

Gender stereotype has also been identified among the factors that affect the low and limited participation of women in the fuelwood value chain activities. It is a preconception about attributes and roles that ought to be possessed and performed by men or women [33,58,60]. As noted in a study reviewed by Ihalainen et al. [33], fuelwood production and trading are gendered (male activity), especially for being physically demanding and accident-prone activities such as harvesting and transportation. Women, on the other hand, involve in less physically demanding activities such as trading [56,61], which according to Demeke et al. [60], are directly linked to their higher reproductive responsibilities. Furthermore, Ofem et al. [60] highlighted that women in Northern Nigeria preferred less energy-intensive, less time-consuming, and low-risk jobs that resulted in low financial output, which has been admitted as self-concept [60].

Overall, to encourage women to participate actively in the formal fuelwood value chain activities, awareness, proper training, and propagation of sentiments away from societal stereotypes are needed. This has already been demonstrated by Azeez et al. [30], who found that the existing cultural and literacy level of the women of South Nigeria surmounted the challenges and encouraged them to participate meaningfully in the fuelwood business activities. Hence, the government should undertake holistic measures to educate the population on the significance of women's participation and their roles in nation-building. In addition, non-governmental organizations should also ensure the accessibility to education and training of women that can promote gender equality and empowerment in Nigeria and northern Nigeria in particular.

6. Conclusions

Concerned about the sustainability of the fuelwood industry along the value chain, this study analyzed the sustainability of the fuelwood chain in Yobe, a rural Northern Nigerian state. The sustainability of the industry was assessed based on the three pillars of sustainability dimensions, namely, economic, environmental, and social, using a value chain framework. The economic aspect was assessed based on the equal distribution of profit along the value chain to determine whether the economic benefit is equally distributed and inclusive. The environmental sustainability aspect, on the other hand, was assessed based on the main source of fuelwood supply, chain actors preferred tree species for fuelwood, and views on tree species that are scarcely available. For the social aspect, gender equality and women empowerment were evaluated. Specifically, the distribution of gender across the value chain and the factors affecting women's participation in the fuelwood value chain, which can hinder women empowerment initiatives were assessed.

Our finding revealed that the profits are not equally distributed, whereby profit share was skewed towards transporters. Non-licensed actors that mainly comprised marginalized communities and wholesalers received the lowest profit. Hence, proactive steps are required to improve proportional profit sharing along the fuelwood value chain (e.g., progressive tax, flexible repayment and low-interest rate for hire purchase of trucks, encourage vertical integration of the supply chain, among others). The primary source of fuelwood production was natural forests, which suggests the need to develop alternative fuelwood sources and sustainable fuelwood production, such as energy plantation crops or agroforestry, to reduce the dependency of chain actors on the natural forest. Preferred tree species and perceived scarce trees by value chain actors show consistency regarding threatened species identified in the previous study. This finding indicates that views and knowledge of local communities can serve as essential inputs to be incorporated into future fuelwood management plans and conservation activities. The study also revealed low and limited participation of women along the value chain, especially in the formal chain, due to cultural norms, lack of entrepreneurial skills and support, gender stereotypes, lack of financial resources, information gap, and insecurity. Gender equality is a critical issue in Nigeria. Thus, programs and activities for women's empowerment in the fuelwood sector are essential to reduce the gaps in access to opportunities.

Based on the finding, it can be concluded that fuelwood productions along the value chain are not economically, environmentally, and socially sustainable. A sustainable fuelwood value chain is believed to be a vehicle for the nation's socioeconomic development, such as the alleviation of poverty, promotion of gender equality (empowerment of women), and protection of natural resources. Recommendation to improve the sustainability of the fuelwood value chain has been discussed and provided, which can serve as useful information to policymakers to develop relevant policies, strategies, and programs to promote the sustainability of the fuelwood industry and assist the country in achieving sustainable use of natural resources and balanced socioeconomic growth in the future.

Our study depends on descriptive analysis to describe and explain the profits reaped by different actors in the chain. The significant differences and relationship between profitability and characteristics of the chain actors (e.g., socio-demographic background, the

formality of business, and volume of sales, among others) remain to be analyzed. A more comprehensive understanding of fuelwood profitability and the underlying factors that contribute to the economic return of chain actors is crucial for potential policy adjustments if fuelwood is to be a means out of rural poverty.

Nevertheless, the finding from this study provides a general overview of the sustainability situation in the fuelwood value chain in Yobe, Nigeria. Although the finding can be generalized to the northern states of Nigeria due to common similarities, including socioeconomic conditions and ecoregion that affect the diversity of vegetation, further research needs to be conducted for the southern region to fully understand the sustainability conditions of the fuelwood value chain in Nigeria using a similar methodology. This initiative can assist in developing a comprehensive national strategic policy related to sustainable fuelwood production.

Furthermore, only a few sustainability issues (economic, environmental, and social) were selected, analyzed, and discussed in this study. Future studies can include other sustainability issues in the value chain framework. This includes price and taxation along the value chain (economic), communities' or families' needs, children's participation or child labour and job safety (social), and environmental impacts (ecological impacts) such as the soil, water and wildlife, and harvest-growth ratio.

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