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Research Article

Diversity and potential of firewood used to smoke fresh fish within main fishing basins of northern regions of Cameroon

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Abstract

Fresh fish is a highly perishable commodity, one of the most popular processes to avoid losses in the northern regions of Cameroon is to smoke it. In these regions with fragile ecology, cutting trees for firewood is an activity with a high adverse impact. To develop a sustainable management approach to these natural resources, the present study aims to sample firewood used in the smoking of fresh fish in association with all ecosystem services they provide to stakeholders. From October 2019 to March 2020, a survey was carried out among 120 fishermen and 120 fish processors on the firewood used for smoking fish and the ripples associated with their use. This survey identified 18 tree species used to smock fresh fish. These trees provide many other ecosystem services with tangible and intangible benefits. These trees are of 08 Orders, 10 families, and 14 genera. The most used firewood is *Azadirachta indica*: 16.29%; *Acacia sp*. (12.92%); *Prosopis africana* (11.8%); *Vitallaria paradoxa* (8.43%); *Coffea sp*. (7.87%); *Syzigium guineensis* (6.18%); *Uapaca guineensis* (6.18%); *Milicia excelsa* (6.14%). Moreover, only five of the 18 firewood were cut from cultivated orchards, most of them, 64.7% were spontaneous trees which are endangered by this activity. However, it is important to emphasize the sustainable management of these resources to limit the consequences linked to deforestation.

Keywords: Fish, firewood, smoking, northern Cameroon

1. Introduction

Fish is a valuable source of nutrients that contributes significantly to nutrition and food security, entering the diet of nearly 2/3 of the world's population (FAO, 2012; Béné *et al.,* 2016). However, due to a lack of sufficient means of preservation and processing, nearly a quarter (1/4) of the fish caught is either lost or loses its nutritional qualities before reaching the consumer (Hissein *et al.,* 2018). Traditionally, this loss of fresh fish is delayed by its processing either by drying or smoking. These two practices make it possible to build up reserves for the low fishing seasons, supply fish to populations living in remote areas and place it on the market. products corresponding to eating habits (FAO, 2009). The smoking which is commonly used in the northern part of Cameroon is the traditional open ovens that consume excess firewood and again, those in this smoking practice are reliable in contacting dangerous diseases due to their constant contact with the smoke (Ekomy *et al.,* 2013). The strong use of fish smoking implies a strong exploitation pressure on firewood resulting in abusive and irrational exploitation of trees in this part of the country with a fragile ecology. The removal of these products from the forest can therefore be considered a source of deforestation, but also of forest degradation (IUCN-PC, 2013). Yet close to 8 million people, living in rural areas and are financially poor, therefore, depend on forests, which are sources of food, medicinal plants, firewood, and building materials (Topa *et al.,* 2010). In addition, the use of certain plants in smoking leads to the deposition on smoked fish of volatile organic compounds known for their carcinogenic properties (Schnatter et al, 2005).

To contribute to sustainable and safe exploitation of this resource, knowledge of the wood used as a source of energy in the smoking of fish becomes a necessity. The objective of this study is to list the plants whose woods are used in the smoking of fish in northern Cameroon to determine the most suitable and to propose ways for the sustainable management of these resources. It is therefore a question of making a descent into the main fishing basins in this part of the country to identify the plants used, quantify their use and assess the dependence of the actors on this resource.

2. Material and Methods

2.1. Sampling site

The part of Cameroon above the 6th parallel north includes three administrative regions: Adamaoua, North and the Far North. This geographical area covers two agroecological zones: the high Sudano-Guinean savannas and the Sudano-Sahelian zone. The dry and humid Sudano-Guinean area that covers the region of Adamawa is dominated by humid savannas where about 1200mm of rainfall per year (Manetsa *et al.,* 2011), allowing an important agricultural and livestock activity; there are two important fishing basins. The soils are volcanic basalts, a combination that dominates up to the Faro River. To the East of the region, granites continue to reign with the sedimentary forms of rock from the Mbere River valley, and an area of metamorphic rock surrounds them. These soils consist mostly of red or brownish laterite, the result of mountain erosion due to alternating dry and wet seasons. In this zone, two Departments were prospected: the department of Djerem where were explored Mbakaou and Saxon and the department of Mayo-Banyo where Ali-Mali and Ndoumdjandi were explored. The Sudano-Sahelian domain which covers two regions (the Far North and North) is dominated by a typically hot and dry tropical climate. Less than 800mm of rainfall is recorded there per year (Djoufack *et al.,* 2012). Agriculture and livestock are the main activities of the local population. Tropical ferruginous soils, ferallitic soils, hydromorphic soils and recent alluvial soils dominate in the Benoue basin, while

lithosols sometimes associated with poorly evolved soils are limited to mountainous reliefs (GIZ/PARSE-AD, 2017). Topomorphic vertisols and hydromorphic soils cover the floodplains of Logone (Mayo-Danay).

In this agroecological zone, two Departments were explored in each Region: Mayo-Danay and Logone and Chari in the Far North region; Benoue and Mayo-Rey in the North. At each department, two fishing and fish processing sites were explored: Tekele and Yagoua in the Mayo-Danay; Goromo and Zina in Logone and Chari; Lagdo and Garoua in Benoue; Tcholire and Rey-Bouba in the Department of Mayo-Rey.

2.2. Sampling approach

During the 2019/2020 fishing season, a survey was carried out in the three northern regions of Cameroon. From October 2019 to March 2020, fishermen and processors were interviewed based on an investigation sheet. At each site, 10 fishermen and 10 processors with at least 5 years of experience in the trade were interviewed. A total of 120 fishermen and 120 processors were surveyed during the fishing season.

The information gotten through the questionnaire covered the socio-professional characteristics of the persons (Name, age, ethnicity, nationality, length of experience and other activities carried out). The questions were also asked about the actors on the firewood used for smoking fish, the reason for their choice, the intensity of use of these woods, their socio-economic importance and the risks to which these actors are exposed. The various answers were noted and the counting was done at the end of the survey.

For identification, the plants cited were registered under their local names. When it was possible to get the tree that supplies the wood, elements of its aerial parts that can help in the identification of trees (leaves, flowers, fruits…) were gathered and a herbarium formed; names in local vehicular languages were searched and noted. The identification of these trees was done with the support of botanists of the University of Ngaoundere and the leadership of fishing centres. To distinguish the different results obtained, Microsoft Excel was used to calculate the frequencies and to realize the figures.

3. Results

3.1. Presentation of the surveyed population

The surveyed population consisted of fishermen and processors. Fishermen are those whose profession was fishing, whether or not they own a boat or fishing gear. They are mainly made up of men (95%) in all the localities surveyed except for the Benoue basin where some women (5%) like Djoukouns, Laka and Hausa have been registered in this category of actors whose dominant age (38.75%) is between 30 and 40 years old. Processors are those who smoke (in an oven) or dry (in the sun) the fish to get the dry fish. On the other hand, this category of actors is dominated by women (57.5%) who are usually the wives of fishermen or traders. The dominant age in this category is between 40 and 50 years. Smoking is also practised by men (42.5%) who are either traders or foreigners from neighboring countries such as Nigerians and Chadians found in Mayo-Danay and Benoue; Nigerians, Nigeriens, Malians... present in the department of Mayo-Banyo. In addition to their main activity (fishing and smoking fish), they also carry out other activities such as Agriculture (33.23%), trade (18.67%) and some are civil servants (3.80%) (Figure 1).

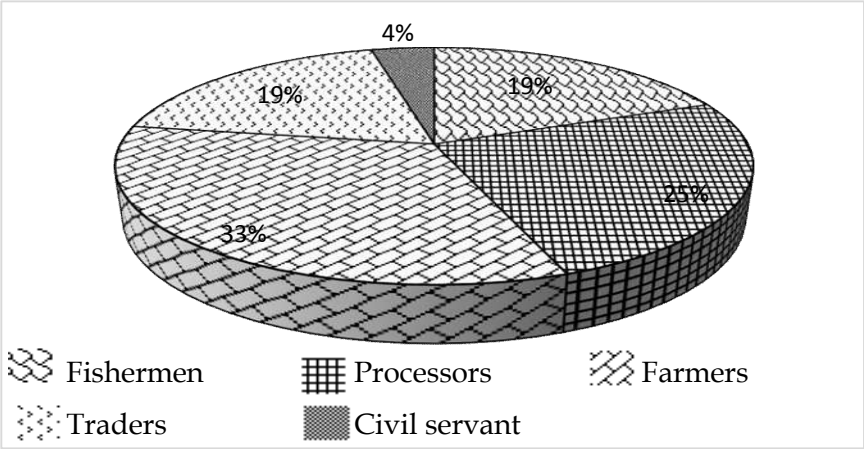

Figure 1: Socio-professional status of the surveyedpopulation

3.2. Inventory and importance of trees providing firewood for fish smoking in Northern Cameroon

3.2.1. Plants Listed

During our sampling, 18 different plants used for smoking fish were identified. These plants are divided into 8 orders, 10 families and 14 genera as shown in the table below (Table 1). Their names vary from one locality to another community and from one language to another, according to their services to the population.

Table 1: Variety of trees providing wood for smoking fish

Family	Scientific names	Fulfuldé	Massa	Gbaya	Mboum
Anacardiaceae	*Mangifera indica* L.	Mongoro			
	Anacardium occidentale L.		Anana		
Meliaceae	*Azadirachta indica* A. Juss.	Gagné			
Hymenocardiaceae	*Hymenocardia acida* Tul.	Samatadjé			
Mimosaceae	*Acacia seyal* Del.		Guilar Hlawna		
	Acacia nilotica (L.) Willd. ex Del.		Malendjena		
	Acacia sieberiana DC.		Swenga		
	Acacia polyacantha Willd.		Guilar Ha'na		
	Faidherbia albida (Del.) Chev.	Tchaski	Tchoutna		
	Acacia sp.				
Moraceae	*Milicia excelsa* (Welw) C.C. Berg.			Iroko	Iroko
Myrtaceae	*Eucalyptus* sp.		Ecalyptusna		
	Sizygium guineense (Willd.) DC.	Assourahi		Zomoli	Asora
Phyllanthaceae	*Uapaca guineensis* Muell. Arg.			Bobo	
Rhamnaceae	*Ziziphus mauritiana* Lam.	Djahbé	Waina		
Rubiaceae	*Coffea* sp.				
Sapotaceae	*Vitellaria paradoxa* Gaertn. f.	Karedjé	Koudina	Kol	Soro
	Prosopis africana (Guill. & Perr.) Taub.		Hoina		

3.2.2. Frequency of firewood use in fish smoking

Fish conservation is not the only goal sought in fish smoking. Some traditional dishes are prepared with smoked fish giving them a special flavor and taste. Thus, smokers have developed preferences for certain species of wood for their calorific attributes and their ability to influence the organoleptic properties of smoked fish by giving them a good coloration and a sweet fragrance. In each of these communities, actors tend to use more redwoods (*Azadirachta indica* (16.29%), *Prosopis africana (*11.8%)) and/or yellow woods (*Acacia* sp. (12.92%)), which, according to them burn very slowly and emit very little smoke compared to white woods. Other woods are also widely used because of their availability (Table 2).

The most used firewoods in the department of Djerem are *Prosopis Africana* (11.8%) and *Vitellaria paradoxa* (8.43%), while in the Mayo-Banyo, the most used are *Coffea* sp (7.87%) and *Melicia excelsa* (6.74%). In Benoue, on the other hand, processors use much more of *Azadirachta indica* (16.29%) and *Acacia* sp (12.92%), whereas in Mayo-Danay it is rather the plants' genus *Acacia sieberiana, A. polyacantha* (3.93%) and *Ziziphus mauritiana* (2.81%) that are the most used. Indeed, some plants have great adaptability and grow on any type of soil (*V. paradoxa*) including flooded soils (*Eucalyptus* sp.) while many prefer moist soils or proximity to shallows (*Sizygium guineense*), sandy clay (*Prosopis africana*), others deep clay soils (*Acacia* sp.), sandy limonous, well-drained and does not support stagnant waters, frequent or prolonged floods (*Mangifera indica, H. acida*). Thus, depending on the nature of the soil and the climatic conditions that vary from one department to another in the area of study, the distribution of plants varies from one department to another. This would justify the fact that some plants are used more in some departments than others.

3.2.3. Bioavailability, importance of plants and risks associated with their use in fish smoking

3.2.3.1. Bioavailability and socio-economic importance of plants used for smoking

Plants are at the centre of human life, as they perform well-enslaved services. Ecosystem services are the benefits that people can derive from ecosystems; they can be classified as supply services, lumber and firewood, regulatory services for example, water regulation, and cultural and recreation services (**Table 3**). Some trees that provide firewood for fish smoking are grown in orchards (*M. indica* (2.25%), *Coffea* sp. (7.87%), *A. accidental* (2.25%)); planted to beautify cities (*A. indica* (16.29) or finally are not yet domesticated and are wild trees in the savannah. Many of them provide many ecosystem services to the population: Food (*Magifera indica*, *Anacardium occidental* (2.25%), *Sizygium guineense* (6.18%); Lumber (*Milicia excelsa* (6.74%), *Eucalyptus* sp.(0.56%), *Uapaca guineensis* (6.18%); Firewood (*Hymenocardia acida* (3.37%), *Prosopis africana* (11.8%); Soil fertilization (*Faidherbia albida* (0.56%), *Acacia polyacantha* (3.93%)); Wind breeze (*Acacia seyal* (0.56%); Insecticide (*Hymenocardia acida* (3.37%), *Azadirachta indica*); Medicinal (*Ziziphus mauritiana* (2.81%), *Acacia polyacantha* (3.93%)). In the Logon generally and in the Massa, Mousgoum and Toupouri lands, in particular, the woods of *Prosopis africana*, because of their strength and hardness, are used as support for millet and Hangar attics; for the manufacturing of agricultural tools (Houe's Handles, axe, cart etc...) in-house tools (household tools) such as mortar and pestle. Its leaves and dry pods are used as fodder for domestic animals (especially beef). The branches of *Ziziphus*

mauritiana are used to make sticks and those of *Azadirachta indica* to make the roofs of the huts. The high pressure of their use for fish smoking causes a threat to the survival of wild plants that are not maintained by regular introductions to orchards.

3.2.3.2. *Risks of using plants in fish smoking*

The use of plants in fish smoking causes health risks to processors due to smoke inhalation, burns and heat exposure. Smoking activities are carried out in thick layers of smoke and operators are exposed to respiratory, eye and even cardiovascular problems. This operation is considered an energy-consuming and potentially environmental problem.

Table 2: Frequency of firewood for smoking fish.

Regions	**Places**	Scientific names of plants	**% Use**
Adamawa	Mayo-banyo (5)	*Coffea* sp.	7.87
		Hymenocardia acida Tul.	3.37
		Mayo-Banyo (5) *Milicia excelsa* (Welw) C.C. Berg.	6.74
		Sizygium guineense (Willd.) DC.	6.18
		Uapaca guineensis Muell. Arg.	6.18
	Djerem (4)	*Eucalyptus* sp.	0.56
		Hymenocardia acida Tul.	3.37
		Prosopis africana (Guill. & Perr.) Taub.	11.80
		Vitellaria paradoxa Gaertn. f.	8.43
North	Bénoue (4)	*Acacia* sp.	12.92
		Anacardium occidentale L.	2.25
		Azadirachta indica A. Juss.	16.29
		Mangifera indica L.	2.25
Far-North	Mayo-Danay (6)	*Acacia seyal* Del.	0.56
		Acacia nilotica (L.) Willd. ex Del.	3.37
		Acacia sieberiana DC.	3.93
		Acacia polyacantha Willd.	3.93
		Faidherbia albida (Del.) Chev.	0.56
		Ziziphus mauritiana Lam.	2.81

Table 3: Analysis of the bioavailability and socio-economic importance of trees used as firewood through their mainecosystem services

		Ecosystems services provided to the population								
Plants	*Bioavailability*	Hardware services				Intangible services				
Acacia sp.	Spontaneous plant			BO	MD	-	-	-	-	Shady
Acacia nilotica (L.) Willd. ex plantDel.	Spontaneous	AL	BC	BO	MD	-	-	-	-	Ornamental
Acacia polyacantha Willd.	Spontaneous plant	AL	BC	BO	MD	-	-	-	Fert	-
Acacia seyal Del.	Spontaneous plant	AL	BC	BO	MD	-	BV	H/M		Shady
Acacia sieberiana DC.	Spontaneous plant	AL	BC	BO	MD	-	-	-	-	
Anacardium occidentale L.	Cultivated plant	AL		BO	MD	-	-	-	-	Shady
Azadirachta indica A. Juss.	Cultivated plant	AL	BC	BO	MD	PI	-	-	-	Shady, Ornamental.
Coffea sp.	Cultivated plant	AL	-	-	-	-	-	-	-	-
Eucalyptus sp.	Cultivated plant			BO	MD	-	-	-	-	-
Faidherbia albida (Del.) Chev.	Spontaneous plant	AL	BC	BO	MD	-	-	-	Fert	-
Hymenocardia acida Tul.	Spontaneous plant	AL	BC	BO	-	PI	-	-	-	-
Mangifera indica L.	Cultivated plant	AL	BC	BO	MD	-	-	-	-	Shady
Milicia excels	Spontaneous plant		BC	BO	MD	-	-	-	-	-
Prosopis africana (Guill. & Perr.) Taub.	Spontaneous plant	AL	BC	BO	MD	-	-	-	-	-
Sizygium guineense (Will) DC.1828	Cultivated plant	AL	BC	BO	MD	-	-	-	-	-
Uapaca guineensis	Spontaneous plant	AL	BC	BO	MD	-	-	-	-	-
Vitellaria paradoxa Gaertn. f.	Spontaneous plant	AL	BC	BO	MD	-	-	-	-	-
Ziziphus mauritiana Lam.	Spontaneous plant	AL	BC	BO	MD			H/V		Shady

Ecosystem services with material benefits. BO= lumber production; BC=firewood; Al=food/spices/forage; MD=medicinal;PI= insecticide plant; BV=Windbreak; HV/M=live/dead hedges; Fert=fertilizer plant

4. Discussion

4.1. The importance and variation of the forest depend on the environment.

Forests in general provide many benefits to society through the various economic activities created in terms of employment and income generated from the use, exploitation, and processing of forest products, as well as the benefits related to the regulation of water, climate, and soil protection (FAO, 2014). Some plants were recorded during our survey in some specific areas than others (Tables 1 and 2). This would be justified by their availability, which is influenced mainly by abiotic factors. Indeed, at the heart of ecosystems, soils and plants are influenced by abiotic parameters, such as climate, source rock and topography, and living organisms. According to Freschet *et al.,* (2018), all these biotic and abiotic influences have multiple implications in terms of the genesis, spatial organization and functioning of the soils, as well as the structuring of plant communities. Thus, the combination of a small number of bioclimatic variables makes it possible to predict the distribution of vegetation types in different continents in a very realistic way (Prentice *et al.,* 1992). At the local level and within a type of climate, properties and disturbance regimes are two main factors that determine the presence of species and plant communities

(Chapin *et al.,* 2011).

4.2. Use of plants in fish smoking and their consequences

The plants recorded as the most used in the study area during the survey are: *Azadirachta indica*, *Acacia* sp, *Prosopis africana*, *Vitellaria paradoxa*. This result is different from that of Hyacinthe et al 2018 who found Sambi (*Uapaca guineensis*) and Azobe (*Lophira alata*) as the most used plant for smoking in coastal areas of Cameroon. According to Kaina *et al.,* 2018, these plants are highly sought after because of their high calorific power. This would explain their increased use in some fishing ponds where these species are available. The other woods are probably used because of their availability and the scarcity of wood sought. Commonly used smoking systems (traditional methods) are considered energy-consuming and potentially environmental (plant loss) and health problems (Ndoye *et al.,* 2002). Contrarily to the coastal regions of Cameroon which use another combustible nutshell, animal and vegetable trash including kitchen trash to reduce or limit deforestation without using firewood for smoking fresh fish (Hyacinthe et al 2018), only firewood is used to smoke fish in the Northern regions of Cameroon. According to Valeix et al. (2004), predatory resource exploitation is not organized in space and time, not considering the autecology and the natural resilience or regeneration of exploited forest species, freeing itself from how local communities are organized and ignoring the legal framework for such activities is a risk for the sustainability of ecosystems. in the short, medium or long term. Wood extraction is a cause of degradation of plant formations (Fontondji, 2007) which hurts the environment and health. In the environment, the most noticeable consequences boil down to climate change, the main impacts of which in the Sudano-Sahelian region are related to changes in rainfall patterns. The distribution of rainfall over time has a great impact on productivity, especially after cultivation. This would lead to significant declines in production, ranging from 10 to 25 per cent, particularly for sorghum and long-cycle maize. (UINC-PC 2013).

4.3. Consequences of wood combustion on human and environmental health.

Also, depending on the wood essence and the combustion temperature, different contaminants can be found in the smoke released during the burning of wood: carbon monoxide, volatile organic compounds (VOC), acrolein and formaldehyde, fine particles (PM 2.5), nitrogen oxides and PAHs, dioxins and furans (Kjällstrand *et al.,* 2000; Mitra *et al.,* 2002; Bhargava *et al.,* 2002) which also hurt the environment and human health. The environmental impact of VOC is related to their chemical reactivity with other gaseous compounds in the atmosphere, one of the consequences of which is the production of Ozone, which induce impacts on the vegetation. Ozone can disrupt the activity of photosynthetic plants, alter their resistance, decrease crop productivity, and cause characteristic lesions (Bergmann *et al.,* 1995; Gimeno *et al.,* 2004). In human health, smoking operations are carried out in thick layers of smoke and operators are exposed to respiratory, eye and even cardiovascular problems (Ekomy *et al.,* 2013). The effects of PAH lead to central nervous system damage, airway irritation, conjunctivitis, haematological toxicity, and leukaemia risks (Schnatter *et al.,* 2005).

Similarly, aromatic hydrocarbons have irritating properties and can be carcinogenic (INRS

toxicological records). Aldehydes are known to be fragrant, and their health effects are not yet fully identified. However, they have been proven to be irritating to the mucous membranes, especially those of the airways (nose, lungs). In addition, they are also suspected of being vectors of cancer. Among them, formaldehyde causes itching if in contact with the skin and irritation of the mucous membranes, eyes and airways.

5. Conclusion

In a nutshell, it was all about listing the plants used as firewood in the smoking of fish in northern Cameroon. A total of 18 plants, of which 5 were cultivated and 13 spontaneous were recorded in the study area. A strong use of fish smoking implies a strong exploitation pressure on firewood resulting in abusive and irrational exploitation of trees in this part of the country with a fragile ecology. This promotes global warming by accelerating deforestation and the emission of smoke that carries greenhouse gases. To limit these consequences, it is, therefore, necessary to use improved ovens that consume less energy than the traditional ovens currently used in northern Cameroon and create parks or orchards of the most used plants to promote sustainable management of these resources.

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Declaration of interests

The authors of this article do not declare any conflictof interest.

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