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Fuelwood value chain analysis in Cassou and Ouagadougou, Burkina Faso: From production to consumption

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ABSTRACT

The majority of households in Burkina Faso, particularly in the rural areas, rely on fuelwood as their main source of energy for cooking and heating. This consumption trend is expected to continue and even increase in the coming years, driven mainly by the population growth. Although sustainable woodfuel management has been considered in the country, pressure on forest resources is continuously increasing, as a result of fuelwood production. In this study, the different processes within the fuelwood value chain (FWVC) were analyzed in the village of Cassou and Ouagadougou, with a survey directed to the FWVC actors (from harvesters to consumers). Social, economic and environmental aspects were considered in the analysis, as well as the legal dimension within the VC. From the analysis, two lines of formality were identified (i.e. formal and informal). Formality varied depending on the location and the process implying also a gender aspect; for instance, all harvesters and most of the collectors (mainly men) in Cassou belonged to associations (formal), while most of the transporters and traders (mainly women) in Ouagadougou were not part of any association (informal). Fuelwood price fluctuation was also affected by the formality since formal actors followed the official prices while informal ones established the prices freely. Informality also leads to uncontrolled exploitation of forest resources contributing to the forest decline. The present study provides a general overview of the situation in Cassou, a small village in Burkina Faso and suggests that other issues need to be considered to fully assess the sustainability of fuelwood VC in the country and to be able to create strategies and policies to e.g. decrease the negative impact on the environment. Therefore, it would be most needed to carry out a detailed analysis, involving formality, with all the actors – covering gender issues, processes and flows at a larger scale across different regions.

Introduction

Energy consumption worldwide is expected to increase by 48% between 2012 and 2040, with the highest annual average change (2.6%) occurring in Africa (US EIA, 2016). The contribution of biomass (i.e. fuelwood, charcoal) to the total energy demand is about 15% worldwide and 86% in some developing countries (FAO, 2016). In Sub-Saharan Africa (SSA), where biomass is the main energy source, its consumption has been projected to remain at high levels or even rise in the next decades (World Bank, 2011), with an increase of 343 million people relying on wood-based biomass between 2004 and 2030 (IEA 2006 and 2010, as cited in World Bank, 2011). However, the potentiality of biomass for energy depends greatly upon land availability (Ladanai and Vinterbäck, 2009).

In Burkina Faso, woodfuel is the primary energy source (85%; MEDD, 2012) and is expected to increase in the coming decades mainly due to population growth. Though, the decline of forest area in the country is mainly associated to the expansion of cropland through land clearing (Tondoh and Degrande, 2015), energy experts have recently identified woodfuels exploitation as the second most important driver of deforestation in the country, driven mainly by poverty rate (Arevalo, 2016). As a strategy to prevent forest decline and as part of a participatory sustainable management approach, specific areas – the so-called Forest Management Units (or *Chantier d'Aménagement Forestier*, CAFs) – were established in Burkina Faso for sustainable fuelwood supply to the capital city, Ouagadougou (Coulibaly-Lingani et al., 2014). However, fuelwood produced under this approach represents a small proportion of the total energy produced in the country and only about 6% of total woodfuel demand seems to be covered, mainly in the urban centers of Ouagadougou and Bobo-Dioulasso (Ministère de l'Environnement et du Cadre de Vie 2004, as cited in Schure et al., 2014).

In this context, it is necessary to understand how fuelwood is currently produced, transformed and distributed to the end users in Burkina Faso, as well as to identify and understand the challenges and problems encountered along the chain that are affecting forest cover in the country and the proper production and consumption of this important energy source. This paper aims to analyze, through a

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questionnaire survey, the current fuelwood value chain (VC) in two key areas within the fuelwood sector: Cassou village (Southern Bukina Faso) and the capital city Ouagadougou. Firstly, we present a general energy outlook for Burkina Faso and the theoretical framework for this study. This is followed by a section describing the methodology applied and the study areas. The results and discussion sections are structured to cover social, environmental and economic aspects, as well as some legal dimensions within the sustainability, and at the end of the paper some conclusions are presented based on the authors' views but also from the value chain main actors' perspective.

Energy outlook for Burkina Faso

Main sources of energy in Burkina Faso

With over 18 million inhabitants (annual change 2.9% in 2014; WB, 2016), Burkina Faso has been facing one of the highest population growth rates in the world; being ranked in 2014 as 11th among the 20 countries with highest population growth (World Atlas, 2016). This increase in population and the consequent economic growth are the main factors that could influence the energy consumption levels in the country. Though energy consumption in Burkina Faso during 2012 was among the lowest (0.02 quadrillion of BTU) in Western Africa, the tendency is to continue growing, as shown by the annual growth estimated at 1.05% for the period 2000–2012 (Knoema 2011–2017).

Most of the population (about 90%) still relies on woodfuel as the main source of energy (REEEP, 2012); which is typical for the majority of countries in Sub-Saharan Africa. According to the latest census carried out in 2006 (MEF, 2009), fuelwood in simple stoves was the main source of energy in most of the rural households (93.7%), followed by wood in improved stoves (2.4%), charcoal (1.2%), gas (0.8%) and petroleum (0.3%). On the other hand, in urban areas the corresponding energy sources and percentages were fuelwood in simple stoves (56.8%), gas (15.1%), charcoal (10.2%), wood in improved stoves (9.7%), electricity (0.7%) and petroleum (0.5%). In terms of potential for renewable energy development, solar resources and small-scale hydro have higher potential (60% and 30%, respectively) than biomass (10%) in Burkina Faso, although their contribution (i.e. hydroelectricity 1%) to the energy consumption in the country is still low compared to that from biomass (85%; MEDD, 2012). In contrast, in countries such as Ivory Coast, Liberia and Guinea-Bissau, biomass shows higher potential (40% each) for renewable energy development (ECREE, 2012).

The production of woodfuel in Burkina Faso is among the highest in Western Africa. According to FAOSTAT (2017), Burkina Faso was the third major producer of woodfuel after Ghana and Nigeria, with an annual growth of 1.4% from 2010 to 2015.

Forest resources for energy

Forest area in Burkina Faso represents less than 1% of the total forest land in Sub-Saharan Africa (FAOSTAT, 2017). However, Burkina Faso is among the countries with the largest forest area in Western African region after Ivory Coast, Ghana, Senegal, Nigeria and Guinea (WB, 2016). There are two alternative forest management regimes in Burkina Faso: i) classified forests (i.e. strictly protected from livestock and farming) and ii) protected forests, which include community-managed forests and village forests (Etongo, 2016). About 14% of the total land area in the country (3.9 million ha) is state-owned classified forests (MEDD, 2012). Of the total land area, only 800000 ha of forests are under forest management plans (MEDD, 2012), which represents around 14% of the total forest area in the country and around 21% of the total state-owned forests. According to the World Bank (2011), about 441000 ha are under sustainable forest management (CAFs) and it is expected that 270000 ha will be added in the near future mostly for woodfuel production. Nevertheless, management practices have not been properly followed as prescribed in the plans, with a subsequent overexploitation of the forests (Ferdinand Tanyi, 2015). In fact, the government estimate of forest loss in the country was at 107626 ha (0.83%) for the period 1992–2002 (MEDD, 2012).

A sustainable forest management approach was initiated in the country during 1986 by a joint UNDP/FAO project. Part of this initiative included the establishment of operational Forest Management Units (*Unités d'Aménagement Forestier*, UAF) within dedicated forest management areas (*Chantier d'Aménagement Forestier*, CAF). Officially CAFs are the only places for woodfuel production under designated cutting sites and management plans (Schure et al., 2014). UAFs cover areas ranging from 2000 to 4000 ha and are managed by Forest Management Groups (*Groupement de Gestion des Ressources Forestières*), mainly represented by people living in or around the CAFs (Coulibaly-Lingani et al., 2011, 2014).

Fuelwood value chain analysis (VCA) towards a sustainable fuelwood management

There are different views on the contribution of woodfuel on deforestation rates; however, most studies agree that woodfuel plays a crucial role in deforestation and forest degradation (Sulaiman et al., 2017). Sander and Zeller (2007, as cited by Sulaiman et al., 2017) even claimed wood energy as the major cause of deforestation and forest degradation in Sub-Saharan countries. This, together with the lack of forest regeneration measures, the unclear land and forest tenure, access and use rights and the lack of good governance have a huge impact on the forests in Burkina Faso (Schure et al., 2014; Etongo et al., 2015), often leading to conflicts among farmers. Thus, sustainable woodfuel production and consumption also requires that clear land use, tenure policies and sustainable forest management (SFM) practices are in place.

The United Nations has defined SFM as a "dynamic and evolving concept aiming to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations" (FAO, 2016). Due to increasing pressure on forest resources and its generalized negative effects (i.e. climate change, desertification, forest degradation, etc.), public awareness towards sustainably managed forests has increased during recent years. In fact, it is included as one of the seventeen UN Sustainable Development Goals aiming to "Sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss" (UN, 2016). Therefore, it is necessary to understand the different phases and the role of the main actors of the woodfuel VC, from woodfuel production to its final consumption. The VC concept denotes a set of agents, with related activities and markets, which contribute directly to the production, transformation and distribution to final markets of a single product (Bellù, 2013). Its analysis, the value chain analysis (VCA), represents a tool to differentiate various stages in production and utilization of a certain product (in this case, fuelwood). This analysis allows us to identify bottlenecks and target groups, understand the value added, trace the effects of a policy along the chain of commodities, the value chain as whole, etc. (Bellù, 2013).

The current fuelwood VC in Burkina Faso was analyzed following a general VC chart for fuelwood (Fig. 2A), which considers the different stages in the chain (from wood harvesting to fuelwood consumption) and the main agents involved (from wood cutters to consumers). The chart was produced based on the literature reviewed (Schure et al., 2014, Bellù, 2013, among others). It is recognized that there are two parallel and overlapping lines of processes existing in the fuelwood VC in Burkina Faso – formal and informal (Bellù, 2013), which were also defined within our analysis. Formality of VC was mainly based on the participation of the interviewees in organized associations.

For this VC analysis, economic, environmental and social aspects were considered, as well as some legal dimensions within the fuelwood VC. From the economic point of view, the analysis included: fuelwood prices and quantities under different processes, household consumption

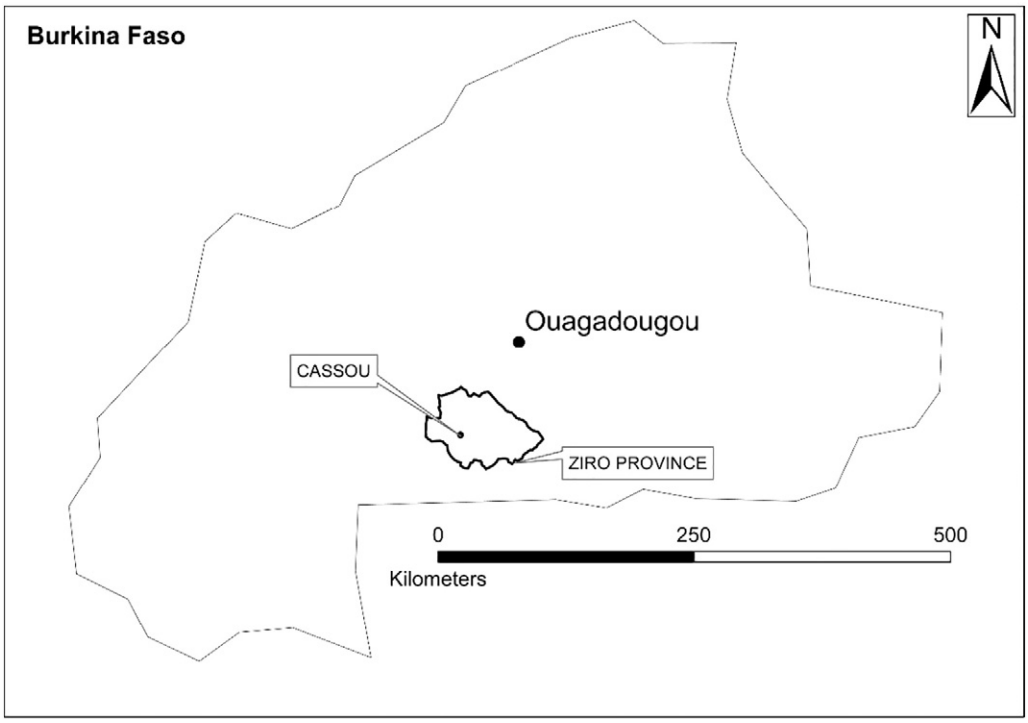

Fig. 1. Map of Cassou within the Ziro province.

of fuelwood and fuelwood trade. Within the environmental aspects, the preferences and actual use of different tree species for fuelwood were analyzed under different processes. Social analysis mainly considered gender and level of education of the VC actors, and finally the legal dimensions included legality of different processes throughout the VC (i.e. viability of organized associations).

Methods

Study site

The study was carried out in Cassou village and in the capital city Ouagadougou. According to the Statistical Yearbook (2015), Ouagadougou is the largest city of the country with a population of 1915102 reached by 2012 (INSD, 2016). The village of Cassou is one of the 29 villages and the capital of the rural commune of Cassou located in southern Burkina Faso, in the Ziro province. This region is under the south-Sudanian ecological zone (Fontes and Guinko 1995, as cited by Etongo, 2016), with two marked seasons: dry (7–8 months) and rainy season (2–3 months; Tondoh and Degrande, 2015). Rainfall, the highest in the country, ranges from 800 to 1000 mm (Etongo, 2016). These climatic conditions confer to the area more opportunities for activities and resources such as: rain-fed agriculture, fuelwood and forest products, than in any other region in the country (Etongo, 2016). The author also reports that the highest average population density in the country occurs in Cassou, because of migration and natural increase. The population of Cassou village was estimated at 3867 and ca. 6 people per household, according to a household survey carried out in the village (Tondoh and Degrande, 2015). According to the same authors, there is a peaceful coexistence between the main ethnic groups found in the village; which are: Mossi, Gouronsi (Nuni), Fulani and Waala or Dagara-Doula. Most of the population is Muslim followed by Catholics, Protestants and Animists (Tondoh and Degrande, 2015). Cassou is one the three villages found within Cassou forest together with Bakata and Gao. The opportunities encountered in Cassou village along with its strategic location within the Cassou forest, made it an attractive pilot area for the fuelwood VC study in Burkina Faso.

Cassou forest covers about 29515 ha and is located in Ziro Province, ca. 150 km from Ouagadougou (see Fig. 1). This area is administratively defined as the Protected and Managed Forest of Cassou and represents one of the last remaining dry forests in the country with numerous lowlands and important forest islands. Tondoh and Degrande (2015) reported that management of natural resources at Cassou is carried out by: i) the land chief, ii) the Village Development Committees, and iii) the Forest Management Groups together with iv) the local forest services. The forest area is rich in wood species; however anthropogenic pressure, livestock and forestry have driven the scarcity or even disappearance of some of the wood species (Tondoh and Degrande, 2015). In fact, large amounts of fuelwood are imported to Ouagadougou from Cassou; which makes the area a reference point in terms of energy from wood.

Data collection

In order to obtain information about the fuelwood VC in Burkina Faso, a questionnaire survey was carried out during June–October 2015 in Cassou village (harvesting, collecting and consumption) and the capital city Ouagadougou (transportation, trade and consumption). The survey collected information on the 5 identified processes within the chain (Fig. 2A). The questionnaire consisted mainly of close-ended questions, the majority aimed at getting quantitative and qualitative information about: (i) type and number of species used for fuelwood, (ii) location of harvesting, (iii) quantity (stere and *charrette*[†]) and fuelwood prices (FCFA[‡]) of each process, as well as (iv) formality of activities and (v) proportion of self-consumption versus commercial trading of fuelwood. In addition, there were open-ended questions that addressed the main issues and challenges faced by the actors along the chain, as well as ideas and recommendations for improvements. Fourteen respondents per process (n = 84) were selected using the

[†] *Charrette*: French word for 'cart', which is utilized in Burkina Faso for transporting fuelwood carried by a donkey.

[‡] FCFA (XOF) is the West African CFA Franc, which is the currency used by eight independent states including Burkina Faso. 1 euro = 655.957 CFA (Oanda, 2017).

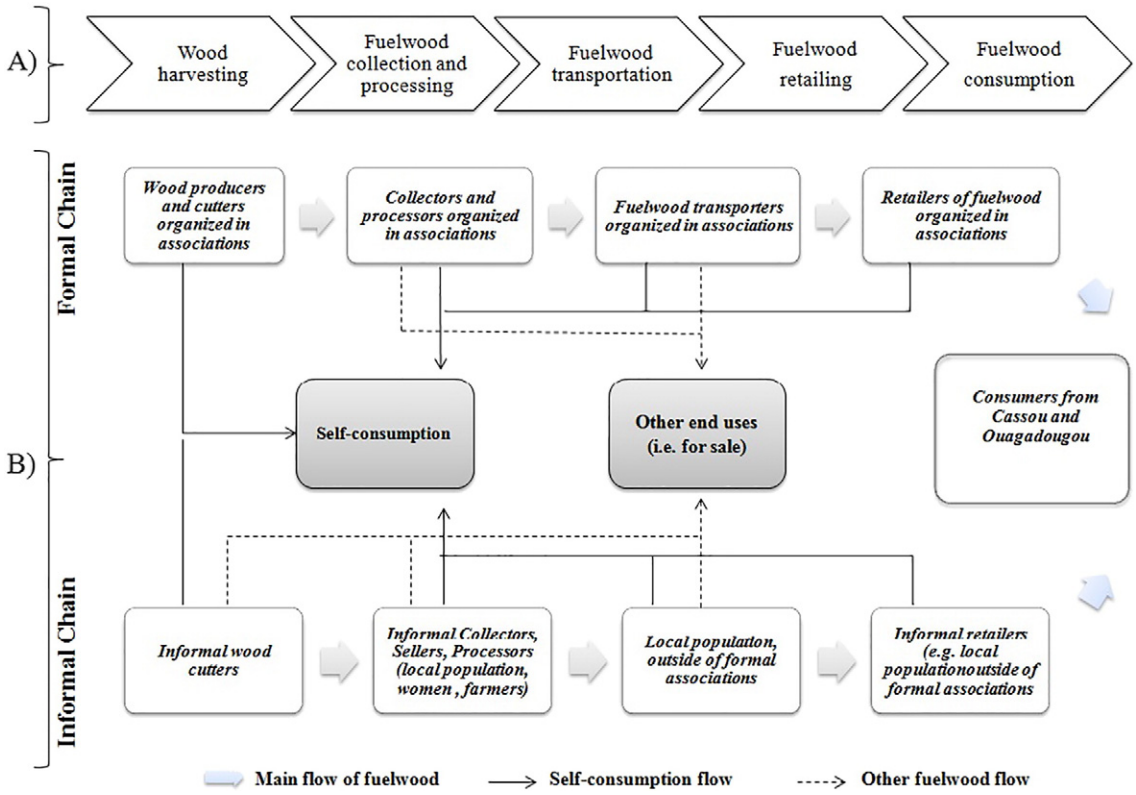

Fig. 2. A) General fuelwood value chain chart. B) Fuelwood value chain with main stakeholders in each process and considering formality of the activities.

snowball sampling method (see more about the method in Voicu and Babonea, 2011). The survey was carried out by a trained interviewer and, whenever it was required, a local language (*Gourounssi*) translator, in face-to-face individual appointments with respondents. The average response time was 16 min for all the processes, with minimum and maximum response rates of 11 min and 20 min for the consumption and transportation processes, respectively.

The answers were analyzed with descriptive statistic using IBM SPSS Statistics and Microsoft Excel. For practical reasons, the quantities of fuelwood are presented in cubic meters (m^3) of stacked wood, although answers were given in different units (i.e. stere, charrette, etc.). Stere is the general unit for measuring fuelwood quantities in Burkina Faso, which corresponds to 1.5 charrettes or cartload or 1 stacked m^3. The volume of the trucks used in this study corresponds to 18 m^3, which is commonly used in the area according to the local fuelwood experts. Trucks (i.e. DAF, Mercedes Benz, Berliet, Iveco) are owned by private operators and can also be rented. Most of the trucks have been in use for already some time and present advanced state of deterioration.

Results

Value chain graph

The fuelwood VC obtained from the survey (Fig. 2B) shows the main stakeholders involved in the chain according to the formality of the process (i.e. formal and informal sub-chains). More detailed information on the respondents is described in the following section. The graph demonstrates that regardless of the formality, the main flow of the fuelwood goes as follows: harvesters → collectors → transporters → traders → consumers. However, two other flows were also identified, the self-consumption one and other flows such as fuelwood sale. All the stakeholders use fuelwood for self-consumption as shown in the graph. Nevertheless, the proportion of fuelwood self-consumed varies upon the process, as described later. On the other hand, both formal and informal collectors and transporters, but also informal wood cutters have other end uses for the fuelwood. In the case of the wood cutters fuelwood is also sold to transporters, as expressed by the respondents.

Profile of respondents

The total number of respondents was almost evenly distributed between men and women (Table 1). However, the distribution varies within processes: harvesting and collection processes were mainly represented by men, while trade and market mainly by women. Transportation and consumption processes were quite similar in terms of gender of respondents and they were mainly represented by women. Consumers were also mainly women both in Cassou and Ouagadougou.

Table 1
Profile summary of fuelwood value chain actors interviewed in Cassou and Ouagadougou.

Process	Place	Gender (n)		Age (years)		Association (%)/gender	
		M	F	M	F	Yes	No
1) Harvesting	Cassou	13	1	34	32	100/ M = 100 F = 0	– – –
2) Collection and processing	Cassou	13	1	34	39	85/ M = 85 F = 0	15/ M = 8 F = 7
3) Transportation	Ouagadougou	5	9	38	46	21/ M = 14 F = 7	79/ M = 21 F = 58
4) Trade and market	Ouagadougou	0	14	–	52	7/ M = 0 F = 7	93/ M = 0 F = 93
5) Consumption	Cassou	4	10	38	30	–	–
	Ouagadougou	4	10	46	41	–	–
	Total (n)	**39**	**45**	**39**	**49**	**53**	**47**

In terms of age, the oldest respondents were found in transportation and trade and market (average 42 and 52 years old, respectively) and similar ages were found in the rest of the processes. On average, the women interviewed were older than men (Table 1), although in harvesting and consumption the men were older than women.

More than half (53%) of the respondents are part of certain associations, which here we connect with the formality of the process (Table 1). Harvesters were the only group with all the respondents belonging to an association (Forest Administration Group), and they were harvesting only from CAFs. For the collecting process, 85% of respondents were part of the association. On the other hand, most of the transporters and traders did not belong to any association (79% and 93%, respectively). Formal transporters were mainly represented by men (14%) while informal ones were represented by women (58%).

Among all the interviewees, 36% had primary level education and 10% had completed junior high school; however, 54% did not have any type of education (Fig. 3A). The less-educated people were represented by the interviewees at the trade and market process (79% without education). On the other hand, collectors and processors (hereinafter "collectors") were the ones with more education records (71% primary education and 7% junior high school). At Cassou, the number of interviewees with primary education was higher (29%) than in Ouagadougou (15%).

For most of the interviewees, the activity carried out within the fuelwood VC does not represent their main source of income. Farming was the main occupation for all the harvesters and most of the collectors (Fig. 3B). For about 57% of transporters and traders, fuelwood transportation and trading represented the main sources of income. The remaining 36% in the trade and market process were housewives while transporters had more occupations, such as wood sellers, restaurant manager, cake sellers, etc. The consumers interviewed at Cassou were mainly local beer (i.e. pito) sellers (43%), restaurant managers (36%), and other e.g. butcher's shop keepers (21%). In Ouagadougou, the main occupation for the consumers interviewed was quite similar to Cassou with 29% of those interviewed being housewives.

Quantities and prices along the fuelwood VC

According to the interviewees, about 4.9 m^3 of fuelwood are harvested daily from CAFs and from new clearings. On average, about 6 m^3 of fuelwood are collected and processed (Fig. 4A). All harvested and most of the collected wood are legally obtained. In terms of transported fuelwood, it is shown that all the informally transported wood (2.1 m^3/day) goes to the market (sold informally), while in the case of the legally transported fuelwood (2.4 m^3), about half of it is self-consumed and the rest is sold (1.33 m^3/day). Consumption of fuelwood was on average 0.3 and 0.2 m^3/day in Cassou and Ouagadougou, respectively.

The highest level of self-consumption was observed in harvesting and collecting processes within the fuelwood VC (Fig. 5A). In transportation process, about less than half of the transported fuelwood was used for self-consumption. For about 57% of respondents (harvesters and collectors), half of the fuelwood is sold on. Therefore, from the harvested amount of fuelwood, approximately, 3 m^3/day is sold on

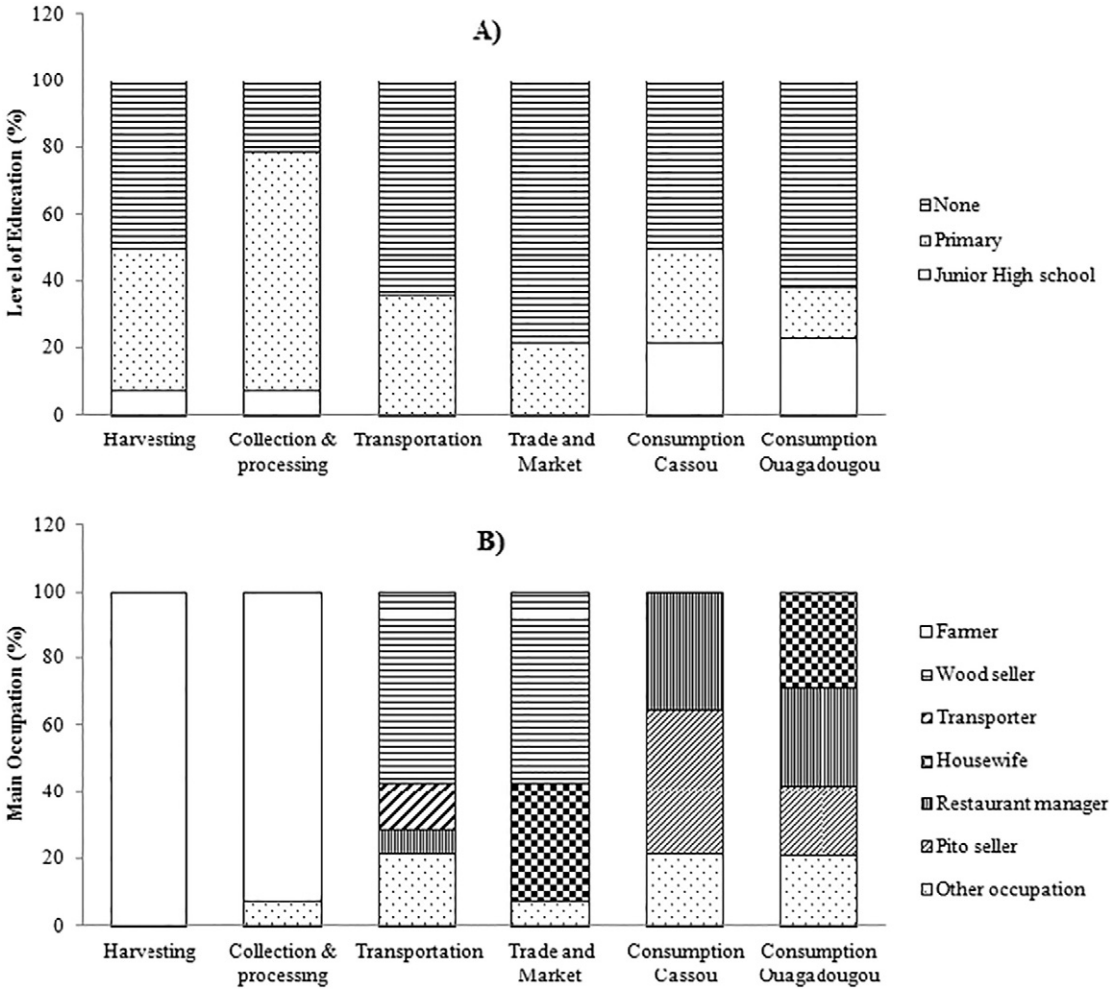

Fig. 3. (A) Highest level of education and (B) main occupation of interviewees within fuelwood value chain processes.

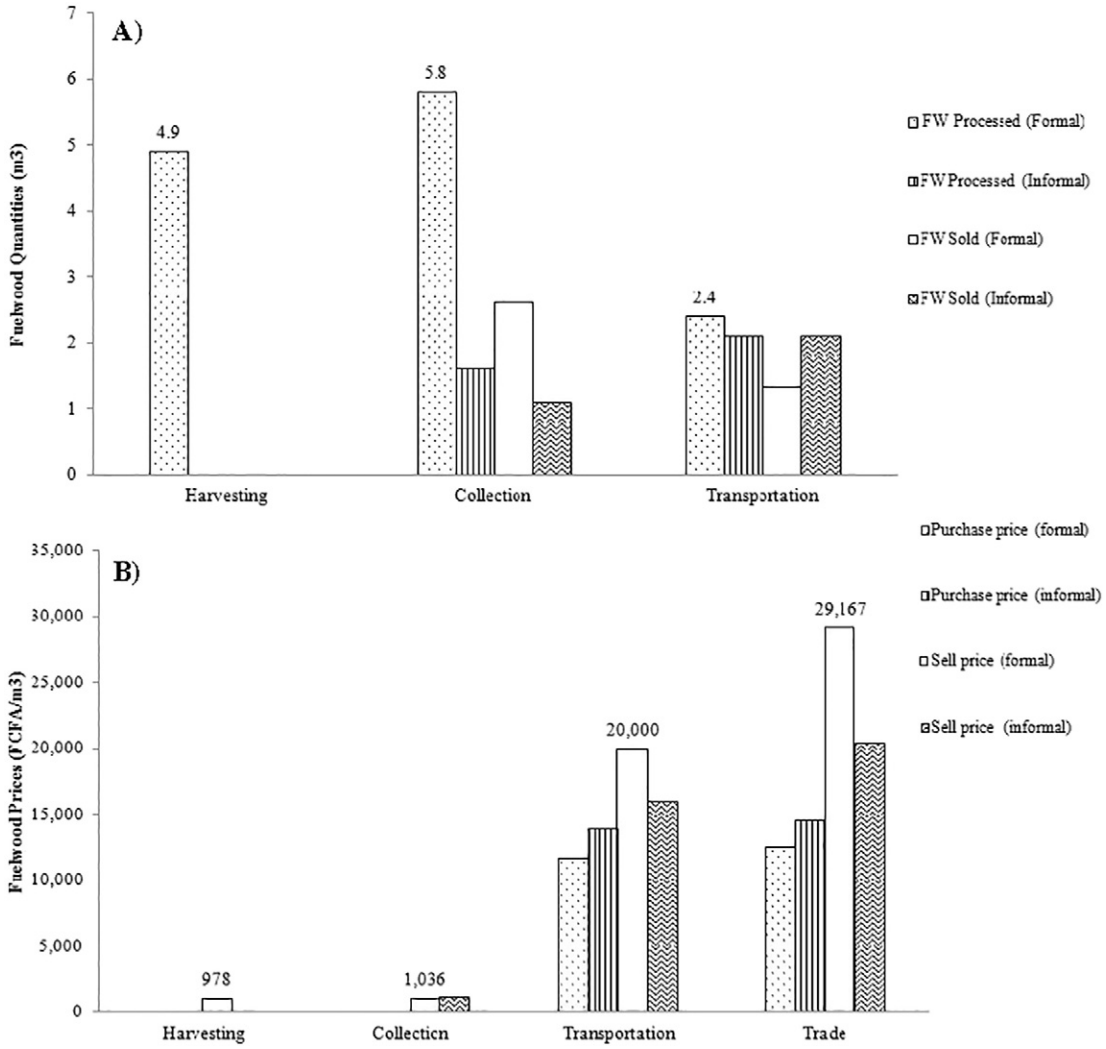

Fig. 4. Fuelwood quantities (A) and prices (B) along the value chain processes.

(Fig. 5B). Collectors are selling, on average, 2.4 m^3/day, which is in line with the level of self-consumption estimates by respondents. For transportation process, about 86% of the respondents are selling all the transported fuelwood, which on average was 1.6 m^3/day.

In terms of prices, harvesters are selling fuelwood on average at 978 FCFA/m^3, and collectors are selling it at 1055 FCFA/m^3. Formal traders pay less than informal ones for the fuelwood to be sold (12500 FCFA/m^3 vs. 14472 FCFA/m^3, respectively). However, the situation is the opposite with the selling price, which is higher when formally traded. According to the consumers, the selling price of fuelwood is on average 952 FCFA/m^3 in Cassou, which corresponds to the selling prices for harvesting and collecting processes. However, the price in Ouagadougou (~48000 FCFA/m^3) was much higher than in Cassou. Fuelwood prices for transportation and retailing were higher compared to other processes of fuelwood VC (Fig. 4B).

Tree species for fuelwood

The most preferred tree species for fuelwood according to the interviewees were: *Detarium microcarpum* Guilt. and Perr., *Crossopteryx febrifuga* Afzel. Ex G.Don and *Anogeissus leiocarpa* (DC.) Guill. and Perr. (Fig. 6A). For trade and market process, the most preferred and sold tree species was *A. leiocarpa*, followed by *D. microcarpum*, *Vitellaria paradoxa* C.F. Gaertn. and *Diospyros mespiliformis* Hochst. ex A.DC. For the former, the preference was higher than the business itself (i.e. more preferred than sold), except for *V. paradoxa*, which was defined as most sold and less preferred for trade and market (Fig. 6B).

Challenges faced by the main actors within the fuelwood VC in Ouagadougou and Cassou

The respondents identified in a closed-ended question several difficulties affecting the normal development of fuelwood VC in Cassou and Ouagadougou. In Fig. 7, the main challenges are divided according to the social, economic, ecologic and infrastructure-related importance. Most of the problems were connected to economic issues (50%), followed by the infrastructure (19%), social (17%) and the ecologic ones (14%). In terms of economic challenges, the main concern was the variation in wood prices (70%), followed by the fact that fuelwood is a business with a small profit (17%) and other problems such as taxation (13%). In terms of infrastructure, the condition of the roads was the main problem identified by the respondents (19%). Three social challenges were identified: the lack of communication and planning among the VC actors (54%), population growth (33%), and corruption occurring within the chain (13%). The last group of challenges was the ecological one with the scarcity of resources (14%) as the only problem identified by the interviewees in all the VC processes. For harvesters and collectors, the main obstacle was the condition of the roads. The collectors interviewed perceived the low price of fuelwood per m^3 as a major challenge. However, for transporters and traders the slack fuelwood

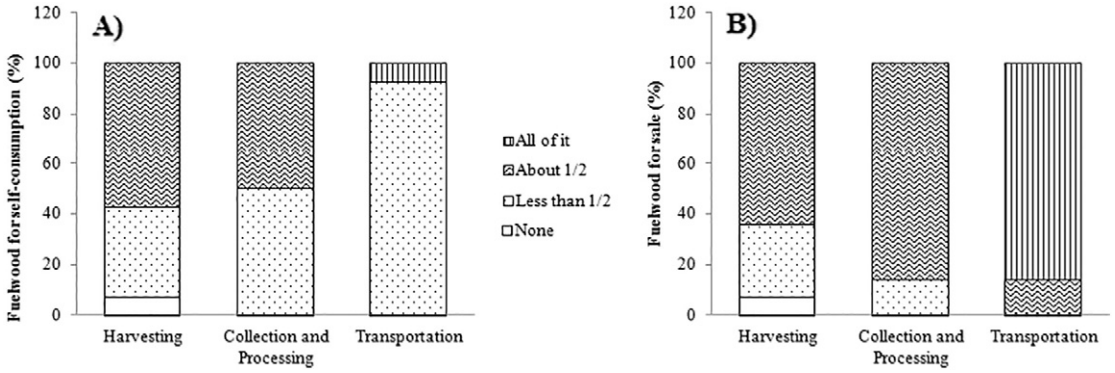

Fig. 5. Fuelwood self-consumption (A) and trade (B).

market and the price of wood were considered the most important challenges, respectively.

Discussion

In this section, we discuss the results in terms of three key aspects of sustainability – economic, social and environmental – as well as the legal aspects, which are defined based on the formality of the activities and the processes within the VC. Previous studies have also dealt with informality issues within the fuelwood VC in African countries (Cerutti et al., 2015; Ramcilovic-Suominen et al., 2012) and more specifically in Burkina Faso (Schure et al., 2013; Schure et al., 2014). These studies have shown the impact that informal activities have on the access and control of resources, on policy making and distribution of benefits, among others (see also Ramcilovic-Suominen and Hansen, 2012).

Social and legal aspects in the fuelwood VC

The information provided by the interviewees showed that when it comes to formality of the processes, all harvesters and most of the collectors in the Cassou area belong to the formal one by participating in related associations (i.e. Forest Administration Groups), and also by harvesting from the CAFs, which are the areas officially established for woodfuel production in Burkina Faso under forest management (Schure et al., 2014). In contrast, most of the transporters and traders who were interviewed in Ouagadougou do not belong to any union and therefore the legality of some activities related to the fuelwood VC cannot be controlled. For instance, prices are not regulated or do not follow the official rates. This may cause, in most of the cases, urban traders to make substantial profits at the expense of the rural producers by taking over the business (Roe et al. 2002 as cited

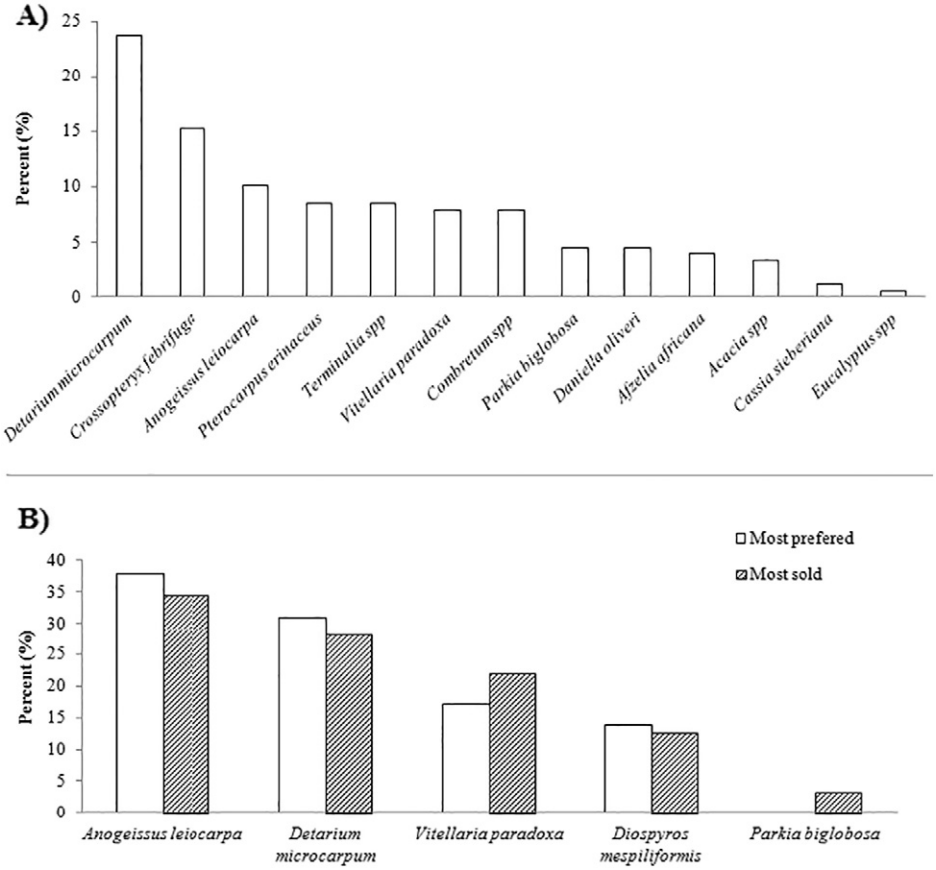

Fig. 6. A) Most preferred tree species for fuelwood (average % for all processes) and B) most preferred and sold tree species for fuelwood according to trade and market process.

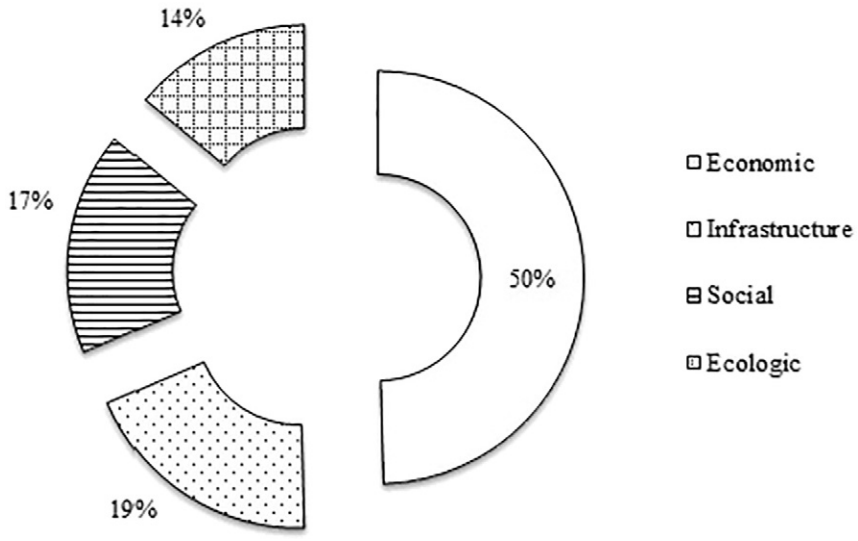

Fig. 7. Challenges in the fuelwood VC, as described by the respondents.

by OECD, 2012). However, this is an assumption that needs further study.

The data collected also indicates that different processes in the VC seem to be gender-dependent. For instance, harvesting and collection of fuelwood in the studied areas are mainly carried out by men, although a previous study showed that for domestic use, women are the ones who collect fuelwood from the field on a daily basis (Tondoh and Degrande, 2015). This may be explained by the fact that men are harvesting wood from the CAFs as a source of income while women are doing it mainly for cooking and domestic uses without any economical profit. On the other hand, fuelwood transportation and trade are mainly represented by women, according to the interviewees' profiles, which is also supported by Bellù (2013). However, these two activities seem to be usually carried out by men (Shively et al. 2010 cited in Schure et al., 2014) and in many cases by the same person, as it is not a daily activity (Meyer 2008 cited in Meyer, 2011). In this respect, it may be important to define the formality of these activities and the location. For instance, fuelwood transportation within the Cassou area may be carried out by women mainly by charrette on an informal basis, while long-distance woodfuel transportation may be done by men using trucks as the transportation vehicle (formal).

As presented in the chapter on profile of respondents, the collectors (mainly men) are more educated, while the transporters (mainly women) represent the least educated people. According to UNESCO (2007, as cited by World Bank, 2014), the youth literacy rate in Burkina Faso (39%) is lower than in other low-income countries, and women's literacy (33%) is lower than men's (47%). Gender issues may also play a role in this specific case since gender inequality connected to literacy has been already identified in Burkina Faso (Kompaoré et al., 2007). Although improvements have been taking place since the country's independence, access to education for women has been limited for various reasons, such as women's heavy workload, early marriage and poverty, among others (Kompaoré et al., 2007). Even though the government has been concerned about illiteracy among women, the gap between men and women remains. Traders, mainly represented by women, had also a low level of education, which is quite interesting since it may be expected that they will have some level of education for wood trade. However, this is the case for the informal trade since most of the traders did not belong to any association. The situation within the formal trade might be different and more training would represent better performance and success for the business.

In terms of location, the number of consumers in Cassou with primary education was higher than those in the capital city, and the number of people without any education was higher in Ouagadougou than in Cassou. These somewhat unexpected results could be due to the high importance that education is given in Cassou village. In this sense, Tondoh and Degrande (2015) found that 30% of people's expenditure in the area goes to education, which is at the same level as health and food expenditure. It may also be the case that in the capital city there are more working opportunities contributing to dropout from high schools; however, this is just speculation that needs further research.

Looking at the education issue from another perspective, it is also considered as one of the parameters influencing the choice of energy at household level along with income, location, household size and cultural issues (Schure et al., 2014). In fact, Ouedraogo (2006) found out that the use of LPG and charcoal is positively influenced by formal education level of the household head. According to the same author, the users of fuelwood for cooking had the lowest per capita income; significantly lower than those using charcoal and natural gas, meaning that household income may determine the type of energy to be used (Ouedraogo, 2006). In addition, the financial situation also influences the environmental aspects as it was observed that the poorer a rural household is, the more dependent it is on forest resources for income (e.g. fuelwood, timber, food) (Pouliot and Treue, 2013). While in this study the information about income was not obtained, Tondoh and Degrande (2015) estimated that the contribution obtained from trees to the total household income is about 15%. If we consider that this low percentage applies also to our specific study, it could explain why the process in which respondents are participating does not represent their main source of income, and an extra income is needed for covering their living expenses and their families, especially if he/she is the only one working in the household.

Besides the gender and education matters described above, there are some other social aspects that also need to be considered for the proper and sustainable fuelwood VC development in the region, as identified by the interviewees. For them, the lack of communication and planning between the different actors was defined as deficient, which undoubtedly need to be improved for a better development of the fuelwood VC. Fraud and corruption actions should also be addressed properly; however, the informality of the activities may interfere in the establishment of proper actions and therefore formality should be appropriately considered. For some of the interviewees, population growth was also mentioned as a challenge to be considered, and it is obvious that more people will represent more energy needs, more pressure on resources, and less availability of resources. In fact, the forecasts indicate that the population will continue to grow in Burkina Faso, reaching 40 million in 2050 (UN, 2014). Therefore, new strategies, action plans and practices need to be developed and implemented aiming at efficiency and

sustainability of natural resources, together with innovative and alternative energy resource uses. In terms of infrastructure, interviewees consider that poor road conditions affect negatively the transportation of fuelwood from the harvesting/collecting points, increasing the transportation time and therefore reducing the efficiency of the process.

Economic issues in the fuelwood VC

The official price of a cubic meter of wood from FMAs is fixed at 2200 FCFA. Of this amount, half (1100 FCFA) is dedicated to forest workers, 14% as forestry tax, 27% for Forest Development Fund and 9% for the Village Investment Fund (Arevalo, 2016). In general, the price paid to fuelwood producers has remained constant since the 1990′s; however, the consumer price in the city has increased. Considering that all the harvesters and most of the collectors interviewed belong to organized associations, they support the official prices for fuelwood, selling it at 978–1055 FCFA/m^3. For most of these actors, this is however not the main source of income, which may indicate that these activities are not profitable as they are carried out currently. Thus, their main recommendation was that official prices should be changed and updated to reflect the current costs, since at the moment the business is considered unrewarding. This, in turn, may lead to actors engaging in informal/illegal practices in order to earn enough to cover living expenses. However, extra costs (i.e. taxes and bribes) should be also considered since they could make the illegal business less profitable than the legal one (OECD, 2012).

The variations found in fuelwood prices within VC process could be explained by the location of the interviewees and the formality of the process. Harvesters and collectors located in Cassou area are selling the fuelwood at the price they are supposed to sell it, according to the official price following the legal and formal path. However, transporters and traders from Ouagadougou buy and sell fuelwood at very high prices (uncontrolled) adjusted to their needs to make a profitable business. In fact, most of the transporters and traders considered their work as their main source of income. It has also been shown that outside CAF areas, the prices are set freely by operators and wholesalers; apart from that there are also certain taxes on cutting and movement (Energy policy, laws and regulations: Handbook, 2015). The challenge faced by the actors related to the fluctuations in fuelwood prices appears to be related to the process; for instance, for collectors, low prices of fuelwood for selling it but for traders the high prices for buying it. While the prices and quantities of fuelwood obtained in this analysis might be challenging to understand and in some cases lacking coherence, they are nonetheless indicative and helpful in showing trends of directions.

In most of the fuelwood VC processes, wood is not only considered as a business because an important part of the fuelwood is also self-consumed. In this respect, up to 50% of harvesters and collectors were using about half of the harvested or processed fuelwood for themselves, relatives and extended family. In Arevalo's study (2016), on average one household consumed 2 cartloads/month, which is approximately 0.2 m^3/day lower compared to our findings. This might be because interviews were conducted at Cassou where fuelwood is more accessible as a result of its proximity to the CAFs. In general, rate of fuelwood consumption depends on the location and region, i.e. scarcity of fuelwood inevitably leads to lower consumption (Dietz et al., 2004).

Environmental issues in the fuelwood VC

The number of tree species identified by the interviewees as the most preferred for fuelwood (thirteen in total) indicates that species with different characteristics and from different taxonomic families are currently utilized for fuelwood in Burkina Faso. Further, a clear correspondence is found between the most preferred and the most sold tree species.

The most preferred species within the fuelwood VC (Fig. 6) are among the most exploited wood species in southern Burkina Faso (Paré et al., 2010), not only for energy purposes but also as traditional medicine, woodcarving and food. This is supported by Kristensen and Balslev (2003), who also identified *D. microcarpum*, *P. erinaceus* and *A. leiocarpa* as the most used for fuelwood in Burkina Faso; followed by *V. paradoxa* (also mentioned by the interviewees), and *Hymenocardia acida*. Some of the species (i.e. *D. microcarpum*, *C. febrifuga* and *P. erinaceus*) are used for fuelwood due to flame intensity and the small amount of smoke emitted (Tondoh and Degrande, 2015). Other species mentioned by interviewees, including *V. paradoxa* (Shea) and *Parkia biglobosa* (Néré), are also used for fuelwood, but those are preserved and planting is frequent because of their value (Kristensen and Balslev, 2003; Tondoh and Degrande, 2015). *A. leiocarpa*, *V. paradoxa* and *P. erinaceus* are also preferred for construction purposes, due to the wood properties and resistance to termites (Kristensen and Balslev, 2003). Since the same species are utilized for many purposes, one would expect that their populations in the study area will decline, as has been found in other areas such as Senegal (Lykke, 2000). In fact, in the study carried out by Melin et al. (2016) in the Cassou area, the abundance of *C. febrifuga*, the second most preferred tree species by the respondents, was very low. On the other hand, the same authors also found that some of these species are still common in Cassou forest; for instance, *A. leiocarpus* was the most common species found in the area, with *V. paradoxa* and *D. microcarpum* also included in the second group of the most common ones.

The knowledge among consumers on the tree species commonly used for fuelwood differed depending on the location. For instance, Cassou fuelwood consumers are familiar with tree species, while for urban consumers this was in general unknown. This difference was most likely due to the proximity of the respondents to the forest in the Cassou area, unlike in Ouagadougou. Local knowledge should be incorporated within proper management plans; this may contribute to the identification of threatened species and ecosystems and also ensure focus on locally preferred species and enhance appreciation of protected areas among local people, as stated by Lykke (2000).

Besides deforestation and forest degradation, overexploitation of tree species for fuelwood has a negative impact, e.g., on people's livelihood, since the forests represent an important source of income for most of the population living in the area. This is a common case throughout the Sub-Saharan Africa, and the neighboring countries including Ghana (Ramcilovic-Suominen et al., 2010). In addition, the increasing pressure on natural resources along with population growth and the need for energy relate to the lack of resources, which was identified by the respondents as the main and only ecological issue within the fuelwood VC. Low farming productivity (e.g. due to droughts) may also cause extra pressure on forest resources and it has even been identified as a significant driver for deforestation in Southern Burkina Faso (Etongo et al., 2015), due to the fact that farmers need an extra income. Besides the consequences of lack of resources at local scale, several negative effects could also affect at national and even international level, such as climate change, biodiversity and livelihood loss, among others. Therefore, increasing awareness among people is crucial to understand the value of the forests for the environment and their livelihood for current and future generations. Unfortunately, ecological issues seem to be less important than the social and economic ones, as expressed in the survey by the stakeholders interviewed.

Conclusions

Woodfuels represent the main source of energy for cooking and heating in Burkina Faso. This has been the case for a long time and the trend is to continue mainly due to population growth. In rural areas, fuelwood will remain the most common woodfuel, causing enormous pressure on the forest resources.

The simultaneous action of formal and informal chains observed in the analysis represents a big challenge for the fuelwood sector affecting directly the fuelwood prices and a big impact on the forests. Clear links

were found between formality and the location, process of VC, as well as gender. Activities related to fuelwood production carried out in the rural area and mainly by men are apparently more formal than fuelwood transportation and trade carried out in urban areas and mainly by women. Considering that the present analysis is a general overview of the situation in Cassou, a small village in Burkina Faso, there are still many issues that need to be considered to fully assess the sustainability of fuelwood VC in the country and also to be able to create strategies and policies to e.g. decrease the negative impact on the environment. Therefore, it would be most needed to carry out a detailed analysis, involving formality, with all the actors – covering gender issues, processes and flows at a larger scale across different regions.

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