Ethnobotanical study of indigenous woody plants in traditional agroforestry of the Sudano-Sahelianzone of Cameroon: case of Mandara Mountains

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Abstract

A study was carried out in the district of Meri, located in Mandara Mountains (Cameroun) in order to valorize and conserve indigenous plant resources for the sustainable use. This study identified woody plants and their capacity to meet the needs of the local populations in a sustainable manner observed in traditional agroforestry. The Participatory Rural Appraisal Method was used to the collect ethnobotanical and socio-economic data with 100 persons. The Analyses of the results obtained from the questionnaires revealed that 50 woody species distributed in 25 families were conserved or planted by local populations in their agrosystems. That was also noted that leaves were the most used part with a percentage of 74.46 %. About 61.70% of species (31 species) were used as edible fruits, 51.06% of the species are used as firewood, 44.68% of the species are used in medicines, 38.29% of the species are exploited for their roots and 31.91% of the species have useful seeds. The most important species in terms of total use value are: Tamarindus indica (Uvt= 137), Acacia albida (Uvt = 111), Sclerocarya birrea (Uvt = 84), Anogeissus leiocarpus (Uvt = 75), Balanites aegypttiaca (Uvt = 70) and Ziziphus mauritiana (Uvt= 59). Obtained information can contribute to valorize and conserve indigenous plant resources and the local ethnobotanical heritage for the sustainable use.

Keywords: *Plant resources, ethnobotanical study, Mandara Mountains, Cameroon, sustainable use.*

I. INTRODUCTION

Recognition of the role of Non-Timber Forest Products (NTFPs) in community livelihoods has stimulated the interest of re-establishing these products in forest management. Conservatives, foresters, development actors and local populations are currently very interested in these products, particularly for their potential [1]. Furthermore, the exploitation, use and sale of NTFPs represent the local population's way of life. These NTFPs are sources of energy, food, medicines and service products and, for peasants without sufficient resources, they are real safety nets.

The northern part of Cameroon is characterized by southerly and Sahelian-type climates towards the north direction. These types of climates favor the establishment of savannas and steppes characterized by low plant diversity compared to equatorial forests [2].

Nevertheless, despite the low density of plants, local population's increasing needs for them have given rise to various forms of exploitation that do not always guarantee the intrinsic capacities of the resources to regenerate ([3], [4], [5], [6] and [7].

Besides global climate change, over-exploitation affects the availability of NTFPs in natural land. They cause the reduction of the number of species and the alteration of the structure and composition of plant communities [8].

In the Sudanian and Sahelian phytogeographical sectors of Cameroon, few quantitative ethnobotanical scientific data are available. It is necessary to make useful wild plants known with their use values, to popularize them and to recommend effective conservation strategies through in situ conservation[9] or by integrating them into agroforestry [10].

The main objective of this work was to identify NTFPs used by local populations not only to benefit from them but also to better develop effective conservation strategies. The specific objectives were: (1) to access used woody plant diversity in traditional agroforestry in Mandrara Mountains and their harvested organs and (2) to determine values of use of species and the categories of use.

II. MATERIALS AND METHODS

A. Study area

This study was carried out in district of Meri, located in the Mandara Mountains region (Cameroon). Itis in the Sahelian phytogeographical sector[11] and it is bordered to the north by Tokombéré, to the west by Soulede-Roua, to the south by Gazawa and Mokolo and to the east by Maroua[12](Fig. 1). It has a climate that belongs to the Sahelo-Sudanian type, characterized by the existence of a long dry season and a short rainy season covering a period from June to September [13]. Rainfall varies between 600 and 900 mm per year. The average annual temperature is 27 ° C with a maximum of 38 ° C from March to April and at least 18 ° C from December to January[14]. The vegetation is characterized by shrubby and spiny steppes composed of trees, shrubs, and Poaceae [11]. Some characteristic woody plants are: *Anogeissus leiocarpus, Boswellia dalzeilii, Balanites aegyptiaca, Acacia albida, Acacia nilotica, Ziziphus* spp. and *Combretum* spp. Several ethnic groups occupy the district of Méri as Moufou, Guiziga, and Peulhs. However, there are less represented ethnic groups like Mafa, Kapsiki, Moundang, Toupouri. The economy is based mainly on livestock and low-income agriculture. Several types of income-generating activities are developed. These are mainly small businesses, the manufacture and sale of local beer, the storage and sale of foodstuffs and agricultural production (cotton, peanuts, and cowpeas).

Four localities were chosen for this study according to the orientation of the cardinal points (Doulek in the north, Kalliao in the south, Mbozo in the south-east and Godola in the west), to represent the whole extent of Meri. Study was carried out in the traditional agroforestry.

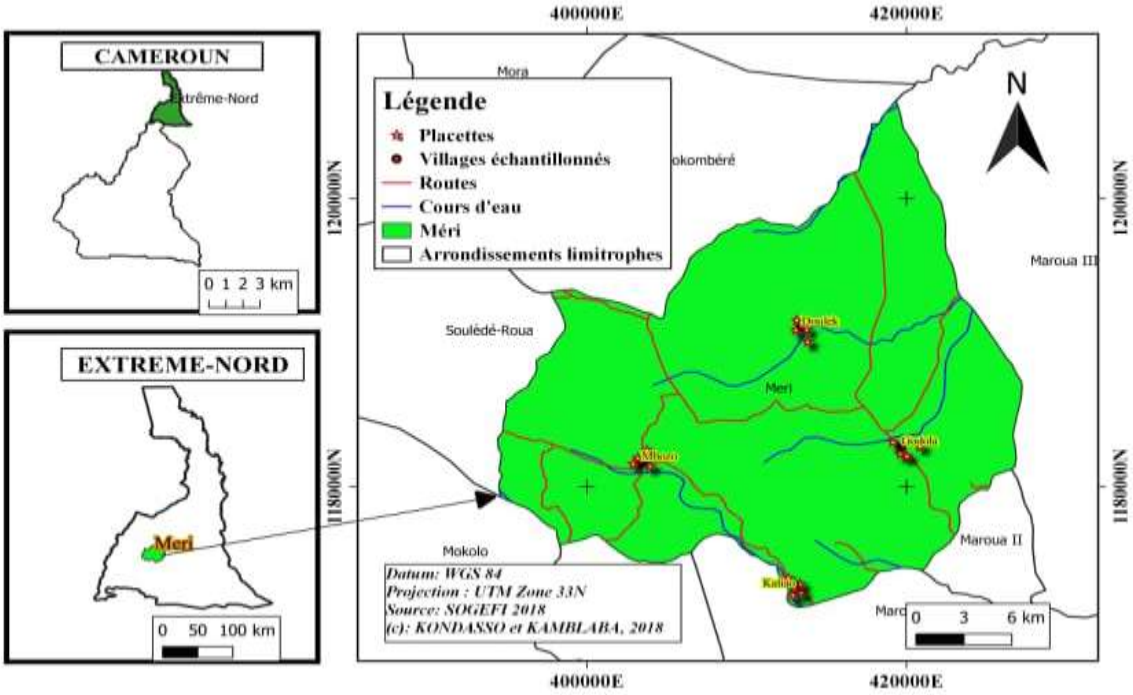

Fig. 1: Location of the study site (this carte is drowned in French)

B. Data collection methods

The ethnobotanical study was carried out during the period from April to September 2017 and covered four localities in Meri subdivision: Doulek, Godola, Kallio and Mbozo. The survey consisted of a survey of 100 persons, drawn randomly across the four localities, with 25 persons interviewed by localities; all aged at least 25 years old. The Participatory Rural Appraisal Method was used to the collect ethnobotanical and socio-economic data. The study was conducted using a semi-structured questionnaire that included the ethnobotanical characteristics of the plants encountered in the study area.It was to give the profile of the informant, species exploited by categories of uses (food, medicinal, energy wood, and fodder and wood crafts) and harvested organs, etc., the study emphasized the importance of Ethnobotanical Use Value (UV) as a

working tool for selecting the most desirable plants. Interviewed persons were represented by 67%, of men and 33%) of women.

C. Data analysis

1) Taxonomic richness of the used plants

The number of species, the number of genera and the number of families were determined. This diversity index makes it possible to assess the potential of the plants used in the study site**.**

2) Response rate

The response rate of organ k of species was calculated using the formula of [15]:

$$F_{ki} = (S_{ki}/N) \times 100,$$

Where S is the number of persons who gave a positive response for the use of organ k and N is the total number of persons interviewed.

The response rate indicates the most used organs for each species. It ranges from 0 to 100. The value 0 indicates that the organ is not used and 100 when the organ is said to be used by all respondents. The total response rate of species i is the sum of F_{ki}.

3) Ethnobotanical Value of Use

The Ethnobotanical Value of Use of the species was calculated according to the method used by [16], [17]and [15]. The Use Value of species i in use category k is represented by its average usage score within this category:

$$Vu(i) = \frac{\sum Sk}{n},$$

Where Sk is the number of positive responses for use category k and n is the total number of respondents for this use category of all studied species.

The total Value of Use of species i is then calculated by the sum of the Values of Use of this species within the different use categories:

$$Vu_T = \sum_{i=1}^{n} (Vu(i))$$

The Value of Use was used to significantly determine which species have a high Value of Use in each environment.

III. RESULTS AND DISCUSSION

A. Diversity of used plant species and harvested organs

At the end of the ethnobotanical surveys, 50 woody species, divided into 25 families were inventoried as exploited species by the populations in traditional agroforestry in Meri Division. These species are multipurpose. Thus, they are a source of food, medicine, fodder as well as firewood and timber. This number is lower than that of [17] who have reached 147 spontaneous species useful in southern Burkina Faso. This difference can be explained by the fact that these authors considered the herbaceous plants and they work in wild and cultivated lands.

Considering the categories of uses, the species used in human nutrition are: *Annona senegalensis, Balanites aegyptiaca, Celtis integrifolia, Diospyros mespiliformis, Parkia biglobosa, Haematostaphis barteri, Vites doniana* and *Ziziphus mauritiana*. For traditional medicine, there are *Boswellia dalzeilii, Khaya senegalensis, Tamarindus indica, Haematostaphis barteri and Acacia albida*. The ones that serve as firewood are:*Anogeissus leiocarpus, Sclerocarya birrea, Acacia albida* and *Balanites aegyptiaca*. This result is close to that of [18] in the Sahelian zone of Cameroon. For fodder, *Ficus sycomorus*, *Acacia albida*, *Khaya senegalensis*, *Anogeissus leiocarpus* and *Tamarindus indica* are the most used frequently. The same observation is made by [19] who found *Khaya senegalensis* and *Ficus sycomorus* among the top 10 forage species in southern Benin.

Various plant organs are used by the local populations for the satisfaction of their economic, food and socio-cultural needs. These are fruits, leaves, roots, barks and sometimes even bark flowers and exudates [20]and [21]. In this present study, leaves, woods and fruits are the most used organs (Fig. 2). About 74.46% of species are used for their leaves by the populations, 61.70% as edible fruits (31 species), 51.06% for the wood, 44.68% for their bark, 38.29% for their roots and 31.91% of the species are used for their seeds (Figure 2).Like this study, in [7] have identified 38 edible fruit species in the Far-North,Cameroon.

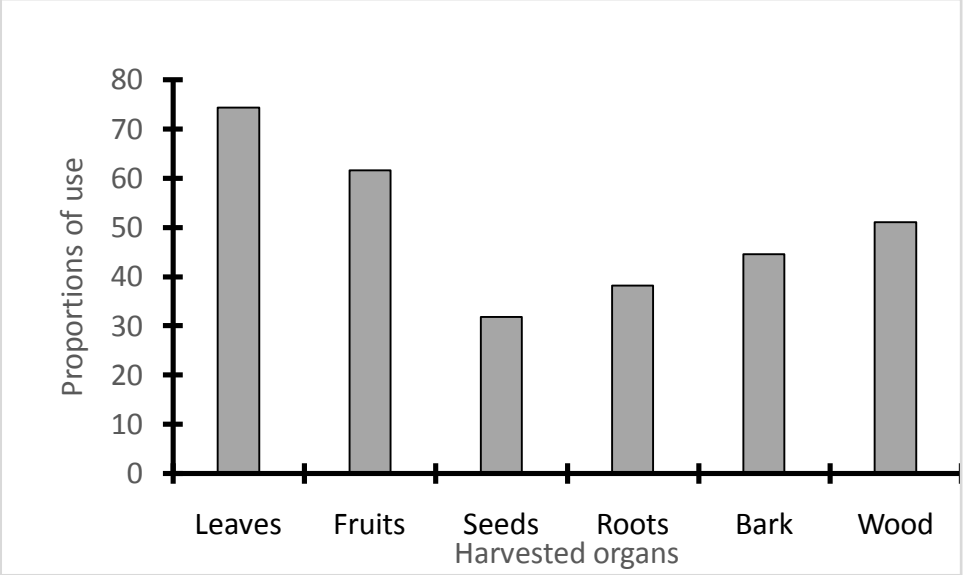

Fig. 2:Percentage of used of harvested organs

The species with the highest response rate was *Tamarindus indica* (total response rate of species equal to 89%) and the species with the lowest response rate was found in *Combretum collinum,Acacia polyacantha, Commiphora kerstingii and Sarcocephalus latifolius* (total response rate of species equal to 1%).

The organ taken from a species is a function of the usefulness sought by the population as well as endogenous knowledge related to the use of the organ of these species. This result is like other similar studies by [22] in the Vipalogo terroir in Burkina Faso. The frequent use of leaves is justified by the abundance of the chemical groups they contain. They are the place of synthesis of the secondary metabolites of the plant[23]-[25].

Similarly, the contribution of roots and bark in the spectrum of the organs used is not a peculiarity for this study, but rather a general characteristic in the treatment of various diseases[26]-[29].Six species used for all their organs were identified. There are Acacia *albida, Azadirachta indica, Balanites aegyptiaca, Khaya senegalensis, Tamarindus indica* and *Ziziphus mauritiana* (Table I).

Table I: Response rate of organs and species

Species	Response rate						
	Roots	Leaves	Bark	Fruit	Seeds	Wood	Total
Acacia albida	7	28	11	8	13	2	69
Acacia ataxacantha	0	1	0	0	0	1	2
Acacia nilotica	0	0	0	0	1	4	6
Acacia polyacantha	0	0	0	0	0	1	1
Acacia seyal	0	6	0	4	3	1	14
Adansonia digitata	3	0	0	2	0	0	5
Annona senegalensis	2	3	1	12	0	0	18
Anogeissus leiocarpus	1	17	13	0		11	44
Azadirachta indica	5	6	3	6	7	3	30
Balanites aegyptiaca	1	10	1	21	8	3	44
Boswella dalzielii	*0*	2	7	0	0	0	9
Calotropis procera	4	4	1	0	0	0	9
Celtis integrifolia	2	10	1	2	0	0	15
Citrus limon	0	1	0	1	0	0	2
Combretum collinum	0	0	0	0	0	1	1

Combretum fragrans	1	1	1	1	0	4	8
Combretum glutinosum	0	1	0	0	0	3	4
Commiphora africana	0	6	0	0	2	1	9
Commiphora kerstingii	0	0	1	0	0	0	1
Detarium microcarpum	0	0	0	3	0	0	3
Diospyros mespiliformis	0	0	0	35	0	4	39
Feretia apondenthera	0	2	0	0	0	0	2
Ficus ingens	1	0	5	20	0	2	28
Ficus platyphylla	0	1	0	17	1	4	23
Ficus sur	0	1	0	2	0	0	3
Ficus sycomorus	1	22	19	19	0	1	62
Fluggea virosa	0	4	0	0	0	0	4
Haematostaphis barteri	2	12	5	0	2	0	21
Hyphaene thebaica	1	3	1	3	0	0	8
Khaya senegalensis	11	16	19	15	6	1	68
Lannea acida	1	0	0	15	5	4	25
Mangifera indica	0	1	0	2	0	0	3
Moringa oleifera	0	2	0	0	0	0	2
Parkya biglobosa	0	2	1	10	0	0	13
Piliostigma thoningii	0	1	0	0	1	1	3
Pterocarpus erenaceus	0	2	3	0	0	2	7
Sarcocephalus latifolius	0	0	0	1	0	0	1
Sclerocarya birrea	0	20	5	27	10	2	74
Sterculia setigera	0	2	0	0	0	0	2
Tamarindus indica	5	26	7	43	7	1	89
Terminalia brownii	3	1	5	0	0	1	10
Vitellaria paradoxa	0	0	0	4	0	0	4
Vitex doniana	0	5	3	16	0	0	24
Ximenia americana	0	1	0	3	0	0	4
Ziziphus mauritiana	4	9	3	32	5	4	57
Ziziphus mucronata	2	0	0	1	3	0	6
Ziziphus spina-christi	0	0	0	4	0	1	5

B. Value of Use of species

The main listed fruit species are also on the list of the most consumed species in Burkina Faso [18]. Similarly, the leaves of *Ficus sycomorus*, *Acacia albida*, *Balanites aegyptiaca* and *Sclerocarya birrea*are also cited as common. The leaves of *B. aegyptiaca* are cooked and used as sauce eaten with couscous of millet, sorghum or maize[4]. Leaves of *Ficus sycomorus, Acacia albida and Sclerocarya birrea* are used as fodder.

The woody species that have been recorded in the study area are like those reported by [30]as species consumed in times of hunger in Burkina Faso. In addition, the species most used by populations are those that develop in their immediate environment and are easily accessible. Species such as Khaya senegalensis (Uv = 19%), Boswellia dalzielii (Uv = 17%) and Anogeissus leiocarpus (Uv = 13%) are cited as the most debarked (Table II). This is the same observation made by [31] for statistics on NTFPs in the Togolese Republic.

Table II: List of species, their local namesandtheir use values.

Species	Local names	Uv					UvT
		FO	ME	FW	FO	TI	
Acacia albida	Modrov (guiziga)	1	26	42	42	-	111
Acacia ataxacantha	Zezey (mofou)	-	-	1	1	-	2
Acacia nilotica	Dourvonoh (guiziga)	2	-	4	3	-	9
Acacia polyacantha	Gararay (mofou), patuki (fulfuldé)	-	-	3	-	-	3
Acacia seyal	Djedjew (guiziga)	-	2	10	9	-	21
Adansonia digitata	Boko (fulfuldé)	4	1	1	1	-	7
Annona senegalensis	Gonokoy(guiziga)	15	3	7	-	-	25
Anogeissus leiocarpus	Kodjoli (fulfuldé)	-	21	28	25	1	75
Azadirachta indica	Gayé (fulfuldé)	-	11	8	-	1	20
Balanites aegyptiaca	Dagot (Guiziga)	27	9	23	10	1	70
Boswella dalzielii	Titin (guiziga), teting (mofou)	-	12	-	5	-	17
Calotropis procera	Magabak (Mbokou)	-	5	4	-	-	9
Celtis integrifolia	Wanko (fulfuldé), Mebed (mofou)	19	4	14	8	-	41
Citrus limon	Limou (fulfuldé)	1	1	1	-	-	3
Combretum collinum	-	-	-	1	-	-	1
Combretum fragrans	Meguisbette (guiziga)	-	3	8	1	-	12
Combretum glutinosum	Barkasalaf (guiziga, mbokou)	-	-	8	1	-	9
Commiphora africana	Dedek (mofou)	-	2	2	4	-	8
Commiphora kerstingii	Bourguederou(fulfuldé)	-	1	-	-	-	1
Detarium microcarpum	Kurlala (Mofou, Guiziga)	4	-	2	-	-	6
Diospyros mespiliformis	Houan(guiziga), deguere (mbokou)	37	5	25	2	1	70
Feretia apondenthera	Thoulek (mofou)	-	-	1	3	-	4
Ficus ingens	Vassay (mbokou), aboss(guiziga)	27	7	21	1	-	56
Ficus platyphylla	Doumdehi (fulfuldé)	20	2	13	4	-	39
Ficus sur	Bizang (Mofou)	1	-	1	-	-	2
Ficus sycomorus	Goudov (mofou), Ourof (Guiziga)	28	14	27	25	-	94
Fluggea virosa	Thia (mofou)	-	-	2	7	-	9
Gardenia termiflia	-	1	-	1	-	-	2
Haematostaphis barteri	Touroz (Mofou), Trousse (Guiziga)	30	10	9	14	-	63
Hyphaene thebaica	Babadja (guiziga)	4	2	-	-	-	6
Khaya senegalensis	Tor (mofou), Dalehi (fulfuldé)	5	37	21	19	3	85
Lannea acida	Melepere (mofou)	16	-	-	14		30
Mangifera indica	Manguier	1	-	1	-	-	2
Moringa oleifera	Guilgandja (fulfuldé)	1	-	-	-	-	1
Parkia biglobosa	Louwar (Mofou)	14	1	9	5	-	29
Piliostigma thoningii	Barkedjé(fulfuldé), bassay(mofou)	-	2	3	2	-	7
Pterocarpus erenaceus	Lalan(guiziga, mofou)	-	5	6	2	-	13
Sarcocephalus latifolius	Wraz(mofou)	3	1	2	-	-	6
Sclerocarya birrea	Douwaz(guiziga, mofou, mbokou)	25	8	31	19	1	84
Sterculia setigera	Slikad(guiziga),houboth(mofou)	-	-	2	3	-	5
Tamarindus indica	Maka(mboko), blam (guiziga)	50	25	40	19	3	137

Tapinanthus sp	Mehenek (Mofou)	-	1	-	1	-	2
Terminalia brownii	Sisem (guiziga)	-	6	6	1	1	14
Vitellaria paradoxa	Sogom (mofou)	10	1	5	-	-	16
Vitex doniana	Ngalbidjé (fulfuldé)	28	3	10	5	-	46
Ximenia americana	Tetlez (mofou), thaboulé(fulfuldé)	8	-	2	1	-	11
Ziziphus mauritiana	Djaabé (fulfuldé) reved (mbokou)	48	11	-	-	-	59
Ziziphus mucronata	Golan(Mofou)	1	2	8	5	-	16
Ziziphus spina-christi	Kournadji (fulfuldé)	10	-	4	3	-	17

FO: Food; ME: Medicine; FW: Firewood; FO: Fodder; TI: Timber

The most important species in terms of Total Value of Use are: *Tamarindus indica* (UvT= 137), *Acacia albida* (UvT = 111), *Sclerocarya birrea* (UvT = 84), *Anogeissus leiocarpus* (UvT = 75), *Balanites aegyptiaca* (UvT = 70) and *Ziziphus mauritiana* (UvT= 59) (table V). The result is like that of Mapongmetsem *et al*. (2012) who listed these species among the most appreciated by the populations of North Cameroon.

According [15] and [17], when the Total Ethnobotanical Value of Use of a species is high, this could reflect the high pressure on it. In this case, *Khaya senegalensis* appears as an over exploited species (response rate = 68 and UvT = 85) despite its low abundance in the study site (Di = 0.06 ind / ha). The Total Ethnobotanical Value of Use of species depends of the interest of local populations not of the number of concerned plant individuals.

Local populations in Meri use plants in their agrosystems more for food (total value = 14.60) and firewood (total value = 10.26).The total value of fodder equals 10 and it equals 13 for food. The low value of use value was observed for timber (total value = 1.46) (Figure). According [32], food and fodder are particularly important in seasonally agricultural systems. In this study the total value of fodder was 7.96.

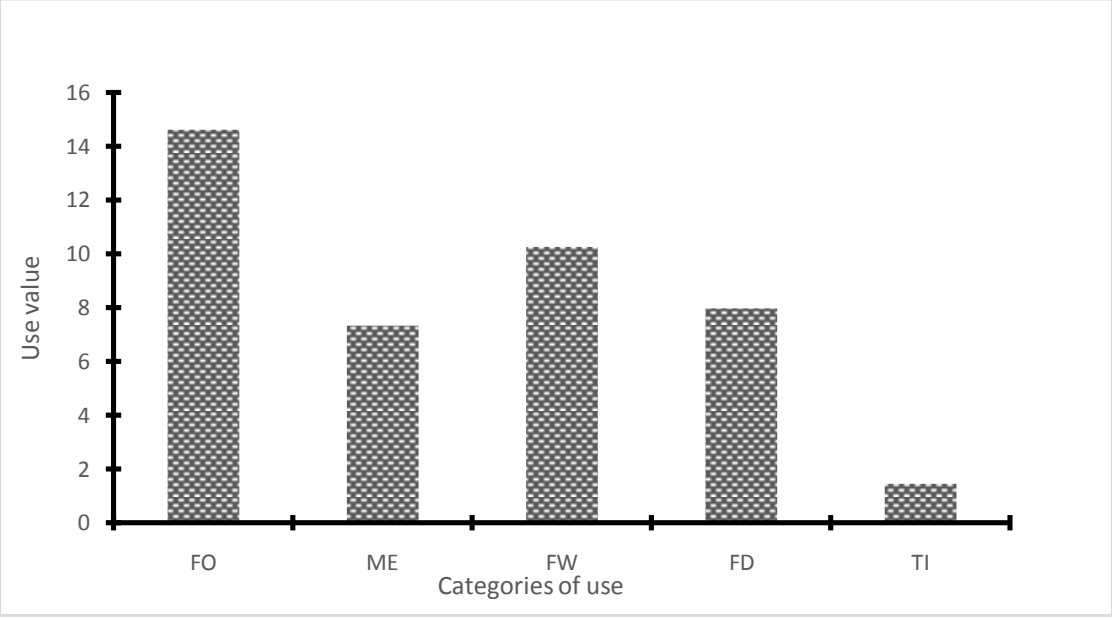

Fig. 3: Total values of categories of use: FO: Food; ME: Medicine; FW: Firewood; FD: Fodder; TI: Timber

IV. CONCLUSION

The present study helped us to inventory 50 woody species exploited by the local populations in traditional agroforestry of Meri (Mandara Mountains, Cameroon). The analysis and description of the exploitation of NTFPs in this site is very informative. These products include a wide range of species from savannahs and home gardens. These results reveal significant removals of NTFPs for several purposes. They are sources of food, medicine, fodder, wood energy and service wood. The organs used are leaves, fruits, energy woods, bark, roots and seeds. Six species are used for all organs studied (*Acacia. albida*, *Azadirachta indica*, *Balanites aegyptiaca*, *Khaya senegalensis*, *Tamarindus indica* and *Ziziphus mauritiana*).The most exploited species are: *Acacia*

albida, *Anogeissus leiocarpus*, *Balanites aegyptiaca*, *Sclerocarya birrea*, *Tamarindus indica* and *Ziziphus mauritiana*. The plants thus listed constitute an important reserve of information on the ethnobotanical practices of the exploited plants. It is therefore essential to establish a management and conservation program for these genetic resources to avoid the rarefaction and / or the disappearance of certain species of economic and medicinal importance.

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