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Biodiversity and Ethnobotanical Use Values of Some Plant Species in Gaya Department (Niger)

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Abstract: The objective of this work is to identify in Gaya the plant species socio-economic inter est for the population, their forms of use and the use values of each species used in the different categories of use. Thus, an ethnobotanical survey using an individual interview guide was conducted in 15 villages. In each village, a village assembly was held to identify the target people. A total of 150 people were interviewed individually. In fact, 87 species divided into 67 genera belonging to 33 families were identified. These species are used in six (6) categories of use, namely human nutrition, pharmacopoeia, fodder, firewood, service wood and craft. The result shows a predominance of woody species (64) in the diversity of species and uses. Total use values vary by species and by use category: Vitellaria paradoxa (2.24), Balanites aegyptiaca (2.0), Combretum nigricans (1.42), Borassus aethiopum (1.41), Vitex doniana (1.35), Diospyros mespiliformis (1.32), Prosopis africana (1.21), Sclerocarya birrea (1.20), Tamarindus indica (1.17), Vetiveria nigritana (1.02). Leaves (33%), fruits (26.13%), wood (18.83%) and bark (13.11%) are the most used organs. The degree of knowledge of their importance is more less homogeneous as shown by the Informant Consensus Factor (ICF) and the Informant Diversity Index.

Keywords: Plant Species, Organs, Use Values, Gaya (Niger)

1. Introduction

Plant resources have an important role at all human activities. Since ancient civilizations and in all societies, the socio-economic benefits derived from the exploitation of forest products are well known and many examples are described [1-6]. The contribution of plants to human subsistence is very important and the whole species or some of its organs can be used. In the Sahelo-Sudanian zone, which is characterized by rainfall deficits and low agricultural yields, the population is highty dependent on the use of plant species in several categories (food, animals feed, firewood, service wood, medical). In the Sahelo-Sudanian environment and in rural communities, plant species contribute to the management of many households where they constitute a sustainable source of food and nutrition, especially in times of shortage. This allows them to mitigate the effects of agricultural deficit and to compensate for nutritional requirements [7]. The plant products are sold on local markets or exported to neighboring areas. This is a significant alternative to improving economic income and resilience to climate change. It should be noted that in Niger, nearly 210 plant species are used for food and human nutrition [8]. The pharmacopy has proven its worth in the treatment of many diseases and spiritual ailments. Various solutions (decoction, infusion, maceration, steam and smoke) from organs of about 270 plant species are used and 127 woody species are devoted to providing firewood, construction wood and design of craft or cultural instruments [1]. Plant organs constitute the key material for fodder production, fattening and livestock productivity. Approximately 235 plant species are used [8]. In agrarian

systems, plants fertilize the soil, improve microfauna, soil porosity and condition water retention. Despite their broad socio-ecological values, these plant species are now threatened with extinction. This study aims to identify the plant species traditionally used by the population of Gaya department, their use categories and to assess their socio-economic importance in each use category. The result of this study will contribute to the preservation of plant diversity and the necessary conditions for the sustainable development of the populations.

2. Materials and Methods

2.1. Context of Study Area

The choice of this site is based on its climatic characteristics, particularly rainfall, flora, agriculture and human activities. The present study was carried out along a climatic gradient in Gaya department located in the western part of Niger Republic. Gaya is situated between latitudes 11° 52'N and 12°15 N and longitudes 003°17 W and 003°31 W, corresponding to the southern part of Dosso Region (Figure 1).

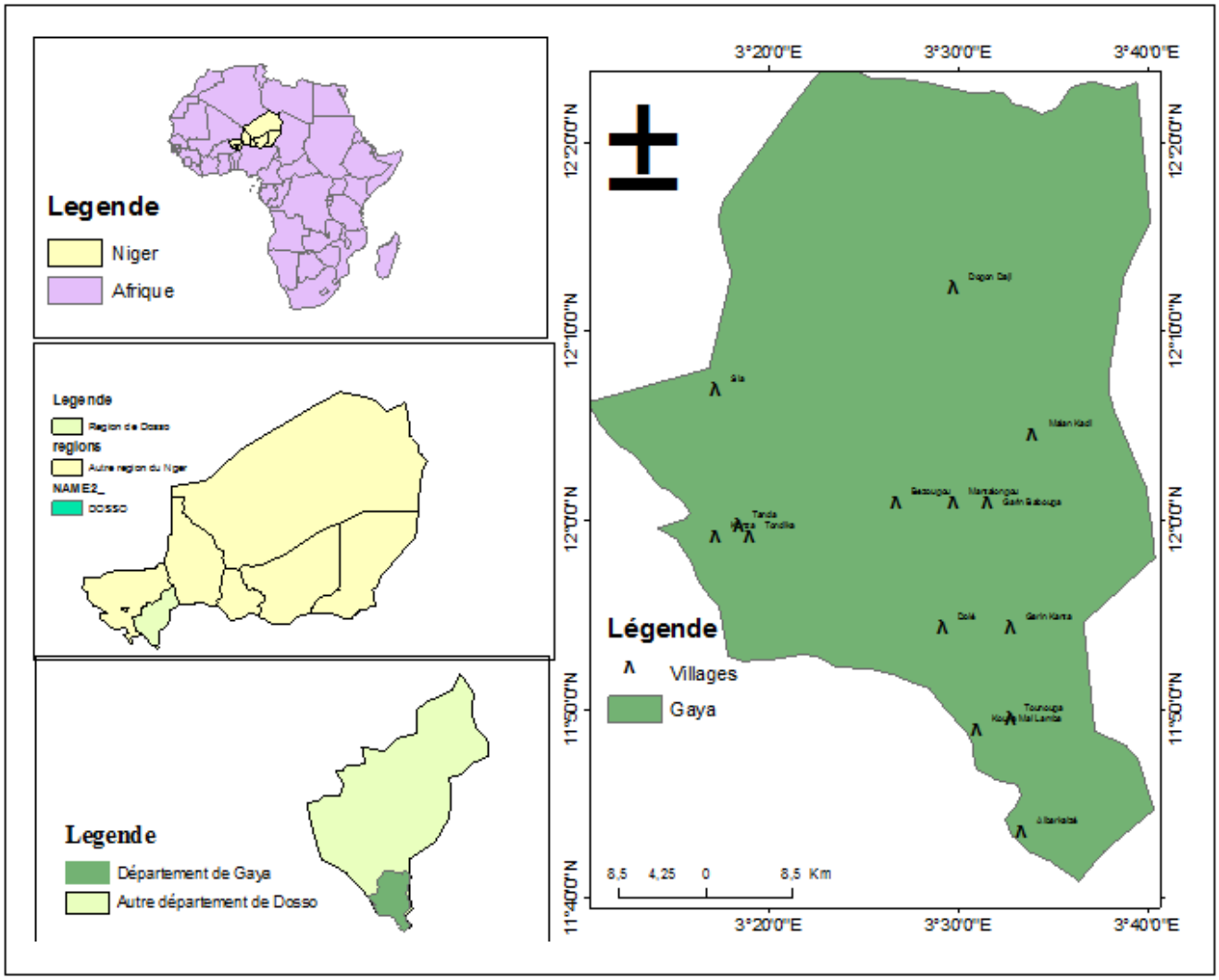

Figure 1. *Location of study area in the geographic map of Niger.*

2.2. Context of Study Area

The study area belongs to Sudanian zone [9] or northwestern Sudanian zone [10] which characterized by an annual rainfall varing from 700 to 800 mm. Exceptionally, it can reach 1000 mm, but the annual average is always above 600 mm. The rainy season lasts about 4 to 5 months, from June to September and the longer dry season covers the period from October to May [7]. The average temperature varies from 25°C in January to 33°C in April with a thermal amplitude of 7°C. The degree of humidity fluctuates between 23% and 80% depending on the time of year. The terrain is generally flat or slightly undulating. The toposequence consisting of the study is marked by the valleys, low lateritic plateaus whose altitude not exceeds 350 m. The sediments are represented by the ferruginous sandstones, fluvial clays of the intercalary continental, sandy and clay formations of the quaternary. The soil varies from ferruginous on the plateaus, sandy in the lowlands to heavy clay in the dallols valleys. The hydrographic network consist of the temporary to permanent ponds, dallols valleys and the Niger River. The

plant formations are diversified and floristically rich. The most characteristic are dry forest, tiger bush (alternation zone of dryland and vegetalized band), tree savannah, shrub savannah, riparian cordon, semi-aquatic grasslands and agrosystems. The population, 76% of which is rural, practics the agro-pastoral activities: rain-fed cereal crops (millet, sorghum, corn), rice cultivation, arboriculture, fishing and trade.

2.3. Data Collection

An ethnobotanical survey was conducted using a individual interview guide. It targeted elderly people in the population who were directly involved in the use of plant organs. The public interviewed included healers, traditional practitioners, fishermen, farmers, and herders, both men and women, with an average age of 49 years. These informants are thought to be better able to describe the categories of use, species and plant parts exploited. They are also better suited to accurately reflect the impact of organ harvesting on plants and the resulting ecological changes. The first informant is the village chief or his representative, who directs the interviewer to the informants requested. In addition, village assemblies were organized (focus group) and the participatory action research method (PARM) was applied. The information sought was:

1) plant species of socio-economic interest;
2) the different forms of valorization of plant species;
3) the parts or organs of plants used in each category of use and their frequency of use.

The choice of villages sampled was guided by accessibility and the existence of the type of informant targeted for interview (traditional practitioners). Fifteen (15) villages were sampled and one hundred and fifty (150) people were interviewed.

2.4. Data Processing

The information collected was compiled, entered and analyzed using an microsoft Excel. The scientific names of the species were determined using the Flora of West Africa [11, 12], the flora of Senegal [13] and the analytical flora of Benin [14]. The local names of the species were provided by the respondents. For each plant species, a score of 1 is assigned in case of citation for a use in a category of use. This allowed us to determine the relative importance of species using calculated values of indicators such as use value (UV), frequency of organs used (F), Informant Consensus Factor (ICF), Informant Diversity Index (ID) and Informant Equitability Index (IE):

1) The use value (UV):

It is expressed by calculating for each species the use value also called frequency of use [15-17]. The use value is the ratio of the number of citations of a given species in a given use domain to the total number of informants interviewed. The use value indicates which species are abundantly exploited in a given category. It also provides a meaningful indication of the degree of pressure on the species. Use value is defined by the formula below:

$$VU = (\sum U)/(N)$$

Where "U" is the number of citations mentioning use of the species; "N" is the total number of informants interviewed.

2) The total use value of the species (TUV)

The total use value of a species is the sum of the use values of the species in all categories in which it is used, to determine which species are important in a given environment. The total use value of each species is determined by evaluating the sum of all use values of the species within the different use categories. The total use value of a species is expressed by the following equation:

$$TUV = \sum_{p}^{1} VU$$

"TUV" is the total use value of the species k considered; "VU" is the use value of species k for a given use category; "P" is the number of evoked use categories or use domains of the species.

3) The frequency of citing organs used by type of use category (F)

For each species considered, this rate indicates the organs or parts most used in a given use category. The frequency of citation of organs used by type of use category varies from 0 to 100. A value of 0 indicates that the organ is not used and a value of 100 establishes that the organ is used by all respondents. The frequency of citing organs used by species and use category is expressed as

$$F=S/(N) \text{ X } 100$$

"F": the calculated response rate; "S": number of citations for the use of the organ concerned; "N": total number of informants.

4) The total frequency of use (FT)

The total frequency of use of an organ or part of the plant in a given category is determined by first calculating the cumulative frequency of use of the same organ or part of the plant for all species used for the same category. This cumulative frequency is then divided by the sum of the cumulative frequencies of all parts used in the category considered.

$$FT=CF/(TCF) \text{ X } 100$$

"CF" is the cumulative frequency of use of the organ considered for all the species exploited in the same category; "TCF" is the total of the cumulative frequencies of all organs or parts of species used in the assumed category.

5) Informant Consensus Factor (ICF)

It demonstrates the level of affinity of populations on the different uses of plant organs present within their terroir. The level of consensus is determined by calculating the Informative Consensus Factor (ICF) defined by [18] and [19]. Its values are between 0 and 1. Its value is low when a small number of species are cited for a given use and high

when several species are cited for the same use. It is calculated by the following formula:

$$ICF=(Nur-Nt)/(Nur-1)$$

Where, "Nur" number of citations for each category, "Nt" number of species for the same category.

In order to appreciate the relationship between the ethnobotanical use value and the number of uses of the species.

6) Informant Diversity Index (ID)

It measures how many respondents use species and how this knowledge is distributed in the population. The respondent diversity index is given by the formula below:

$$ID=Ux/(Ut)$$

Where "Ux" number of uses of the species cited by an informant and "Ut" total number of uses.

7) Informant Equitability Index (IE):

It measures the degree of homogeneity of informants' knowledge. It indicates the degree of agreement between informants regarding the uses made of the species. Its value is between 0 and 1. The informant equitability index is expressed by the following equation:

$$IE=ID/IDmax$$

Where "ID" represents the diversity index of the respondent or informant "IDmax" is the value of the highest respondent/informant diversity index found.

3. Results

3.1. Plant Species Diversity

The department of Gaya is floristically rich in its specific composition and in its ecosystem diversity. Its flora, estimated at 380 species, represents 16.71% of the 2274 plant species of Niger Republic flora. These species are divided into 215 genera and 77 families. The best represented families are Poaceae and Fabaceae-faboideae with respectively 61 species and 45 species. These families are significantly followed by Cyperaceae (17 species), Fabaceae-mimosoideae (17 species), Fabaceae-caesalpiniodeae (14), Convolvulaceae (14 species), Euphorbiaceae (15 species), Malvaceae (12), Rubiaceae (13) and Acanthaceae (11 species). The Asclepiadaceae, Euphorbiaceae, cumulate 10 species each, the Asteraceae and Combretaceaes include 9 species each. The Cucurbitaceae (8 species), Amaranthaceae, Capparaceae (7 species), Anarcadiaceae Lamiaceae and Tiliaceae have a floristic procession with 6 species each. These same families have the most widespread of the genera. The Poaceae family has 29 genera and the Fabaceae-faboideae family represents by 12 genera. The other families previously mentioned have a number of genera between 9 and 4. Compared to their families, the genera Indigofera (17 species), Crotalaria (11 species), Ipomoea (11 species), Tephrosia (10 species) and Cyperus (10 species) are well distributed with at least ten species. They are followed by the genera, Acacia, Eragrostis, Cassia, Aristida, Brachiaria and Combretum (Figure 2).

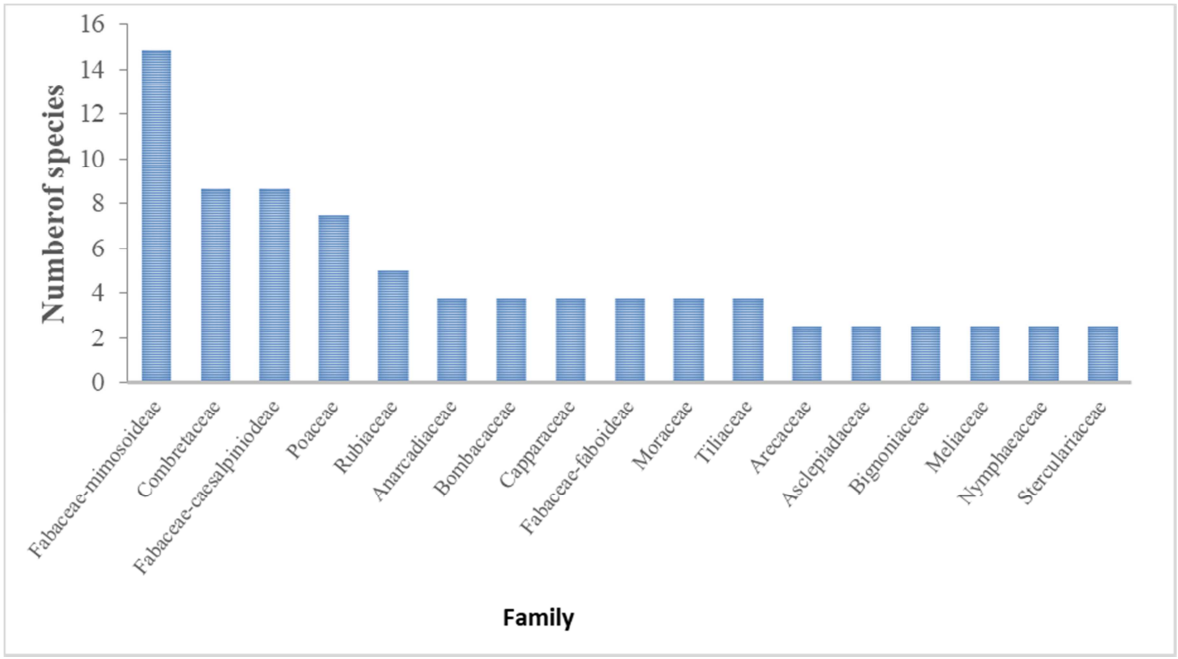

Figure 2. *Distribution of species used within botanical families.*

3.2. Diversity of Plant Species Exploited and Categories of Use

The ethnobotanical analysis shows that eighty-seven (87) plant species, 64 of which are woody and 23 herbaceous, are used in six (6) categories of use (human nutrition, traditinal medecine, fodder, firewood, service wood and craft) by the populations of Gaya department. The species exploited are

grouped into 67 genera belonging to 33 botanical families of which the best represented are Fabaceae-mimosoideae (12 species), Combretaceae and Fabaceae-caesalpiniodeae (7 species each) and Poaceae (6 species).

Among these plant species eighty-three (83) have therapeutic benefits, sixty-seven (77) are fodder, fifty-six (56) provide firewood, fifty-five (55) are edible and used in human food, forty-one (41) species provide wood for service and wood for crafts. Various parts of these species can be sold to improve the annual income of the populations. The same species can be used in one or more categories of use. As such, thirty (30) species are used in all use categories, twenty-five (25) species are exploited in 4 use categories and nine (9) species are used only in three use categories. The remaining twenty-nine (29) species are only used in one or two use categories (Figure 3).

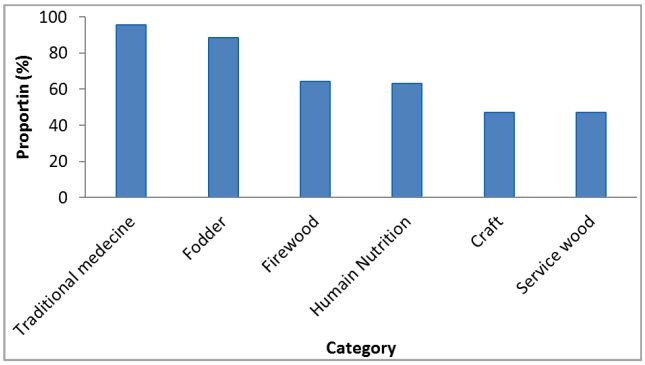

Figure 3. *Use categories and proportion of species used.*

3.3. Ethnobotanical Use Values

The analysis of the data collected reveals six (6) categories of use of plant parts or organs. The same species can be used in all or some of the use categories and its use value can vary from one category to another. For example, Vitellaria paradoxa has a use value of 0.60 in human nutrition versus 0.59 and 0.47 respectively in traditional medecine and fodder. However, Borassus aethiopum has an higher use value for wood service and human nutrition (0.45) than for traditional medicine (0.21) or firewood (0.11). Within each use category listed, there is an variation of species with high use values. In traditional medecine, Vitellaria paradoxa has a use value of 0.59, Balanites aegyptiaca (0.47), Diospyros mespiliformis (0.45), Prosopis africana (0.41), Calotropis procera, Sterculia setigera, Tamarindus indica with respectively a use value of 0.40 each. In the category of human nutrition they are: Vitellaria paradoxa (0.60), Balanites aegyptiaca (0.55), Borassus aethiopum (0.45), Vitex doniana (0.44), Diospyros mespiliformis (0.42), Tamarindus indica (0.41), Combretum nigricans (0.40) that have the best use values. The most exploited fodder species are Balanites aegyptiaca, Echinochloa stagnina, Vitellaria paradoxa with respective use values of 0.47 and Vetiveria nigritana (0.34). For lumber and handicrafts, the species with significant use values are: Borassus aethiopum (0.45), Prosopis africana (0.33), Vetiveria nigritana (0.33), Hyphaene thebaica, Bombax costatum, Vitellaria paradoxa (0.26 each), Combretum micranthum (0.19), Balanites aegyptiaca (0.18). The species used for the production of firewood are: Combretum nigricans (0.34), Balanites aegyptiaca (0.33), Vitellaria paradoxa (0.30), Prosopis africana (0.23), Piliostigma reticulatum (0.22), Vitex doniana (0.22), Combretum glutinosum (0.21), and Boscia angustifolia (0.19) (table 1).

Overall, the species with the highest total use value are: Vitellaria paradoxa (2.24), Balanites aegyptiaca (2), Combretum nigricans (1.42), Borassus aethiopum (1.41), Piliostigma reticulatum and Vitex doniana (1.35), Diospyros mespiliformis (1.32), Prosopis africana (1.21), Sclerocarya birrea (1, 20), Tamarindus indica (1.17), Daniellia oliveri (1.05), Vetiveria nigritana (1.02), Ziziphus mauritiana (1.01), Anacardium occidental (1.00), Neocarya macrophylla (0.94), Bombax costatum (0.87) and Hyphaene thebaica (0.86). With the exception of Borassus aethiopum, Prosopis africana and Vetiveria nigritana all of these high value use species are employed in six identified use categories (Figure 4).

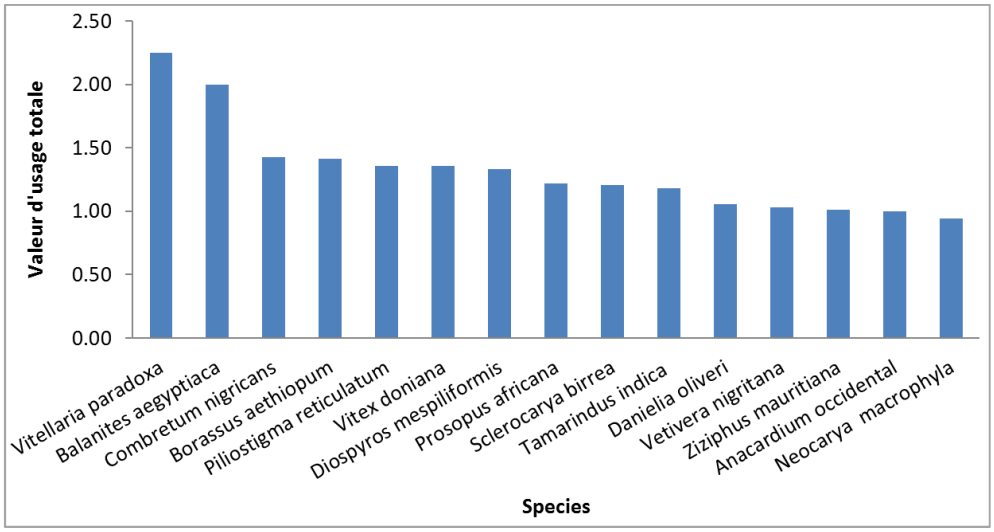

Figure 4. *Plant species with high total use values.*

Table 1. *Plant species: Value and category of use. (HN=human nutrition, TM=traditinal medecine, Fo=fodder, FW=firewood, SW=service wood and Cr=craft).*

Species	Family	Type	Use Catégory						TUV	ID	IE
			TM	HN	Fo	FW	Sw	Cr			
Vitellaria paradoxa	Sapotaceae	L	0,59	0,60	0,47	0,30	0,12	0,16	2,247	0,374	1,00
Balanites aegyptiaca	Balanitaceae	L	0,47	0,55	0,47	0,33	0,01	0,18	2,000	0,333	0,89
Combretum nigricans	Combretaceae	L	0,32	0,40	0,21	0,34	0,07	0,10	1,425	0,237	0,63
Borassus aethiopum	Arecaceae	L	0,21	0,45	0,11		0,48	0,16	1,411	0,235	0,63
Piliostigma reticulatum	Fabaceae-caesalpiniodeae	L	0,33	0,34	0,29	0,22	0,03	0,15	1,356	0,226	0,60
Vitex doniana	Verbenaceae	L	0,33	0,44	0,33	0,22		0,04	1,356	0,226	0,60
Diospyros mespiliformis	Ebenaceae	L	0,45	0,42	0,27	0,14		0,04	1,329	0,221	0,59
Prosopis africana	Fabaceae-mimosoideae	L	0,41		0,21	0,23	0,11	0,26	1,219	0,203	0,54
Sclerocarya birrea	Anarcadiaceae	L	0,27	0,38	0,33	0,18	0,01	0,03	1,205	0,201	0,54
Tamarindus indica	Fabaceae-caesalpiniodeae	L	0,40	0,41	0,19	0,15		0,03	1,178	0,196	0,52
Daniellia oliveri	Fabaceae-caesalpiniodeae	L	0,29	0,30	0,30	0,10		0,07	1,055	0,176	0,47
Vetiveria nigritana	Poaceae	H	0,22	0,01	0,45		0,32	0,03	1,027	0,171	0,46
Ziziphus mauritiana	Rhamnaceae	L	0,29	0,33	0,23	0,10	0,07		1,014	0,169	0,45
Anacardium occidental	Anarcadiaceae	L	0,23	0,34	0,23	0,15	0,01	0,03	1,000	0,167	0,45
Neocarya macrophylla	Chrysobalanaceae	L	0,25	0,34	0,12	0,16	0,03	0,04	0,945	0,158	0,42
Bombax costatum	Bombacaceae	L	0,27	0,14	0,11	0,10	0,01	0,25	0,877	0,146	0,39
Hyphaene thebaica	Arecaceae	L	0,21	0,34	0,04	0,01	0,07	0,19	0,863	0,144	0,38
Acacia nilotica	Fabaceae-mimosoideae	L	0,34	0,12	0,23	0,10	0,01	0,05	0,863	0,144	0,38
Celtis integrifolia	Ulmaceae	L	0,23	0,25	0,34	0,03			0,849	0,142	0,38
Terminalia avicennioides	Combretaceae	L	0,33	0,05	0,22	0,14	0,08	0,03	0,849	0,142	0,38
Combretum glutinosum	Combretaceae	L	0,25		0,21	0,21	0,14		0,795	0,132	0,35
Bauhnia rufescens	Fabaceae-caesalpiniodeae	L	0,37		0,27	0,11	0,01		0,767	0,128	0,34
Sterculia setigera	Stercullariaceae	L	0,40	0,05	0,19	0,08		0,01	0,740	0,123	0,33
Ficus sycomorus	Moraceae	L	0,21	0,21	0,22	0,07	0,01	0,01	0,726	0,121	0,32
Guiera senegalensis	Combretaceae	L	0,27		0,16	0,14	0,12		0,699	0,116	0,31
Combretum collinum	Combretaceae	L	0,22		0,18	0,18	0,08	0,03	0,685	0,114	0,31
Pterocarpus erinaceus	Fabaceae-faboideae	L	0,21		0,22	0,11	0,05	0,08	0,671	0,112	0,30
Combretum micranthum	Combretaceae	L	0,23	0,01	0,16	0,12	0,12		0,658	0,110	0,29
Nymphaea lotus	Nymphaeaceae	H	0,21	0,33	0,12				0,658	0,110	0,29
Echinochlora stagnina	Poaceae	H	0,15		0,47			0,01	0,630	0,105	0,28
Mitragyna inermis	Rubiaceae	L	0,22	0,01	0,23	0,08	0,03	0,01	0,589	0,098	0,26
Cassia sieberiana	Fabaceae-caesalpiniodeae	L	0,30	0,01	0,12	0,07	0,08		0,589	0,098	0,26
Boscia angustifolia	Capparaceae	L	0,22	0,08	0,10	0,19			0,589	0,098	0,26
Lannea microcarpa	Anarcadiaceae	L	0,14	0,16	0,19	0,07	0,01		0,575	0,096	0,26
Grewia bicolor	Tiliaceae	L	0,16	0,18	0,08	0,03	0,01	0,11	0,575	0,096	0,26
Stereospermum khunthianum	Bignoniaceae	L	0,26		0,21	0,11			0,575	0,096	0,26
Corchorus fascicularis	Tiliaceae	H	0,08	0,25	0,23				0,562	0,094	0,25
khaya senegalensis	Meliaceae	L	0,23		0,10	0,07	0,03	0,14	0,562	0,094	0,25
Acacia seyal	Fabaceae-mimosoideae	L	0,23	0,03	0,15	0,10	0,01	0,03	0,548	0,091	0,24
Gardenia sokotensis	Rubiaceae	L	0,27	0,07	0,10	0,10			0,534	0,089	0,24
Parkiya biglobosa	Fabaceae-mimosoideae	L	0,15	0,18	0,14	0,07			0,534	0,089	0,24
Acacia machrostachya	Fabaceae-mimosoideae	L	0,12	0,05	0,12	0,14	0,01	0,04	0,493	0,082	0,22
Ziménia américana	Olacaceae	L	0,16	0,15	0,12	0,05			0,490	0,082	0,22
Adansonia digitata	Bombacaceae	L	0,11	0,19	0,14			0,04	0,479	0,080	0,21
Calotropis procera	Asclepiadaceae	L	0,40		0,01	0,01	0,04	0,01	0,479	0,080	0,21
Cassia mimosoides	Fabaceae-caesalpiniodeae	H	0,23		0,23				0,466	0,078	0,21
Ceiba pentandra	Bombacaceae	L	0,15	0,03	0,05	0,05		0,18	0,466	0,078	0,21
Crossoptryx febrifuga	Rubiaceae	L	0,15		0,16	0,12	0,03		0,466	0,078	0,21
Chrozophora brocchiana	Euphorbiaceae	H	0,30		0,14			0,01	0,452	0,075	0,20
Albizia chevalieri	Fabaceae-mimosoideae	L	0,21		0,07	0,11	0,04	0,01	0,438	0,073	0,20
Kigelia africana	Bignoniaceae	L	0,22	0,04	0,10	0,03	0,01	0,04	0,438	0,073	0,20
Mimosa pigra	Fabaceae-mimosoideae	L	0,26	0,05	0,11	0,01			0,438	0,073	0,20
Boscia senegalensis	Capparaceae	L	0,16	0,10	0,07	0,05			0,384	0,064	0,17
Gardenia ternifolia	Rubiaceae	L	0,15	0,10	0,12			0,01	0,384	0,064	0,17
Annona senegalensis	Annonaceae	L	0,14	0,12	0,08	0,03			0,370	0,062	0,16
Cynondon dactylon	Poaceae	H	0,05		0,32				0,370	0,062	0,16
Typha domingensis	Typhaceae	H	0,22	0,01	0,11			0,01	0,356	0,059	0,16
Faidherbia albida	Fabaceae-mimosoideae	L	0,15		0,16	0,03		0,01	0,356	0,059	0,16
Azadirachta indica	Meliaceae	L	0,15			0,04	0,08	0,05	0,329	0,055	0,15
Waltheria indica	Stercullariaceae	H	0,33						0,329	0,055	0,15
Acacia sieberiana	Fabaceae-mimosoideae	L		0,05	0,11	0,04	0,01	0,05	0,274	0,046	0,12
Aeschynomene crassicaulis	Fabaceae-faboideae	H	0,14		0,12	0,01			0,274	0,046	0,12
Ficus platyphylla	Moraceae	L	0,08	0,03	0,07	0,03		0,01	0,219	0,037	0,10
Dichrostachya cinerea	Fabaceae-mimosoideae	L	0,08	0,01	0,04		0,01	0,01	0,164	0,027	0,07

Species	Family	Type	Use Catégory						TUV	ID	IE
			TM	HN	Fo	FW	Sw	Cr			
Indigofera hirsuta	Fabaceae-faboideae	H	0,08		0,08				0,164	0,027	0,07
Cassia tora	Fabaceae-caesalpiniodeae	H	0,04	0,05	0,05				0,151	0,025	0,07
Peristrophe bicalyculata	Acanthaceae	H	0,10		0,04	0,01			0,151	0,025	0,07
Leptadenia hastata	Asclepiadaceae	Lia	0,05	0,04	0,04				0,137	0,023	0,06
Acacia ataxacantha	Fabaceae-mimosoideae	L			0,11		0,01		0,123	0,021	0,05
Annogeissus leocarpus	Combretaceae	L	0,03	0,01	0,03	0,03	0,03		0,123	0,021	0,05
Entada africana	Fabaceae-mimosoideae	L	0,03		0,03	0,03			0,082	0,014	0,04
Strychnos spinosa	Loganiaceae	L	0,03	0,01	0,03				0,072	0,012	0,03
Ficus dekdakena	Moraceae	L	0,03	0,01	0,01	0,01			0,068	0,011	0,03
Ceropegya rhynchanta		H	0,03	0,04					0,068	0,011	0,03
Crateva adansonia	Capparaceae	L		0,04		0,01			0,055	0,009	0,02
Ludwigia perennis	Onagraceae	H		0,01	0,03		0,01		0,055	0,009	0,02
Eichhornia crassipes	Pontederiaceae	H	0,03	0,01				0,01	0,054	0,009	0,02
Andropogon gayanus	Poaceae	H	0,01		0,01		0,01		0,041	0,007	0,02
Lannea fructicosa	Anarcadiaceae	H	0,01		0,01				0,027	0,005	0,01
Moringa oleifera	Moringaceae	L		0,01	0,01				0,027	0,005	0,01
Ziziphus micronata	Rhamnaceae	L	0,02						0,024	0,004	0,01
Gymnema slyvestre	Asclepiadaceae	L	0,01						0,014	0,002	0,01
Corchorus tridens	Tiliaceae	H		0,01					0,014	0,002	0,01
Cyperus sp	Poaceae	H			0,01				0,014	0,002	0,01
Eucalyptus camaldulensis	Myrtaceae	L					0,01		0,014	0,002	0,01
Oriza barthii	Poaceae	H			0,01				0,014	0,002	0,01
Sida cordifolia	Malvaceae	H			0,01				0,014	0,002	0,01

3.4. Organs or Parts Used in the Use Categories

Many plant parts or organs are commonly used by local people to meet their social and economic needs (Table 2). These plant organs or parts mainly include: root, rhizome, bark, wood, stem, stubble, leaf, fruit, flower, seed, kernel, gum and latex. These twelve (12) plant parts are all exploited in traditonal medecine against eight (8) parts used respectively in human nutrition and as service wood and six (6) organs in fodder. Only the wood, often the stem and rarely the root, provide energy for heating or are used for charcoal production.

In general, the leaves, fruits, wood and bark are the most used parts. The importance of the organ used varies from one category of use to another but also from one species to another. The pharmacopy uses 44.82% of the bark, 27.18% of the leaves, 17.34% of the root/rhizome and 7.88% of the fruits. The bark of Vitellaria paradoxa, Diospyros mespiliformis, Sterculia setigera, Balanites aegyptiaca, Vitex doniana, Prosopis africana and Sclerocarya birrea is the most used. The species whose leaves have the most important use in pharmacopy are: Celtis integrifolia, Chrozophora brocchiana, Bauhinia rufescens, Guiera senegalensis, Acacia nilotica, Prosopis africana, Waltheria indica, and Cassia mimosoides. As for the fruits, those of Acacia nilotica, Tamarindus indica, Kigelia africana and Neocarya macrophylla are the most important in this category.

Of all the edible parts of the plants, fruits are the most appreciated organs of the human nutrition. They represent 67.5% of consumed parts and are followed by leaves (17.23%), seeds or kernels (6.4%) and gum (5.22%). The highest frequencies of fruit use are observed in Vitellaria paradoxa (60.27%), Balanites aegyptiaca (53.42%), Borassus aethiopum (45.21%), Vitex doniana (42.47%), Diospyros mespiliformis (42, 47%), Tamarindus indica (38.36%), Sclerocarya birrea (36.99%), Anacardium occidentale (35.62%), Piliostigma reticulatum (34.25%), Neocarya macrophylla (34.25%), Ziziphus mauritiana (32.88%) and Hyphaene thebaica (28.77%). The leaves of Balanites aegyptiaca (34.25%), Celtis integrifolia (24.66%), Corchorus fascicularis (24.66%) Adansonia digitata (17.81%) and Sclerocarya birrea (9.59%) are the most consumed. The root of young shoots of Borassus aethiopum (20.55%), the seeds of Nymphaea lotus (15.07%), the kernel of Vitellaria paradoxa (15.07%) and the gum of Combretum nigricans (41.10%) are frequently used in human nutrition.

As far as fodder and animal feeding are concerned, leaves and fruits are the most used parts. They constitute the 99% of the plant organs consumed by the animals. Their total frequency of use is 74.34% for leaves and 24.34% for fruits. In this category, we note a significant frequency of use of the leaves of Balanites aegyptiaca (43.84%), Vitellaria paradoxa (42.27%), Vitex doniana, Celtis integrifolia (34.25%), Sclerocarya birrea (28.77%), Bauhinia rufescens (27.40%), Corchorus fascicularis, Cassia mimosoides, Mitragyna inermis, Daniellia oliveri (23.29%), Acacia nilotica, Echinochloa stagnina, Ziziphus mauritiana, Piliostigma reticulatum, Pterocarpus erinaceus (21.92%), Stereospermum khunthianum and Ficus sycomorus (20.55%). As for the fruits, those of Balanites aegyptiaca (36.99%), Sclerocarya birrea (24.66%), Piliostigma reticulatum (23.29%), Vitellaria paradoxa (21.92%), Ziziphus mauritiana (19.18%), Faidherbia albida and Diospyros mespiliformis (16.44%) are well appetite by the animals.

For craft materials, the populations exploit more wood (74.5%), leaves (13.31%), bark (6.8%) and silk or cotton fiber (4.82%). Because of the quality of their wood, Borassus aethiopum (43.84%), Prosopis africana (32.88%), Bombax costatum (23.29%), Vitellaria paradoxa (20.55%), Combretum nigricans (19.18%), Combretum micranthum (19.18%) and Balanites aegyptiaca (17.81%) are the most used species.

Thatch of Vetiveria nigritana is appreciated in roofing and for stuffing mattresses and pilows. Its frequency of use in this category is 31.51%. When wet, the roots of Vetiveria nigritana give off an odor that perfumes rooms and drives away evil spirits. The leaves of Hyphaene thebaica have a frequency of use of 19.18% and are used in the manufacture of ropes, mats, fans and basketry. The cotton of Bombax costatum and Ceiba pentendra is used in making up pilows and mattresses. For these species the frequency of use varies from 10.96% to 6.85%. The bark of Piliostigma reticulatum (15.07%) is used to make codes. the bark of Gardenia ternifolia, Grewia bicolor, Sterculia setigera, Vitellaria paradoxa and Adansonia digitata are used in dyeing and cosmetics.

Exceptionally, the fruit shells of certain species such as Hyphaene thebaica, Khaya senegalensis and Borassus aethiopum can be used for firewood, but they are rarely used. The wood of about twenty species is recognized for its cooking quality and with less production of harmful smoke. It is the wood of: Combretum nigricans, Balanites aegyptiaca, Vitellaria paradoxa, Prosopis africana, Piliostigma reticulatum, Vitex doniana, Combretum glutinosum, Boscia angustifolia, combretum collimum, Sclerocarya birrea, Neocarya macrophylla, Anacardium occidental, Tamarindus indica, Acacia machrostachya, Diospyros mespiliformis, Guiera senegalensis, Terminalia avicennioides, Combretum micranthum. The wood of Prosopis africana, Combretum glutinosum, Acacia sieberiana is exploited for the production of charcoal and is extremely consumed in blacksmithing.

Table 2. *Importance of organs or plant parts in each use category.*

Usage	Root	Bark	leaf	Fruit	Flower	Grain	Gum	Wood	Latex	% total
TM	17,34	44,82	27,18	7,88	0,23	0,90	0,30	0,83	0,53	100
HN	2,48	0,13	17,23	67,49	1,04	6,40	5,22			100
Fo		0,71	74,34	24,34	0,20	0,40				100
SW	0,57	6,80	13,31	4,82				74,50		100
% total	5,10	13,11	33,02	26,13	0,37	1,93	1,38	18,83	0,13	100

3.5. Consensus Informant Factor (CFI)

Analysis of the Consensus Informant Factor (CFI) for the different use categories of plant species shows very similar values (Table 3). The degree of similarity is higher in traditional pharmacopy (0.95), food and feed (0.94) and than in firewood where the consensus value is 0.90. Compared to the previous use categories mentioned, the degree of similarity is low for construction materials (0.85) and building materials (service wood) (0.83). Overall, there is a tendency for responses to be consistent across all use categories with CFI values above 0.8 (Table 3).

Table 3. *Informative Consensus Factor values within use categories.*

Catégories d'usage	Traditional medecine	Fodder	Humain Nutrition	Firewood	Craft	Service wood
FCI	0,954	0,943	0,948	0,904	0,857	0,838

3.6. Informant Diversity Index (ID)

The Informant Diversity Index and Respondent Equitability Index values reveal that a plant species can be used to varying degrees in several use domains (Table 1). Some species are multi-use and exploited in all use categories and by the entire population. These species have a high diversity index. In contrast, those with a low diversity index are used in only one or a few use categories. The diversity index of the respondent varies from one species to another even if they are all used in the same use category. It shows that only one-third (1/3) of species of socio-economic interest are used contiguously by the surveyed populations in all use categories. The majority of species are exploited randomly. This does not imply that the interest of the species is not known by the majority of the population, but the degree of use is restricted and not uniform. These findings are confirmed by low values of respondent's equitability index (< 0.3) for most species.

4. Discussion

The ethnobotanical study in the department of Gaya shows an important diversity of species, plants of socio-economic interest and forms of use. The plant diversity, estimated at 380 species, is related to the abundant rainfall of the northern Sudanian zone, the shallow depth of the water table and the less frequent and less extreme dry years. This result corroborates those of [7] and [4], for which the specific diversity is greater in the Sudanian zone than in the Sahelian region. A total of 87 species of this flora have a significant socio-economic interest for the population. These species are used in six (6) categories (human nutrition, traditinal medecine, fodder, firewood, service wood and craft). Similar data was found by [17]. The most important uses were for pharmacopy (95.4%), livestock feed (88.51%), firewood (64.37%) and human nutrition (63.22%). These results are comparable to those found by [16], on the Allada plateau in Benin where he counts that 87% of exploited plant species are medicinal and 67.22% are eatten. On the other hand, the study conducted in the groundnut basin of Senegal by [17] on the use value of plant species shows that 94.3% of species cited by the populations provide firewood, 91.4% of species are used in pharmacopoeia and 59% are fodder. Correlatively to their total use value, the most important species are Vitellaria paradoxa (2.24), Balanites aegyptiaca (2), Combretum nigricans (1.42), Borassus aethiopum (1.41),

Piliostigma reticulatum (1.35), Vitex doniana (1.35), Diospyros mespiliformis 32), Prosopis africana (1.21), Sclerocarya birrea (1.20), Tamarindus indica (1.17), Daniellia oliveri (1.05), Vetiveria nigritana (1.02), Ziziphus mauritiana (1.01), Anacardium occidentale (1.00), Neocarya macrophylla (0.94), Bombax costatum (0.87) and Hyphaene thebaica (0.86). These high use values can be explained by the fact that the majority of these species are used in all use categories or the species is heavily used in the same use category due to its sale value [20]. This is the case of, among others: Vitellaria paradoxa, Borassus aethiopum, Diospyros mespiliformis, Tamarindus indica, Vetiveria nigritana, Hyphaene thebaica which are sold locally and in urban centers with an important value chain as demonstrated by [21], Borassus aethiopum by [22] in Benin, Diospyros mespiliformis by [23] in Niger, Tamarindus indica by [24] in Niger.

The determination of the plant parts used in the different categories of use established that leaves (33%), fruits (26.13%), wood (18.83%) and bark (13.11%) constitute the most exploited plant parts. The preponderance of these organs has been described by [20] in Eastern Senegal and [25] in Southwestern Burkina Faso. The leaves are not only a food supplement but also the vegetables of the sauces. The importance of such parts differs according to use categories and changes from one species to another. Traditional medicine exploits more the bark (44.82%), the leaves (27.18%) and the root (17.34%). These organs contain more synthesized organic molecules and active precursors in the treatment of diseases. Similar results have been proven for African pharmacopoeia by [26] in Mali republic, [27] in Malawi, [28] in Namibi, [29] in Benin Republic, [30] in Senegal Republic and [31] in Niger Republic. For human consumption fruits (67.49%) and leaves (17.23%) are the most consumed organs. These organs seem to be more palatable and nutritious due to their high carbohydrate, vitamin and trace element content. Contrary to human consumption, animal fattening uses more leaves (74.34%) than fruits (24.34%). In 1990, [32] showed that livestock in the Sahel are mainly fond of leaves and fruits. This result is explained by the abundance of small ruminants in the herd. The species whose leaves are eaten include Balanites aegyptiaca, Vitellaria paradoxa, Vitex doniana, Celtis integrifolia, Bauhinia rufescens and Sclerocarya birrea. In the field of construction, fencing and handicrafts, wood (74.5) and leaves or thatch (13.31%) are valued. The leading species in this category are Arecaceae (Borassus aethiopum, Hyphaene thebaica), Bombacaeae (Bombax costatum, Ceiba pentendra), Combretaceae (Combretum nigricans, Combretum micranthum), Fabaceae-faboideae (Prosopis africana, Piliostigma reticulatum), Poaceae (Vetiveria nigritana, Ctenum elegans), Sapotaceae (Vitellaria paradoxa) and Balanitaceae (Balanites aegyptiaca). Wood is a strong and resistant material that can support the construction for a long time, while the light leaves exert little load on the building and are used for roofing. Wood is also the firewood used for combustible material in rural zone, provides more heat and produces less smoke. More than 30% of the population uses mainly wood from Combretum nigricans, Balanites aegyptiaca, Vitellaria paradoxa, Prosopis africana, Piliostigma reticulatum, Vitex doniana, Combretum glutinosum, Boscia angustifolia, Combretum collimum, Sclerocarya birrea, Neocarya macrophylla as a source of energy because of their high calorific value and density of their stand.

5. Conclusion

This study has made it possible to assess the specific diversity of the vegetation in Gaya department, and the values and use categories of some plant species of social and/or economic interest. The importance of the floristic potential of this vegetation is inseparable from the climatic regime that is favorable to plant growth on the one hand, and on the other hand from the low anthropic pressure exerted on it, as well as from the low human density of the region. The total use values in the use categories vary from one species to another. They are highest for commonly known and easily accessible woody species. Species with high total use values include Vitellaria paradoxa, Balanites aegyptiaca, Combretum nigricans, Borassus aethiopum, Piliostigma reticulatum, Vitex doniana, Diospyros mespiliformis, Prosopis africana, Sclerocarya birrea, Tamarindus indica, Daniellia oliveri, Vetiveria nigritana, and Ziziphus mauritiana. The organs or used parts of plants include root, rhizome, bark, wood, stem, culm, leaves, fruit, flower, seed, fruit kernel, gum and latex. The importance of an organ varies from one use category to another and according to the plant species. Leaves, fruits, wood and bark are the most used parts. Their use is more or less homogeneous in the population. Excessive exploitation of certain species could lead to their disappearance in the long term.

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