Journal of Life Sciences Research
ISSN : 2408-9184
Vol. 3, No. 2, 18-29, 2016
http://asianonlinejournals.com/index.php/Lifsc/index

Assessment of Fuel Wood Values and the Influence of Wood Cutting on the Easily Flooded Plain Woodland of the Sahelian Area, Cameroon

***Moksia Froumsia*[1]**
***Louis Zapfack*[2]**
***Pierre Marie Mapongmetsem*[3]**
***Bernard-Aloys Nkongmeneck*[4]**

[1]Department of Biological Sciences, Faculty of Sciences, University of Maroua
[2]Department of Plant Biology, Faculty of Sciences, University of Yaoundé I
[3]Department of the Biological Sciences, Faculty of Sciences, University of Ngaoundéré
[4]Ecological Museum of the Millennium Research Section
(✉ Corresponding Author)

Abstract

The study focused on fuel wood economic value and the influences of woody cutting on woody species in the flooded plains woodland area. Sahelian woodland suffers from cutting down trees for fuel wood, to insure household energy demands. Investigations were carried out near a sample of users of resources and an inventory of stems of exploited species in woodland. Households in 15 villages and four markets were explored and 496 actors included in the exploitation and the use of firewood and charcoal, as regard 204 men and 292 women, were interviewed individually. Fuel wood quantity and economic value was made through a register. Through 48 transects of 2 000 m length and 20 m each, the availability, the intensity of cutting down trees, measurements and observations were made and noted on stems. Stems which the circumference > 10 cm were counted and their diameter was measured. The sources of domestic energy mostly used were firewood and charcoal which remained easily accessible and available. Completely stem cut down and partial stems cut were noted as the exploitation mode. The charcoal was produced traditionally, using furnace. Significant quantity of firewood (2186.59 t) and charcoal (28340 t) were estimated. It varied periodically a year with a substantial drop. The quantity sale represent 95 % and brought annual income of 122035.8 $ (Firewood) and 31 630 $ (charcoal). The incomes contributed significantly in the rural households' economy and brought an additive to their much reduced agricultural yields. A number of 33 woody species were noted as the mostly exploited for fuel wood. Among them *Anogeissus leiocarpus*, *Balanites aegyptiaca*, *Prosopis Africana*, *Detarium microcarpum* and *Pseudocedrela kotschyi* were firstly mention. The total number of stumps and the partial cut of stems were significant representing respectively 20.91 % and 9.64 % of stems counted. The exploitation was intensive and selective on stems. Cutting down of stems was constituted a major factor for requested species degradation. Results indicated evidence of the impacts of fuel wood exploitation on the woody species. The study concludes that fuel wood yield in the sahelian woodland has not yet reached alarming proportions and can be contained. It could be an imperative to set up an alternative system to ensure sustainable management of resources. Solutions through introduction and popularization of natural gas, biogas, solar energy and the improved hearths could effectively contribute to reduce the intensity of this activity and to guarantee the maintenance of the ecological balance on the already fragile sahelian ecosystems.

Keywords: Wood, Cutting, Impacts, Woodland, Sahel

Contents

Citation | Moksia Froumsia; Louis Zapfack; Pierre Marie Mapongmetsem; Bernard-Aloys Nkongmeneck (2016). Assessment of Fuel Wood Values and the Influence of Wood Cutting on the Easily Flooded Plain Woodland of the Sahelian Area, Cameroon. Journal of Life Sciences Research, 3(2): 18-29.
DOI: 10.20448/journal.504/2016.3.2/504.2.18.29
ISSN | 2408-9184

1. Introduction

In developing countries, the high demography correlated increase in needs very poor people has highlighted the pressure on the forest resources. This has involved an indescribable degradation of woody covered area. The woody resources are considered as free accesses which satisfy their basic needs: i.e. fuel wood for cooking, the handicraft production, and wood to build houses, shelter, furniture (beds, chairs), traditional pharmacopoeia and the animal feed [1]. To fulfil the household fuel needs which is increasing; the populations will assail the woody resources to produce fuel wood (firewood and charcoal). As fuel wood covers the main part of the domestic fuel requirements of people in the Sahelian countries: 92 % in Burkina, 86 % in Mali, 80 % in Niger, 47 % in Senegal, 96 % in Chad [2] results are obtained recent decades noticed a significant destruction of the biodiversity following the loss and change of environment particularly in the tropical forests, leading to a major crisis of species extinction [3-5]. Therefore, it became very difficult to the biodiversity of the tropical area to survive without efficient protection [4-6]. Dry Savannas which share their wealth biodiversity and the diversity of their products, contributed to the poverty reduction [7]. However, they are subjected to and extreme degradation and their biological diversity strongly regressed [8, 9]. Activities of firewood and charcoal exploitation, cutting of building materials, harvesting of non timber forest products and the bush fires are intensified [10-12].

In the sahelian flooded plain areas, woodland areas are invaded by local populations for socio-economic and environmental stakes which threaten the existence of resources [13]. One of the principal causes of degradation is the cutting down of woody species for fuel wood, household use and selling. While firewood and the charcoal constitute the first useful fuel source, less expensive and easily accessible and at the same time, they are considered as a source of income for the poor farmers [14]. However this exploitation of fuel wood is excessive and unsustainable for the future. In this regard, there is no adequacy between the quantities taken, consumed, compared with the potential available of the resources in fields. The exploitation manner is dangerously threatened on the woody cover [15, 16]. Studies provided basic elements starting from landSat and the structure of woody cover in this characteristic right up to the dry savannas zone, but no study is carried on the exploitation of fuel wood, its socio-economic value and its ecological result given on woody species. Nevertheless, significant quantity of fuel wood is exploited and the exploitation manners constitute a major ecological constraint. The aim of the present study is to assess the economic importance and the ecological impact of the cutting down of woody species, an essential phase for the sustainable management of resources in the flooded plain woodlands. Specifically, (i) to estimate the exploited quantities of fuel wood and its income value; (ii) to determine and assess the exploitation manners of fuel wood and the available potential of various exploited species and; (iii) to find out the impact of cutting down trees on the most useful species.

2. Methods

2.1. Study Area

The study was carried out in the flooded plain woodland area in Mayo Danay division located between the 10^{th} and 11^{th} degrees of Northern Latitude and the 14^{th} and 15^{th} degrees of Eastern Longitude, in the Far North region. The relief consists of a vast uniform plain thus the slopes are very weak (3°) with an altitude scarcely exceeding 300 m. The climate is sudano-sahelian and characterized by two unlike seasons: the drying season which long-lasted for 8 months (October to May) and the short raining season which lasted for 4 months (June to September). The mean (± SD) annual rainfall for 1970-2010 was 748±120 mm [17]. As a whole, some interannual variations and space-temporal of rainfall generate an excess to a year's causes flood, consequently leading to a low agricultural product within the famine and the rainfall deficit years caused by ecological crises and logical lower agricultural productivity.Moreover, the complexity of specific and local fluctuations of the lasting drying season makes the sustainable resource more difficult (vegetation, water, soils, pastures, etc) to manage.The mean annual temperature was 28°C. The characteristic flora is that of steppes with thorn-bush made up of savannas shrubby with a very irregular herbaceous floor covered and dominated by thorn-bushes, strongly degraded under the pressure of human actions [18, 19]. The populations in this area were mainly constituted of the Tupuri, Massa, Muzugum, Musey, Kera and Peulh. The economic activities were based on extensive and subsistence agriculture, extensive, fishing, exploitation of natural resources, and small trade.

2.2. Data Collections

The socio-economic investigations were carried out near a sample of the population's users of resources and an inventory of stems of exploited species in the forested zones. They are lead in householders in 15 villages, randomly selected, according to the criteria of their proximity to the forested zones and in the closest urban markets (Kalfou, Yagoua, Doukoula, Moulvoudaye and Bougaye). The investigation let to find out: main exploited species, exploitation manner, charcoal and firewood exploited quantities, sold quantities, their commercial value, prices flux, incomes generated and identification of actors (collectors, wholesalers, retailers and consumers). A whole of 496 actors included in the exploitation and use of firewood and charcoal, as regard 204 men and 292 women, whose minimal age was 20 years, were interviewed individually by a semi structure issue based on an investigation guide. The transport component and persons set out as: conveyors (man or women) (219), donkey (87), handcart (48) and carthorse (41), coal owners (51) and consumers (50). Actors having accepted collaboration hold a register assisted by investigating agents. The assessment of fuel wood production was made close to the actors located at various levels to determine the economic value of the exploited fuel wood. Registrations were noted weekly every information concerning the activities of the exploitation of fuel wood. Data are collected between three periods: characteristic of a year as well as an equal duration during three consecutive years as follow: period P_1 (September to June) corresponds to raining season and characterized by farmers occupation on pastoral work; period P_2 (October-January): corresponds at the end of the raining season which characterize by harvesting activities and an end of a year with Christmas and new year feast; P_3 (February-

May) in drying season characterized by a lack of activities and farmers rest waiting the new raining season. The quantification of fuel wood was done with a weighting machine (Roberval). Quantity of fire wood as well as the bags of coal are weighed 20 times per sample (mean of transport used and bag) to determine their average weigh. For firewood, the quantified values are translated into stere (1 stere = 333 kg) [20].

The enumeration is made in woodlands through transects which measured 2 000 m length and 20 m width, laid out randomly. Whole 48 transects were realized for 192 ha surface area cumulated. To determine the availability, the intensity of cutting down trees of exploited species, measurements and the observations were made and noted on stems. Stems which the circumference > 10 cm were counted and their height was measured. Wholly cut down stems, partially cut stems and dead stems were enumerated. Structural characteristics of exploited species while density, relative predominance; relative frequency and distribution of stems towards circumference class were given. The evaluation of anthropogenic pressure and the renewal dynamics were know from cutting intensity on species, and the rate of death.

3. Results

3.1. Sources of Fuel and Their Use

The sources of domestic fuel used by rural and urban populations in the sahelian zone in Cameroon were: firewood (85.63 %), charcoal (8.44 %), paraffin oil (5.12 %) and gas butane (1.83 %) (Table I). Potential users such as: households, local beer brewers, restaurant owners and bakers, roasted meat salesmen “soya” and shepherds. Firewood remains the most useful fuel source by the populations. It was widely needed for cooking, local beer brewing ("bil-bil" and "arki"), heating houses and cattle in winter. In rural zones, populations were fully dependent on firewood which remained the only fuel easily accessible and available. Another use of fuel was mainly noted in urban zones where, beside fuel wood, households, bakers and restaurants owners respectively used 2.43 % and 18.08 % of petroleum oil and 4.78 and 4.37 % of gas butane. Gas butane was used only by civil servants. Local beer brewers, roasted meat salesmen "soya" and shepherds were primarily dependent on firewood. While, households, restaurant owners and bakers used at the same time and with different proportions firewood, charcoal, petroleum oil and gas butane.

3.2. Production Mode of Fuel Wood

Methods used for fuel wood exploitation were summarised in two types: completely stem cut down and partial stems cut. Fuel wood holders cut down fresh stems and allowed them dry and also collected deadwood in the natural environment. For firewood, fresh wood were cut down and deadwood were collected. For charcoal, the production process was made traditionally. It passed through fresh wood cut, installation of furnace, wood carbonization, conditioning and the transport of coal towards use zone (Fig. 1 a, b, c, d, e and f). Charcoal was obtained after partial carbonization of wood in the traditional furnace. After cutting down, fresh wood was hacked out in small pieces from 30 to 50 cm length and left drying before setting up in bundle. The traditional furnace was pit of in a rectangular or circular form in variable sizes. Charcoal owners put up the furnace by laying out woody pieces in circle. They form a fitting of wood pieces covered with ground, including a lighting gap. It was necessary to await 3 to 4 days of carbonization to open the furnace and to collect coal. Coal obtained was conditioned in bags whose average weight is 52 kg. The coal bags were transported in villages during darkness to the sale points. The production average of furnace was 2340 kg of charcoal.

3.3. Quantity of Produced Fuel Wood

The annual quantity of the firewood was estimated between 2 186.59 t (2012) beside 1 860.49 t (2014). The annual evolution of firewood exploited quantity showed a regressive tendency (Fig. 2). Results showed that a substantial drop of exploited firewood quantity was about 14.91 %. This drop could be explained by the increase in the fuel wood exploitation activities which implied more local populations.

Annual quantity of charcoal was estimated at 328.22 t (2012), then 303.42 t (2013) and finally 188.60 t (2014). A substantial annual drop of 7.55 % of a produced quantity was noted between 2012 and 2013 and significantly considerable of 37.34 % between 2013 and 2014. This drop allowed the decrease of pressure on species. It would be due to the sensitising of populations by monitoring work group in bordering villages. Therefore, an improvement was noted on a move over of charcoal holder to agricultural activities.

3.4. Periodicity of Fuel Wood Exploitation

The quantities of exploited firewood vary periodically a year. A quantity assessment between three periods (P_1, P_2 and P_3) of a year showed that during P_1, the quantity is significant, decreasing in P_2 and more significant in P_3 (Fig. 3). The more productive period was P_1 with 756.50 t, which corresponded to farmers resting time. As farmers labour is ended, they rest and wait of work resumption at the beginning of the following season. During this period, population actively exploit the natural resources for selling and get income necessary to the satisfaction of needs. In P_2 firewood quantity is 584.29 t, this period corresponded to the raining season where farming activities are dominated. P_3 period recorded a significant quantity of firewood produced (708.43 t) slightly lower than P_1. This period (P_3) matched to the decreasing tendency of farming work intensity, getting time to the end of a year festivals. The periodic distribution of fuel woods quantities lead to predict the periods of stressing the actions monitoring for safeguarding resources. In this case, P_1 and P_3 are indicated to reduce the cutting pressure on woody species in the sahelian woody areas.

Concerning charcoal, the annual production also varies between the seasons. In drying season, the exploited quantity varied from 28340 t (2012) to 19098.85 t (2014) and in raining season, it varied from 23992.8 t (2012) and 12958.4 t (2014). The exploited quantity is higher in the drying season than that of the raining season, showing that farmers had fewer difficulties for charcoal production in the first one. The drying season was a

favourable period for fuel wood exploitation, thus the production was significant. During the raining season (June to September), fuel wood exploited quantities were weaker than that in the drying season. Rainfalls constituted a constraint for the wood cut and the installation of furnaces (Fig. 4). The variability of exploited quantities was shown by calculation of variance which was highly significant between periods and months per years ($p < 0,001$). These results permitted to find out the time margin required for intensifying the involvement of woody cover monitoring.

3.5. Sale of Fuel Wood and Income

The quantity of firewood sold was estimated at 2186.59 t corresponding to 6.57 steres (2012); it was 2100.58 t for 6.31 steres (2013) and 1860.49 t including 5.60 steres (2014). These quantities intended that, sale represent 95 % of the whole firewood exploited quantity. Fuel wood owners used man (particularly women by head) (270); donkey (127); carthorse (71) and handcart (87) (Fig. 5 a, b, and c). The mass of firewood varied according to the capacity load of each means of transport: man head (15 kg), donkey (45 kg) wood, handcart (205 kg) and carthorse (445 kg).

The quantities of exploited firewood, which were considerable in these woody areas, varied and prices were increasing (Table II). Firewood sold brought annual income of 122035.8 $. The individual average firewood quantities and incomes were set out annually as follows: head (woman) 183.75 t and the incomes of 51.7 $; donkey 206.85 t for 136.3 $; handcart 550.62 t for and incomes of 309.8 $ and carthorse 919.27 t for 727.1 $ incomes. The income from firewood sold constituted a significant contribution in the rural farmers' economy and permit them to bring an additive to their much reduced agricultural yields.

The quantities of produced charcoal were significant; the prices of bags varied between periods rising gradually each year (Table III). The production of charcoal was primarily intended for sale. It permitted owners to get significant annual income which contributed to household's economy. Quantity resulting from the clandestine and non quantified once would be significant. But it was not subjected for assessment because of the lack of collaboration with owners who operated in surreptitiously. These clandestine owners were partly supported by forest and wild life administrator. Their productions were sold to tradesmen of neighbouring countries who settled the coal bags in paperboards to mislead controllers care. The exploitation of fuel wood constituted for local populations as an activity which enabled them to exploit wood for home use; supplied a flourishing trade activities which yielded an income.

3.6. Species Requested For Fuel Wood

Woody species exploited for fuel wood are selected according to following characteristics': hard wood, capacity to produce good coals, good coal yield, and burns a long time, not spark nor smoke. These various criteria permitted to retain on 33 most exploited species for fuel wood production (Table IV). Among them, 18 species were requested twice for the production of coal and firewood. The most requested species for charcoal were: *Anogeissus leiocarpus*, *Balanites aegyptiaca*, *Prosopis africana*, *Detarium microcarpum*, *Pseudocedrela kotschyi*, *Combretum glutinosum*, *C. fragrans*, *Terminalia avicennioides*, *Combretum molle* and *Pterocarpus erinaceus*. For the firewood, the most used species were: *Balanites aegyptiaca*, *Guiera senegalensis*, *Combretum collinum*, *Anogeissus leiocarpus*, *Terminalia avicennioides*, *Hymenocardia acida*, *Acacia seyal*, *Pseudocedrela kotschyi*, *Ziziphus mauritiana* and *Hexalobus monopetalus*. Cutting down of stems was constituted a major factor for requested species degradation. Green stems were cut and dried for later used as firewood and charcoal production.

Beyond the exploitation of these woody species for fuel wood, species as: *Sclerocarya birrea*, *Bombax costatum*, *Tamarindus indica*, and *Diospyros mespilisformis* were frequently cut off for house clothes rafters, loft construction, shelters, tents and enclosures. Others were useful to make mortars, rammers, cooking tools, drums, hoe handles (Fig. a, b and c). Stems cut for wood-service was selective, it systematically took place by cutting rights stems and relatively well-built. Taking into account their domestic use, their cut down was tolerated, often neglected and remains ignored. However, it was one of the shapes most destroyed of woody species cover because of the selective mode of cutting stems.

3.7. Structure of the Exploited Species

Among the 33 most exploited woody species for fuel wood, the availability stems of 10 was presented in the table below. *Guiera senegalensis* (67.61 stems/ha^2); *Anogeissus leiocarpus* (58.76 stems/ha^2), *Balanites aegyptiaca* (32.57 stems/ha^2), *Combretum collinum* (29.87 stems/ha^2), *Hexalobus monopetalus* (25.79 stems/ha^2) and *Ziziphus mauritiana* (23.19 stems/ha^2) were most abundant species (Table V). On the other hand, *Dalbergia melanoxylon* (1.73 stem/ha^2), *Terminalia macroptera* (1.54 stem/ha^2), *Pterocarpus erinaceus* (0.85 stem/ha^2), *Vitellaria paradoxa* (0.33 stem/ha^2), *Crossopteryx febrifuga* (0.14 stem/ha^2) and *Ficus ingens* (0.04 stem/ha^2), had a very low stems number. Taking into account the importance of the fuel wood cut pressure on requested woody species, it had a significant constraint on the survival of woody species which become increasingly scarce while threatening the ecological aim.

3.8. Impact of the Cutting Mode on Woody Species

Pressures related to the manifold uncontrolled human involvements on trees were exploited of fuel wood and wood service, sporadic increase of bush fires, harvest of non timber forest products, overgrazing, and extension of farming fields. The fuel wood exploitation was made by two principal modes of cut: whole cut down of stem and partial cut of stem (Fig. 8 a, b and c). The exploitation practice by cutting down stems of woody species was an activity which missed organization, of a follow-up and techniques of implied actors.

The total number of stumps indicating the fully cut down of stems was 20451 and that of partial cut was 9427 stems representing respectively a proportion of 20.91 % and 9.64 % of stems counted. The number of full and

partial cut stems was varied at each species (Table VI). For the fully cut down stems, the most cut species were: *Anogeissus leiocarpus* (3918 stumps), *Guiera senegalensis* (3416 stumps), *Balanites aegyptiaca* (2075 stumps), *Combretum collinum* (2007 stumps), *Hexalobus monopetalus* (1193 stumps), *Ziziphus mauritiana* (1135 stumps) and the least cut with less than 10 stems are: *Ximenia Americana*, *Annona senegalensis*, *Grewia venusta*, *Piliostigma thonningii*, *Terminalia laxiflora*, *Daniellia oliveri*, *Vitellaria paradoxa*, *Maerua crassifolia*, *Mitragyna inermis*, *Adzadirachta indica*, *Crateva adansonii*, *Crossopteryx febrifuga*. The partial cut was accentuated on *Balanites aegyptiaca* (2405 stems), *Guiera senegalensis* (1790 stems), *Anogeissus leiocarpus* (1546 stems), *Combretum collinum* (472 stems), *Ziziphus mauritiana (*350 stems), *Hexalobus monopetalus* (295 stems) and *Piliostigma reticulatum* (277 stems). The intensity of cut down trees varied between the two cutting modes and various exploited species. This variability was highlighted by calculating the variance which showed a significant difference ($p < 0, 0001$). The practice of the exploitation by cut down trees was very frequent on various species in a year; it could contribute to the removal of significant stems in the vegetable settlement. The number of cut stems permits that in future resources will rarefy. Moreover, the exploitation was intensive and selective on stems of requested species. The height of cut down stems (stumps) varied between 30 and 60 cm top of ground; at this level, stumps were exposed and the probability of renewal were less significant than those of the mortality. The mortality of Stumps represents a significant factor of degradation of the resource. The activities of cutting down the trees constituted at all levels a serious threat for exploited species and remained a significant factor of the degradation of woody species.

3.9. Fuel Wood Cut Pressures on Species Structure

The potential stems available of exploited species are shown through their density which was assessed of 386.90 stems/ha. The density of fully cut down trees was 106.52 stumps /ha^2 and that of partial cut was 49.1 stems /ha^2. This density was varied between species from 0.14 stem/ha^2 (*Crossopteryx febrifuga*) to 67.61 stems/ha^2 (*Guiera senegalensis*). This variability was highlighted by calculating of the variance which showed a significant difference ($p = 0,021$).

The most species exploited for fuel wood were: *Anogeissus leiocarpus*, *Balanites aegyptiaca*, *Prosopis africana*, *Detarium microcarpum*, and *Pseudocedrela kotschyi* had a variable diametric structure of the stems distribution (Fig. 9). The structure of stems distribution had a pace in "bell" for *Prosopis africana*, *Pseudocedrela kotschyi* and a shape of the fish curve in the case of *Anogeissus leiocarpus*, *Detarium microcarpum* and *Balanites aegyptiaca*. However, there were irregularities between diameter classes, characteristic of scarcity of stems in low diameter class [3-10] cm and those of stems with large diameter as in higher classes than 50 cm. This structure characterises a deceleration of species renewal and the rarefaction of big size stems. These histograms translate the meaning of exploitation impact on stems distribution and exploited species restoration. The intensity of stems cut represents a significant ecological constraint and deeply modified the structure and distribution of these species stems.

4. Discussion

The Fuel Wood was the only source of easily accessible fuel for rural populations. Some households and bakers use beside fuel wood, oil paraffin and gas butane. These results approached those of [14, 21, 22] whose wilful household fuel wood in needed in some Africans sahelian cities. Strong demography in these areas accentuated the fuel wood demand and increase anthropogenic pressure on woody species[14].Considered a yearly fuel wood consumption of 235.2 steres at Maroua for 67187 inhabitants. This consumed quantity exceeded the averages of estimated quantities in other cities, but which could be explained by the tendency of populations to preserve its culinary practices. The exploitation would have largely contributed currently to the reduction of the woody species in this zone. Moreover, [23] showed that the fuel wood consumption yearly by inhabitant in Cameroon was about 2 steres [24].Evaluates with 3.6 kg/person/year, the consumption of charcoal in Yaounde town. This author indicates paucity restaurants and local aluminium pots makers which will respectively use 77 kg and 73.5 kg of charcoal monthly.

Additionally, in several sahelian countries, fuel wood satisfies 60 % (Senegal) and at least 90 % (Niger, Mali) of fuel requirements for rural and urban populations [25, 26]. The recourse to some sources as gas butane for domestic use, electricity and renewable energies as solar type and wind were too expensive and inaccessible for poor populations[27]. Showed that the situation of firewood was alarming in Adamaoua region and worsened these last years with the multiform crisis that crossed Cameroon. This crisis involved a request increased out of charcoal and firewood, thus increasing the rate/rhythm of taking away of significant quantities of wood in the natural forest area. Wood, in spite of its scarcity in the sahelian zones, thus remains the principal source of fuel. The exploitation of woody species for fuel wood was harmful for woody cover and constituted one of main factors in climatic change.

The annual production of the firewood was significant and during these three last years the exploited quantities knew a regression [14-28]. Showed that a significant quantity of wood was exploited to supply Maroua and N'Djamena towns in Cameroon and Chad, respectively. A substantial decrease of firewood produced a quantity of 14.91 % and that of coal produced annually were 7.55 % between 2012 and 2013 and 37.34 % between 2012 and 2014. This drop would be the result of the combining actions of the monitoring with reinforces village committees. Unfortunately, owners were not organized and the exploitation was fraudulent hence production was not all quantified. In several areas of Burkina Faso and Democratic Republic of Congo (RDC), fuel wood produced quantity was increasingly significantly yearly [21-29]. On the other hand, their studies were conducted where activities were well organized and production sources well arranged for sustainable exploitation. The exploited quantities were periodicaly varied per year; they were weaker in farming work and in raining season. Similar observations were made by Ducenne [28]; Schure, et al. [29] for fuel wood production; they showed that the evolution of fuel wood quantities highlights two different rates/rhythms of production, copied on

agricultural activities. The periods of weak production were characterized by abundance rainfalls and frequency which prevented good course of exploitation activities. For charcoal, the production mode, traditional and furnaces technique was largely practised. Similar charcoal production mode was described by Ducenne [28] in Africa subsaharian area.

In the mosaic species enumerated, 18 species were mainly exploited for the charcoal. Similar species were described and identified as the most exploited for fuel wood by [14-29] identified 54 species exploited for fuel wood in which 5 species were used for charcoal production in the forest area. The strength of the whole cut down of stems was 20.91 % and that of partial cut was 9.64 %. The tendency of the curves of distribution of stems of 5 most exploited species showed an exponential decay. This translates the significance of cut activities which strongly influenced the distribution of stems. Cutting activities remained concentrated on big diameters stems above 40 cm. Stems with high and a low diameter scared. Woody cut constitutes a threat for most exploited woody species. The same remark was made by Boussim, et al. [30]; Tchobsala [31] which showed that the wood cut had an influence on the structural, biological diversity, and distribution of species in natural savannas. This structure reveals a downward trend of a general number of stems in lower and higher diameter classes [30, 32]. It was the result of a strong pressure of selective cuts of great stems and that of the bad species renewal. Indeed, the wood cuts repeated do not allowed the vegetation to be quickly reconstituted. The cut down tree, bush fires, pasture and climatic variations were impressed by a regressive tendency woody species. Similar observations were made by Ouedraogo, et al. [1] in sudanian area of Eastern Burkina Faso.

The exploitation of woody species was made by wholly stems cut and partial stem cut (stripping and pruning) where only the air stems were taken. In the Laf forest reserve, [33] described the same cutting methods. Most often, the abusive taking away of woody species for firewood and non timber forest products presented a threat on biodiversity loss and ecosystems degradation [34]. The cutting mode and the recurring bush fires were main feature for damage caused on woody species [30].

The anthropogenic activities were intensive on woody species in the easily flooded plain characterised by it high demography. The pressure of anthropogenic activities involved a deep modification of the vegetation in Maroua plain area [33, 35, 36]. The woody exploiting system was not sustainable; it contributed to the transformation of woody cover land and the destabilization of ecosystem [37].

The rhythm of woody flora degradation was higher in this flooded plain area and related to the exploitation of fuel wood which had a negative action on the stems distribution [35]. Moreover, [38] in the analysis of the evolution of woody cover in savannah woodland revealed the importance of the woody cutting for fuel wood. It showed that in the savannah woodland, woody species had retreated in the last three decades. The increasing fuel wood demand by rural and urban populations was one of the principal causes of the abuse cutting down trees in this zone. The abusive cutting of woody species is a risk of biodiversity loss and ecosystem degradation [1, 35].

5. Conclusion

In the sahelian woodland characterized by the scarcity of woody cover, rural and urban populations exploited woody species for firewood and charcoal. Wholly stem cut down and partial stems cut were used for fuel wood exploitation. Charcoal production process was traditional through traditional furnaces. Significant quantity of firewood and charcoal was annually exploited. The activities generated an important income for farmer's economy and bring an additive rate to their much reduced agricultural production. As the economic implementation of fuel wood, ecological impact was moreover important on woody species. The practice of the exploitation was very frequent on stems of various species yearly and constitutes at all levels a serious threat for exploited species. The intensity of stems cut represented a significant ecological constraint and deeply modified woodland structure. It was an imperative to set up an alternative system to ensure sustainable management of resources. Solutions through introduction and popularization of natural gas, biogas, solar energy and the improved hearths could effectively contribute to reduce the intensity of this activity and to guarantee the maintenance of the ecological balance on the already fragile sahelian ecosystems.

Fig-1. Traditional production of coal: a) stems cut, b) wood stored, c) furnace, d) furnace in combustion, e) conditioning of coal and f) transport of coal.

Source: cliché Froumsia Moksia

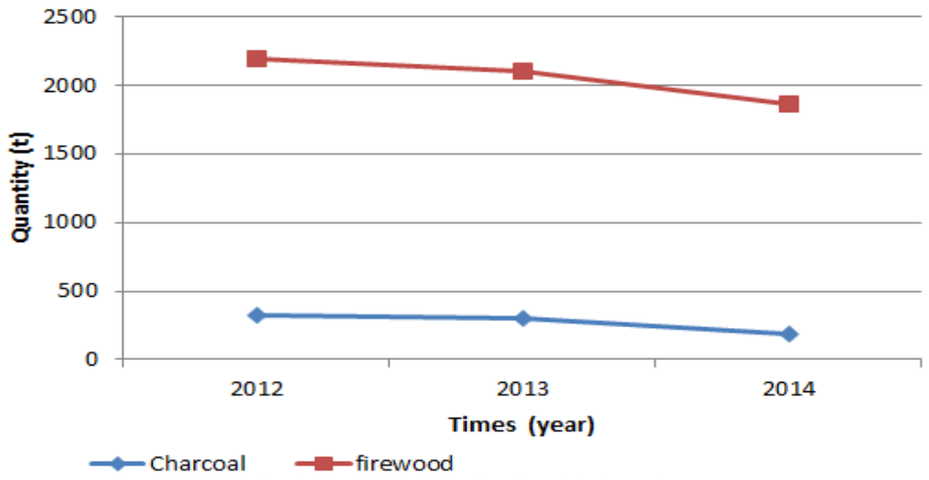

Fig-2. Annual quantity of exploited fuel wood

Source: Froumsia Moksia

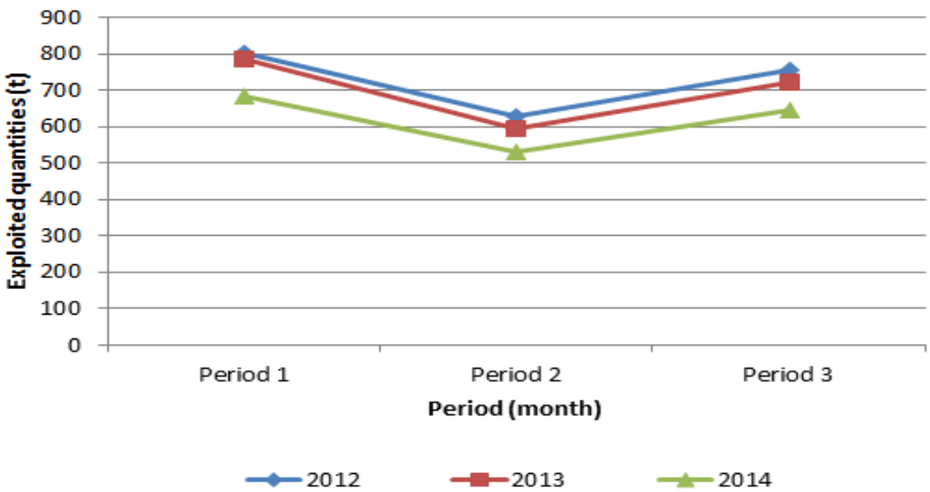

Fig-3. Periodically fluctuation of the exploited quantity of firewood

Source: Froumsia Moksia Data

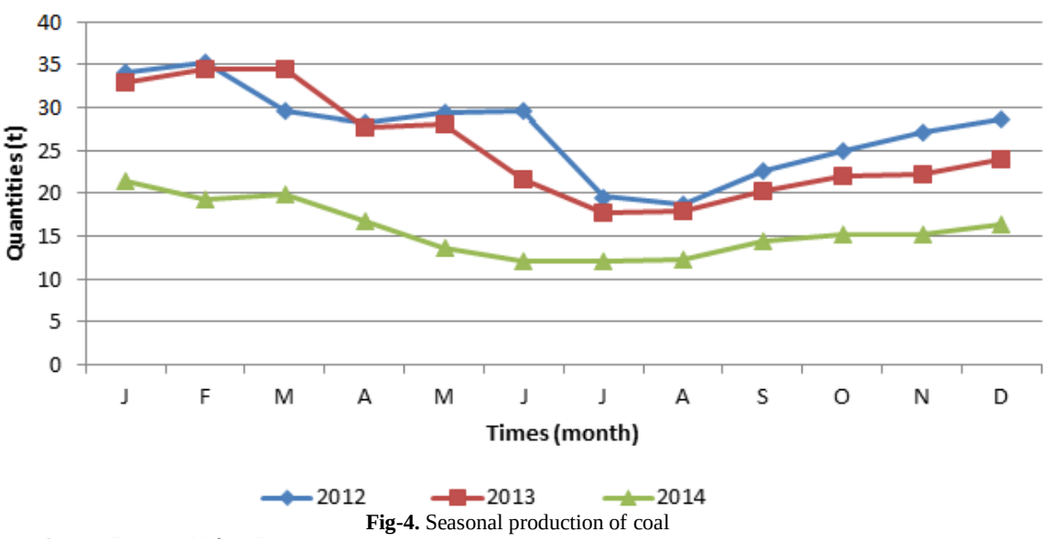

Fig-4. Seasonal production of coal

Source: Froumsia Moksia Data

Fig-6. Means used for fuel wood transport: a) man and donkey, b) carthorse c) and, handcart
Source: cliché Froumsia Moksia

Fig-7. Wood-service exploited: a) shelter support, b) hoes handles and c) mortars and slates
Source: cliché Froumsia Moksia

Fig-8. Stumps and stems of exploited species : a) *Vitellaria paradoxa*, b) *Balanites aegyptiaca*, and c) *Ficus gnaphalocarpa*
Source: cliché Froumsia moksia

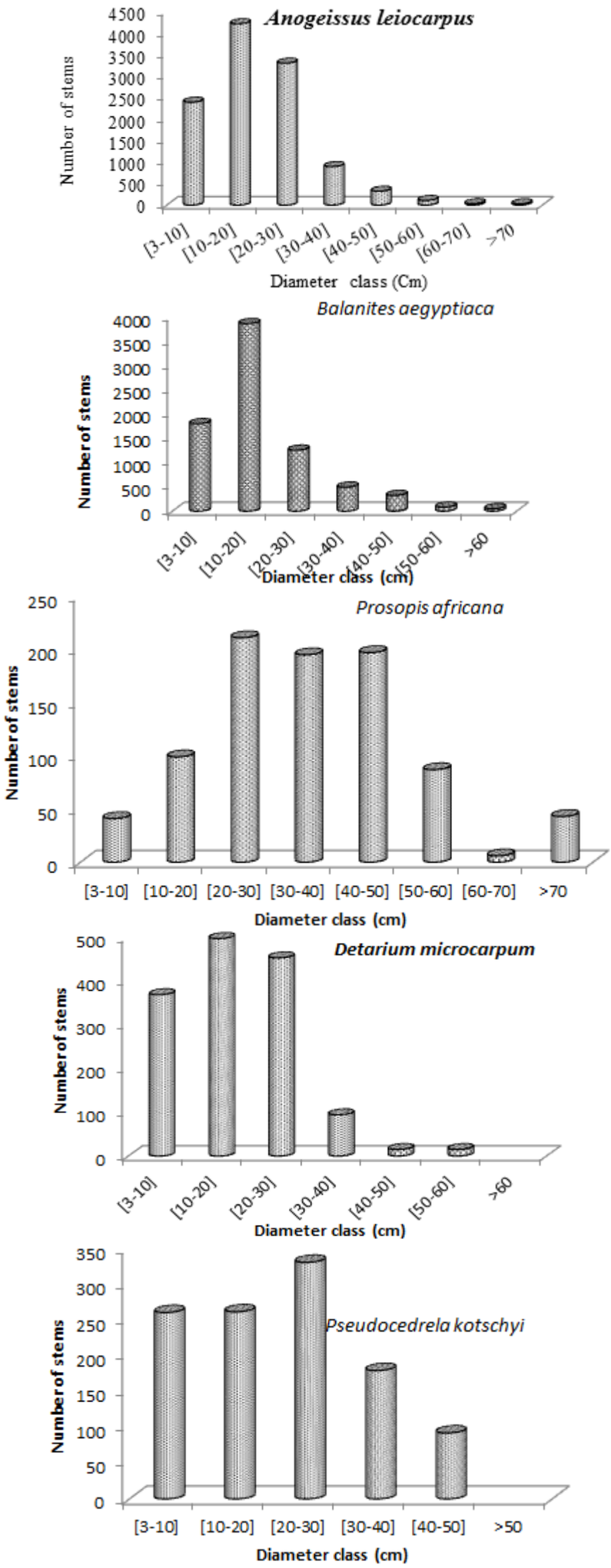

Fig-9. Structure of the 5 most exploited species for fuel wood
Source: Froumsia Moksia Data

Table-1. Utilisation of fuel sources by populations.

User	Firewood (%)	Charcoal (%)	Paraffin oil (%)	Gas Butan (%)
Local beer Brewers	100	0	0	0
Shepherds	100	0	0	0
Households	90.42	2.37	2.43	4.78
restaurant owners and bakers	37.73	39.82	18.08	4.37
Roasted meat salesmen	100	0		0
Mean	85.63	8.44	5.13	1.83

Source: Froumsia Moksia's data

Table-2. Average charge of transport means and income generated.

Transport mean	Number	Average charge (kg)	Unit price (F CFA)			Total price (F CFA)	Taxes (F CFA)	Income average
			P 1	P 2	P 3			
Man	270	15±2.14	500	800	600	7 750 600	775 060	25 850
Donkey	127	45±2.22	1 500	1 800	1 600	9 615 300	961 530	68 150
Handcart	87	205±10.6	4 000	6 000	5 000	14 972 000	1 497 200	154 900
Carthorse	71	445±16.6	8 000	12 000	9 000	28 680 000	2 868 000	363 550

Source: Froumsia Moksia's data

Table-3. Quantities of marketed charcoal and income generated.

Year	Production (t)	Price ($)		Total price ($)	Average income ($)	annual Taxes ($)
		P_1	P_2			
2012	328.22	5	4	28 036	549.73	2 803.6
2013	303.42	6	5	31 630	620.20	3 163
2014	188.60	7	6	23 299	456.842	2 329.9

Source: Froumsia Moksia's data

Table-4. Most exploited species for fuel wood.

Species	Firewood %)	Charcoal (%)	Species	Firewood (%)	Charcoal (%)
Balanites aegyptiaca	13.96	14.38	*Combretum glutinosum*	2.08	5
Guiera senegalensis	8.96	-	*Combretum molle*	2.08	3.33
Combretum collinum	8.33	-	*Lonchocarpus laxiflorus*	2.08	2.29
Anogeissus leiocarpus	6.67	16.25	*Terminalia macroptera*	2.08	3.13
Terminalia avicennioides	4.38	3.54	*Senna singueana*	1.88	-
Hymenocardia acida	4.17	-	*Acacia hockii*	1.67	-
Acacia seyal	3.96	-	*Combretum fragrans*	1.25	3.75
Pseudocedrela kotschyi	3.96	5.83	*Piliostigma reticulatum*	1.25	-
Ziziphus mauritiana	3.96	2.08	*Securidaca longepedunculata*	1.04	-
Hexalobus monopetalus	3.75	-	*Ficus ingens*	0.83	2.92
Strychnos spinosa	3.33	3.13	*Flueggea virosa*	0.83	-
Prosopis africana	3.33	11.04	*Pterocarpus erinaceus*	0.83	3.13
Feretia apodanthera	2.71	-	*Bridelia feruginea*	0.63	-
Dichrostachys cinerea	2.5	-	*Gardenia ternifolia*	0.63	-
Ambligonocarpus andongensis	2.29	5.21	*Crossopteryx febrifuga*	-	3.54
Detarium microcarpum	2.29	8.75	*Vitellaria paradoxa*	-	2.71
Swartzia madagascariensis	2.29	-		-	-

Source: Froumsia Moksia's data

Table-5. Evaluation of abundance of 10 most exploited species.

Specie	Density (Stems/ha)	Relative frequency (%)	Relative dominance (%)	Relative density (%)
Guiera senegalensis	67.61	1.79	7.62	13.27
Anogeissus leiocarpus	58.76	1.79	12.64	11.53
Balanites aegyptiaca	32.57	1.79	7.83	6.39
Combretum collinum	29.87	1.79	3.23	5.86
Hexalobus monopetalus	25.79	1.79	2.47	5.06
Ziziphus mauritiana	23.19	1.60	3.91	4.55
Combretum molle	18.24	1.79	3.25	3.58
Acacia seyal	15.29	1.60	1.57	3.00
Combretum glutinosum	12.81	1.79	2.21	2.51
Piliostigma reticulatum	11.33	1.75	0.96	2.22

Source: Froumsia Moksia's data

6. Acknowledgement

The authors are indebted to the anonymous reviewers for their positive comments and suggestions for better improvement of the manuscript.

Table-6. Impact of the cutting trees manner on woody species

Specie	Stumps	Partial cut	Specie	Stumps	Partial cut
Anogeissus leiocarpus	3918	1546	*Tamarindus indica*	62	52
Guiera senegalensis	3416	1790	*Lannea schemperi*	52	38
Balanites aegyptiaca	2375	2405	*Hymenocardia acida*	50	-
Combretum collinum	2007	472	*Senna singueana*	48	-
Hexalobus monopetalus	1193	295	*Terminalia macroptera*	32	23
Ziziphus mauritiana	1135	350	*Boscia senegalensis*	31	63
Piliostigma reticulatum	762	277	*Cassia sieberianna*	29	23
Combretum glutinosum	648	181	*Gardenia ternifolia*	19	-
Acacia seyal	503	125	*Acacia sieberiana*	16	50
Combretum molle	482	93	*Maerua angolensis*	13	24
Pseudocedrela kotschyi	408	281	*Dalbergia melanoxylon*	11	20
Prosopis africana	337	117	*Pterocarpus erinaceus*	11	17
Feretia apodanthera	318	69	*Maytenus senegalensis*	10	13
Terminalia avicennioides	317	136	*Ficus ingens*	10	11
Strychnos spinosa	314	168	*Diospyros mespilisformis*	10	8
Swartzia madagascariensis	260	110	*Vitellaria paradoxa*	9	6
Detarium microcarpum	210	63	*Maerua crassifolia*	7	-
Flueggea virosa	204	42	*Mitragyna inermis*	7	3
Lonchocarpus laxiflorus	157	71	*Adzadirachta indica*	7	8
Ambligonocarpus andongensis	144	73	*Crateva adansonii*	7	4
Securidaca longepedunculata	139	45	*Crossopteryx febrifuga*	5	5
Acacia hockii	139	63	*Ximenia americana*	3	8
Gardenia ternifolia	110	41	*Annona senegalensis*	3	-
Bombax costatum	97	0	*Grewia venusta*	3	-
Bridelia feruginea	86	19	*Piliostigma thonningii*	3	-
Dichrostachys cinerea	85	35	*Terminalia laxiflora*	2	4
Combretum fragrans	84	49	*Daniellia oliveri*	2	-
Ziziphus mucronata	74	-	*Lannea fruticosa*	-	17
Sclerocarya birrea	66	70	*Stereospermum kunthianum*	-	31
Total				20451	9427

Source: Froumsia Moksia's data

References

[1] A. Ouedraogo, A. Thiombiano, H.-H. K., and S. Guinko, "Diagnostic de l'état de dégradation des peuplements de quatre espèces ligneuses en zone soudanienne du Burkina-Faso," *Sécheresse*, vol. 17, pp. 485-491, 2006.

[2] FAO, *Natural resources and the human environment for food and agriculture in Africa*. Rome: FAO Environment and Energy Paper No. 6, 1986.

[3] V. H. Heywood, *Global biodiversity assessment. United nations environment programme*. Cambridge UK: Cambridge University Press, 1995.

[4] S. L. Pimm, G. J. Russell, J. L. Gittleman, and T. M. Brooks, "The future of biodiversity," *Science*, vol. 269, pp. 347–350, 1995.

[5] T. C. Whitmore, W. F. Laurance, and R. O. Bierregaard, "Tropical forest remnants: ecology, management, and conservation of fragmented communities. Tropical forest remnants: ecology, management, and conservation of fragmented communities," 1997.

[6] N. Myers, R. A. Mittermeier, C. G. Mittermeier, G. A. B. Da Fonseca, and J. Kent, "Biodiversity hotspots for conservation priorities," *Nature*, vol. 403, pp. 853-858, 2000.

[7] J. Galindo, "National sustainable protected area financing baseline assessments," presented at the GEF Congo Basin Protected Area Financing Project, Yaoundé: UNDP/GEF/WWF, 2010.

[8] R. Barbault, "Espaces protégés: Stratégie dépassées ou dispositifs d'avenir ?," *Pour la Sciences*, vol. 35, pp. 14-17, 2007.

[9] C. P. Van Schaik, J. Terborgh, and B. Dugelby, *The silent crisis: The state of rain forest nature preserves. In J. Johnson, editor. Last stand: protected areas and the defense of tropical biodiversity*. Oxford, UK: Oxford University Press, 1997.

[10] R. J. Scholes and B. H. Walker, *An African Savanna. Synthesis of the nylsvley study*. United Kingdom: Cambridge University Press, 1993.

[11] J. Menaut, M. Lepage, and L. Abbadie, *Savannas, woodlands and dry forests in Africa. In: Bullock SH, Mooney HA, Medina E, Eds. Seasonally dry tropical forests*. Cambridge, UK: Cambridge University Press, 1995.

[12] S. J. Richardson-Kageler, "Large mammalian herbivores and woody plant species diversity in Zimbabwe," *Biodiversity and Conservation*, vol. 12, pp. 703-715, 2003.

[13] T. G. Wafo, "Les aires protégées de l'extrême-Nord Cameroun entre politiques de conservation et pratiques locales," Thèse De Doctorat en Géographie-Aménagement-Environnement, Université d'Orléans, 2008.

[14] A. Madi, P. Huub, and B. Sali, *La demande urbaine en bois-énergie et nécessité d'une gestion rationnelle des ressources naturelles: Le cas de la ville de Maroua à l'Extrême Nord du Cameroun. In Jamin J.Y., Seiny Boukar L. et Floret C. (Eds). Savanes africaines: Des espaces en mutation, des acteurs face à de nouveaux défis. Actes du colloque, mai 2002*. Garoua, Cameroun: PRASAC, 2003.

[15] G. T. Wafo, "Les aires protégées de l'Extrême-Nord Cameroun entre politiques de conservation et pratiques locales," *L'Information Géographique*, vol. 73, pp. 62-68, 2009.

[16] M. Froumsia, L. Zapfack, P. M. Mapongmetsem, and B. A. Nkongmeneck, "Woody species composition, structure and diversity of vegetation of Kalfou forest reserve, Cameroon," *Journal of Ecology and the Natural Environment*, vol. 4, pp. 333-343, 2012.

[17] M. Froumsia, "Impact des activités anthropiques sur le couvert ligneux dans la réserve forestière de Kalfou, Cameroun," Thèse de Doctorat Ph/D, Université de Yaoundé I, 2013.

[18] R. Letouzey, *Carte phytogéographique du Cameroun au 1/500.000. 1) domaine sahélien et soudanien. IRA herbier national*. Toulouse: Institut de la Carte Internationale de la Végétation, 1985.

[19] E. J. Westphal, J. D. Embrechts, H. A. E. Ferwerda, H. J. W. Van Gils-Meeus, J. M. Mutsaers, and C. Westphal-Stevels, *Cultures vivrières tropicales avec références spéciales au Cameroun*. Wageningen: Pudoc, 1985.

[20] S. Coulibaly, *Résultats de l'inventaire forestier réalisé au niveau de la zone de Sapouy-Biéha (Tome1). Projet PNUD/BKF/93/003 A Aménagement des Forêts Naturelles*. Ouagadougou: DVFAF, DGEF, MEE, 1997.

[21] A. M. Kabré, J. Somda, S. M., and A. J. Nianogo, *Bois-énergie au Burkina Faso: Consolidation des moyens d'existence durable (2006-2009). Ouagadougou, Burkina Faso: (Eds) Bureau*. Burkina Faso: UICN, 2009.

[22] M. Ehemba, "Le biocharbon, quelles stratégies choisir?," *Dossier Le Biocharbon*, pp. 3-6, 2009.
[23] E. Pouna, "Contribution à l'analyse méthodologique des conditions d'intégration de nouvelles technologies de bois-énergie au Cameroun," Thèse De Doctorat, Présenté à l'INPL, 1989.
[24] Ndjodo, *Le marché de charbon de bois à Yaoundé. Mémoire de fin d'études*. Yaoundé: ENSA, 1982.
[25] Anonyme, *Recueil de textes officiels relatifs à la gestion des forêts et de la faune au Cameroun*. Cameroun: Ministère de l'Environnement et des Forêts, 1998.
[26] T. A. Benjaminsen, "Bois-énergie, déboisement et sécheresse au Sahel: Le cas du Gourma malien," *Sécheresse*, vol. 7, pp. 179-185, 1996.
[27] P. M. Mapongmetsem and C. H. Akagou Zedong, "Situation des bois de feu dans les savanes humides de l'Adamaoua," *Flamboyant*, vol. 42, pp. 29-33, 1997.
[28] H. Ducenne, *Guide technique de carbonisation artisanale améliorée*. N'Djamena: Agence Energie Domestique et Environnent (AEDE)-ECO Consulting Group, 2002.
[29] J. Schure, V. Ingram, and C. Akalakou-Mayimba, "Bois énergie en RDC," *Projet*, 2011.
[30] J. Boussim, A. Ouédraogo, and B. Lankoandé, *Etude des impacts écologiques dans les unités d'aménagement forestier des régions du centre-Nord et du centre-Ouest. In: Kabré A. M., Somda J., Savadogo M. et Nianogo A. J. (Eds): Bois-énergie au Burkina Fas: Consolidation des moyens d'existence durable (200-2009)*. Ouagadougou, Burkina-Faso: Bureau, UICN-Burkina-Faso, 2009.
[31] Tchobsala, "Influence des coupes de bois sur la dynamique de la végétation de la zone peri-urbaine de Ngaoundéré Adamaoua," Thèse De Doctorat Ph/D Université de Yaoundé I, 2011.
[32] C. D. Diatta, M. Gueye, K. Soulèye, and L. E. Akpo, "Diversité de la flore et de la végétation ligneuses de la réserve de Ngazobil (Joal-Fadiouth) au Sénégal," *Journal Des Science*, vol. 9, pp. 1-13, 2009.
[33] M. Ntoupka, "Impacts des perturbations anthropiques (pâturage, feu et coupe de bois) sur la dynamique de la savane arborée en zone soudano-sahélienne nord du Cameroun," Thèse De Doctorat. Université Paul Valéry, 1999.
[34] B. Sambou, A. T. Ba, C. Mbow, A. Goudiaby, and I. Sonko, "Evaluation des risques de dégradation de la flore et de la végétation liée à l'exploitation forestière. Hommes, plantes et environnement au Sahel Occidental. Boussim I. J., Lykke A. M., Nombré I., Nielsen I. et Guinko S. Eds," *SEREIN-Occasional Paper*, vol. 19, pp. 185-201, 2004.
[35] R. Letouzey, *Etude phytogéographique du Cameroun. Eds*. Paris: Paul Lechevalier, 1968.
[36] R. Letouzey, "Manuel of forest botanic tropical Africa." vol. 1, ed France: Nogent- Sur -Marne C.T.F.T, 1986, p. 194.
[37] M. Froumsia, *Ecologie et gestion durable de Xylopia aethiopica (Dunal) A. Rich. (Annonacées) dans la zone de contact forêt-savane (Mbitom-Pangar)*. Mémoire de DEA: Université de Yaoundé I, 2007.
[38] T. G. Wafo and F. Huynh, *Caractérisation et suivi de recul des ligneux dans les aires protégées du nord Cameroun analyse par télédétection spatiale dans la réserve de Kalfou*. Alger: Journée d'Animation Scientifique (JAS09) de l'AUF, 2009.