Original Research Article

Diversity And Distribution Of Woody Species In Agrosystems In The Maradi Region Along A North-Central-South Gradient

ABSTRACT

This study aims to characterize the diversity and distribution of woody forage species in the agrosystems of the Maradi region along a North-Central-South gradient. Data were collected in 187 plots of 50 m x 50 m each, i.e. 2500 m² in area. These data were subjected to a factorial correspondence analysis (FCA) followed by a hierarchical ascending classification (HAC) with 50% similarity, which allowed the identification of three plant groupings G1, G2 and G3 that characterize the Dakoro, Guidan Roumdji and Madarounfa sites respectively. The results showed that a total of 13 families were identified in all zones, with a predominance of Fabaceae in Guidan Roumdji (81.25%), Dakoro (70.68%) and Madarounfa (41.35%). The highest tree density was obtained in Madarounfa (10.43 individuals/ha) followed by Guidan Roumdji (7.76 individuals/ha) and finally Dakoro (7.6 individuals/ha). The most dominant biological types are microphanerophytes in Guidan Roumdji (92.19%) followed by Mesophanerophytes in Dakoro (65.05%) and Madarounfa (62%). For the phytogeographic type, Sudano-Zambezian-Saharo-Sindian (SZ-Sah.S) species are the most dominant, followed by Sudano-Zambezian (SZ) species for all zones with more than 84%. These results can be indicators for decision making in the fight against the degradation of plant biodiversity in the region.

Key words: Distribution, tree fodder, Maradi, North-Central-South gradient

1. Introduction

Tree fodder plants play a crucial role in the fodder balance of extensive livestock systems in the Sahelian zone, especially during the lean season [15, 6]. They provide many products and services to the Nigerien population including, among others, leaves, wood, fruits, gums, pods, seeds, etc [21]. In the Sahelian zone [8] noted that most of the fodder consumed by animals is provided by natural ecosystems and agrosystems. However, since the late 1960s in Niger, episodic droughts have led to the degradation of woody formations, which is manifested by changes in the floristic composition and structure of the vegetation [29, 4]. The causes of the degradation in the sahel are the harsh climatic conditions of the last decades, the increasingly high demand for agricultural land, the continuous pressure of livestock, and the inadequacy of natural resource management practices [39, 30]. Also, the Sahelian zone constitutes the northern limit of the distribution area of many species [17]. In recent years with the southward shift of isohyets, the distribution area of some species is decreasing in its northern part [34, 13]. Phytogeographic and phytoecological studies constitute true models to interpret the state and the phenomena of regression or progression of woody floristic diversity [18, 24]. An inventory of this diversity will provide a better understanding of its constituent elements and allow monitoring of its dynamics over time [46]. However, the Maradi region, which is under strong anthropogenic pressure [11], is one of the areas where millions of hectares have been regreened through the practice of assisted natural regeneration in recent years [20]. The importance of woody plants in satisfying the needs of rural populations and in animal feed therefore requires knowledge of the current state of this resource for grazing in order to carry out actions for its preservation and maintenance of all its functions [2]. Hence the need to know the distribution of fodder trees in agrosystems along a North-Central-South gradient in order to better understand the current status of the stand over the region. Thus, the objective of this study is to determine the diversity and

distribution of woody forage in the agrosystems of the Maradi region along the North-Center-South gradient. The results of this research will provide indicators for the protection and sustainable management of the woody forage resource of the agrosystems.

2. MATERIALS AND METHODS

2.1 Study sites

This study was conducted in the Maradi region along a North-Central-South gradient (Figure 1). In the north, the Ajekorya and Baban Kori sites were selected. Ajekorya is located at about 25km south of the town of Dakoro at 6°47'24'' E longitude and 14°20'20.9'' N latitude and Baban Kori is located 70km from Dakoro, at 6°58'36.4'' E longitude and 13°55'47.7'' N latitude. The population is estimated at 807,813 inhabitants [9]. The climate of the area is semi-arid Sahelian in the south and Sahelo-Saharan in the north, characterized by a long dry season (8 to 9 months) from October to May followed by a short rainy season (3 to 4 months) from July to September [34]. The average annual rainfall recorded during the last 30 years (1988 to 2018) was 378.4±90.9 mm/year. Three types of soils are tropical ferruginous soils or dune soils are the most dominant and are of crop production, hydromorphic soils are spread in depressions and in fossil valleys and clay-lateritic soils on the lateritic plateau of the southern strip [35]. In the phytogeographic subdivision of Saadou (1990), the vegetation of the zone is characterized by the presence of Combretaceae thickets on the lateritic plateaus, savannas on the southern sandy terraces and steppes on the dunes and in the dry valleys. The flora of the area is dominated by xerophytic woody species such as species of the genus Acacia, Boscia senegalensis (Pers.) Lam. Ex Poir, Balanites aegyptiaca and Ziziphus mauritiana. The herbaceous stratum is dominated by therophytes such as Cenchrus biflorus Roxb., Schoenefeldia gracilis Kunth. and Aristida mutabilis Trin. et Rupr..

In the center: the study was carried out in the village of Karazomé located at 15 km from the town of Guidan Roumdji with geographic coordinates of 6°51'21.4'' East longitude and 13°39'31.2'' North latitude and the village of Karo Sofoua located 7km from the town of Guidan Roumdji at 6°37'09.3'' East longitude and 13°37'48.1'' North latitude. The population is estimated at 671,084 inhabitants [9]. The climate is Sahelian, semi-arid, characterized by three distinct seasons: a cold season from November to February with a minimum temperature of 15°C; a hot season from March to May with a maximum temperature of about 40°C; and a rainy season from June to September, sometimes until the second decade of October. The average annual rainfall recorded over the last 30 years (1988 to 2018) is 449.5±104.1mm/year. Minimum temperatures fluctuate between 15 and 20°C during the cold dry season (December to February) and maximum temperatures reach 39 to 42°C during the hot dry season (April to June) [10]. According to their agronomic aptitudes, two types of soils are mainly encountered in the Department, of which sandy soils are the most dominant and are of low fertility. They are poor in organic matter due to water and wind erosion, the absence of fallow land and abusive land clearing [36] and hydromorphic soils, rich in mineral elements suitable mainly for irrigated crops. Generally speaking, the vegetation is of the grassy steppe type, with shrubs and trees on the sandy soils. The herbaceous stratum is dominated by the following species: *Cenchrus biflorus* (karanguiya in Hausa), *Zornia glochidiata* (Narak in Hausa).

To the North: the village of Safo located 15km from Madarounfa with geographic coordinates 7°07'18.6'' East longitude and 13°24'28.4'' North latitude and the village of Bargaja located 5km from Madarounfa with coordinates 7°05'48.8'' East longitude and 13°17'35.8'' North latitude. The population is estimated at 575,167 inhabitants [9]. The climate is of the Sahelo-Sudanese type, characterized by the alternation of two seasons: a rainy season that lasts 4 to 5 months and extends from May to September, and a dry season that is subdivided into a cold season from November to February and two hot interseasons (March, April and May, then October and November). The average annual rainfall over the last 30 years (1988 to 2018) was 535.1±93.5mm. The average temperature varies quite a lot from one season to another: it ranges from 21.9°C in January to 38.6°C in May; the minima vary from 13.6°C in January to 26.9°C in May while the maxima vary from 30.2°C in January to 40.4°C in April [45]. Two (2) types of soils are encountered in this area whose physical characteristics are as follows: Heavy soils found

mainly in the valley of the Maradi goulbi formed of silty-clay allusion and have a good agricultural vocation, ferruginous soils are observed on the rest of the department which is classified into two (2) types namely: tropical ferruginous soils formed on a veneer of clayey sand located in the west, south and east and ferruginous soils that present another facies and are located mainly in the northeast. The vegetation of the area is characterized by shrubby, wooded and wooded savannahs and Combretaceae thickets. In the natural formations there are also forest galleries along the watercourses. The flora is dominated mainly by Combretaceae (*Guiera senegalensis*., *Combretum micranthum*, Combretum nigricans, *Combretum glutinosum*) associated, according to the topography and the type of soils, with species such as *Lannea microcarpa*, *Diospyros mespiliformis* and species of the Mimosaceae (*Acacia macrostachya, Acacia ataxacantha*), Cesalpiniaceae, (*Piliostigma reticulatum*), Capparaceae and Tiliaceae families. In natural vegetation, the upper stratum is less and less present and is dominated by : *Prosopis africana, Isoberlinia doka, Afzelia africana, Bombax costatum* and *Sclerocarya birrea*. The herbaceous cover is dominated by *Aristida adscensionis* and Zornia glochidiata, the accompanying species are: *Schizachyrium exile, Diheteropogon hagerupii, Pennisetum pedicellatum* [26].

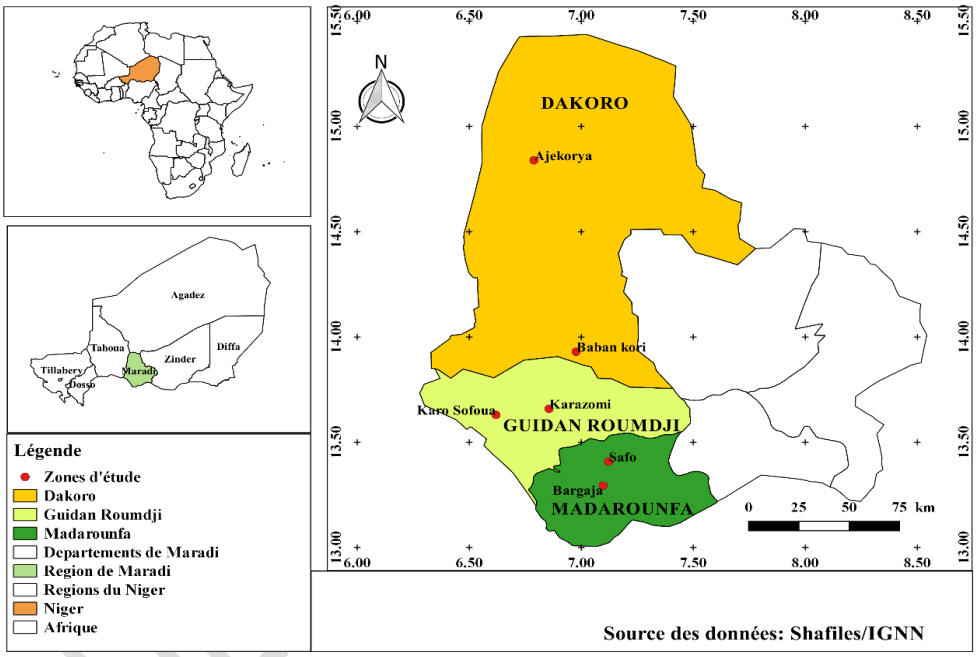

Figure 1: Location of study sites.

2.2 Data collection and sampling

In order to study the vegetation of the Maradi region, an inventory of woody species following a North-Central-South gradient was carried out on a set of 187 plots, including seventy (70) plots in Dakoro located in the North; sixty-six (66) in Guidan Roumdji located in the center and fifty-one (51) in the South located in Madarounfa. The data was collected during the month of April 2021 in plots of 50 m x 50 m, i.e. 2500 m². Two perpendicular transects running east-west and north-south from the centre to outside of the village [46, 12] were used to set up the plots. Plots were spaced 200 m apart along the transects. During the inventory, the scientific names of the species were determined in situ, and unidentified species were photographed and a portion of the leaves and inflorescences were collected to help identify them. The dendrometric parameters measured on each tree were related to the total height of the trees with a graduated pole, the circumference at the base of the trunk at 1.30m and the two diameters of the crown in the two perpendicular directions (East-West and North-South) were determined with tape measures measuring 1.5m and 50m respectively. Individuals with a diameter less than or equal to 2cm were considered as sprouts or seedlings and their number per species [25] was counted in each plot.

2.3 Data processing

The collected data were entered into the Excel spreadsheet. The floristic richness, the biological types were determined thanks to the classification of Raunkiaer (1934). The index of specific diversity, the index of importance values were calculated using the formulas below, the phytogeographic type, the structure in diameter and height were determined.

Shannon-Weaver diversity index (H) expressed in bits

$H=-\sum_{i=1}^{S} pilog2pi$ (1)

With S being the total number of species and pi the relative frequency of species
Diversity is low when H is less than 3 bits; medium if H is between 3 and 4 bits; high when H is greater than or equal to 4 bits.

The Pielou fairness was calculated from the formula(E)

$\mathbf{E=\frac{H}{Hmax}}$ (2)

with H: Shannon diversity index

The Pielou equitability reflects the way individuals are distributed across species.
If E [0 -0.6], the Pielou equitability is low (dominance phenomenon existing in the community).
If E [0,7 -0,8[, the Pielou equitability is average.
If E [0.8 -1], Pielou equitability is high (lack of dominance in the community) [14].

Maximum diversity index (Hmax)

$Hmax=log_2S$ (3)

with **S** Total number of species

Average Lorey Height (HL)
The average height of Lorey expressed in (m) is the average height of individuals weighted to their basal area. It is calculated by the following formula:

HL= $\frac{\sum_{i=1}^{n} gi*hi}{\sum_{i=1}^{n} gi}$ (4)

with **gi**=$\frac{\pi}{4}\ di^2$ [38] (5)

Basal area

The global basal area (G) expressed in (m²/ha) and given by the formula below

G= $\frac{\pi}{40000xS}\sum_{i=1}^{n} di^2$ [7] (6)

S=Plot area in hectare and di=diameter of stem i (cm).

The density

Density (N/ha) is a simple index of average competition in the stand. It is defined as the number of individuals considered in the inventory per unit area per hectare [42]. It is a biological index that provides information on the abundance of individuals of a species in a given site and is obtained by the formula :

N=$\frac{n}{S}x10000$ (7)

with S=Area of the plot (ha) and n number of trees in the plot
Wittig and Guinko (1995) cited by Traoré & Toé (2004) have established criteria for assessing regeneration capacity based on the number of seedlings (NP) per hectare. These criteria are :
-No regeneration if NP < 1 ;
- Poor regeneration if 1 < NP ≤ 1000 ;
- Regeneration good if 1000 < NP ≤ 10000;
- Very good regeneration if NP > 10000.

Cover

The cover corresponds to the surface of the ground that would be covered by the projection of the aerial parts of the individuals of the species (Gounot, 1969). It is expressed in percentage (%) and is calculated by the formula :

R=$\frac{r}{s}$ **avec r=**$\frac{\pi}{4}\sum_{i=1}^{n} di^2$ (8)

With r=coverage of all individuals in the plot (m²); di=mean crown diameter of individual i (m); s=plot area (m²).

Biological type

The biological type is the set of morpho-physiological characteristics that allow to endure a determined climate, especially the unfavorable season. They are also the parameters that better account for the physiognomy of plant formations [40,41,33,31]. These are the biological types in reference to [37] classification of phanerophytic woody vegetation (woody plants whose buds are located more than 50cm above the soil surface).

- ✓ Nanophanerophytes <2m high
- ✓ Microphanérophytes 2 at 8 m height;

- ✓ Mesophanérophytes 8 at 30 m height.

Phytogeographic type

The phytogeographic type adopted is that of the chronological subdivisions generally accepted for Africa [44] and widely used [46]:

- ✓ SZ: Sudanese-Zambezian;
- ✓ GC: Guinean-Congolese;
- ✓ Sah.S: Saharo-Sindian;
- ✓ GC-SZ: Guinean-Congolese-Sudanese-Zambezi
- ✓ GC-SZ-Sah.S: Guinean-Congolese-Sudanese-Zambezi-Saharan-Sindian
- ✓ I : Introduced

3. RESULTS AND DISCUSSION

3.1 Floristic richness

There are 13 families found in all the zones (Table 1). The table shows that the Fabaceae families are the most dominant in all the study areas with 81.25% in Guidan Roumdji, 70.68% in Dakoro and 41.35% in Madarounfa. The results of this study showed that the floristic richness is dominated by Fabaceae on all the study sites. The floristic richness results obtained for the whole study area are higher than those obtained by [2] on natural pastures in the Maradi region which are 11 families. However, they are lower than the results obtained by [3] in the same area but in the Goulbi Maradi where he counted 22 families of which the most representative are the Mimosaceae and in the Goulbi Kaba which has 19 families also dominated by the Mimosaceae. This difference in the number of species could be due to the specific climatic conditions favorable to the development of various species in the Goulbi Kaba and Goulbi Maradi valleys. States that in natural formations [32], the floristic richness is higher in the Sudano-Sahelian zone and [27] states that in Niger the specific richness is higher in the bioclimates of the southern part of the country which are the most watered.

Table 1: Distribution of families by zone expressed in percentage

Families	Dakoro	Guidan Roumdji	Madarounfa	Total (%)
Fabaceae	70,68	81,25	41,35	64,21
Arecaceae	0,75	1,56	28,57	10,41
Zygophyllaceae	15,04	-	3,76	6,35
Meliaceae	-	4,69	9,02	4,57
Malvaceae	-	0,78	10,53	3,81
Anacardiaceae	2,26	5,47	3,01	3,55
Combretaceae	6,02	2,34	-	2,79
Ebenaceae	-	2,34	2,26	1,52
Rhamnaceae	4,51	-	-	1,52
Capparaceae	0,75	0,78	-	0,51
Bignoniaceae	-	-	0,75	0,25
Lamiaceae	-	-	0,75	0,25
Moraceae	-	0,78	-	0,25
Total	100	100	100	100

3.2. Specific diversity

The diversity indices of all the sites were presented in table (2). The Shannon diversity index is average at Madarounfa with 3.01 bites but low at Dakoro and Guidan Roumdji with values of 2.27 bites and 1.76 bites respectively. These low values could be due to anthropogenic activities, particularly the abusive cutting of old individuals in these areas for the manufacture of mortars, pestles and wooden chairs. This result corroborates that obtained by [14] which reveals that the low diversity of grouping is mainly due to anthropogenic factors because in Niger the problem of natural resource management is characterized by an imbalance between the increased needs of rapidly growing populations and the search for a general improvement of their living conditions. Thus, many species that have become rare or disappeared from natural pasture formations due to destructive anthropic

practices are maintained by farmers in agrosystems for multiple benefits, which has changed the landscape of the fields [23]. The high value of Shannon diversity index in Madarounfa area is due to the practice of ANR advocated by Projects and NGOs which is protected and monitored by village monitoring committees [5]. The Pielou equitability index is average in all sites and varies from 0.44 to 0.73. The highest value of this index is obtained at Madarounfa (0.73) and the lowest at Guidan Roumdji (0.44). The maximum diversity index is highest in Madarounfa (4.08) followed by Guidan Roumdji (4) but is low in Dakoro (3.58). It is noted that the Madarounfa zone has the highest specific diversity parameters of all the zones studied. These results are inferior to those obtained by [19] in the Mainé soroa area where the Pielou equitability index is higher than 0.8. This difference is due to the high diversity within the grouping and that many species participate in the cover in this area.

Table 2: Species diversity at the three sites

Area	S	H	Hmax	E
Dakoro	12	2,27	3,58	0,63
Guidan Roumdji	16	1,76	4	0,44
Madarounfa	17	3,01	4,08	0,73
Probability		0,198	0,00	0,125

S: species richness; H: Shannon diversity index; Hmax: maximum diversity; E: Pielou equitability

3.3. Biological distribution of the raw and weighted spectrum

The biological distribution of the raw and weighted spectrum is presented in figure (2). The results show that in the Guidan Roumdji area, microphanerophytes are the most dominant biological types in both the gross spectrum (92.19%) and the weighted spectrum (82.53%). On the other hand, in Dakoro, Mesophanerophytes are the most dominant biological types for the gross spectrum (58.65%) and the weighted spectrum (65.05%). As for the Madarounfa area, microphanerophytes (49.62%) followed by Mesophanerophytes (48.87%) dominate in raw spectrum and Mesophanerophytes in weighted spectrum (62%). Finally, nanophanerophytes are poorly represented in all areas (less than 1%). This could be explained by the anthropic pressure exerted on the large trees. This dominance of microphanerophytes characterizes the predominance of shrubs in this area. These results are similar to those found by [30] who reported that the most prevalent physiognomic types in this area are shrubby formations. This dominance of Microphanerophytes to the consequence of the low rainfall observed at the site [1]. In the Dakoro and Madarounfa areas, Mesophanerophytes are the most represented compared to the other types. This dominance of Mesophanerophytes is due not only to the presence of large trees in these areas but also by the climatic conditions that are more favorable to them.

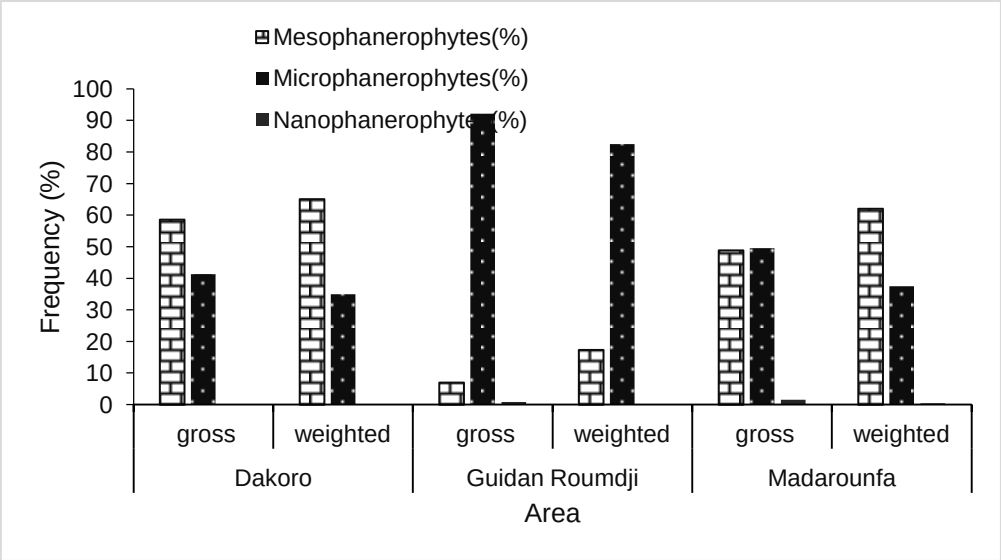

Figure 2: Distribution of raw and weighted spectra by area

3.4. Phytogeographic distribution

The phytogeographic type is shown in Table (3). From this table, it appears that Sudano-Zambezian-Saharan-Sindian (SZ-Sah.S) species are the most dominant for both the gross and weighted spectra, followed by Sudano-Zambezian (SZ) species for all zones with over 84%. Guinean-Sudanese-Zambezi (GC-SZ) and Guinean-Congolese-Sudanese-Zambezi-Saharan-Sindian (GC-SZ-Sah.S) species are poorly represented at all sites (less than 5%). These results are consistent with the results found by [14] which presents a dominance of Sudano-Zambezian species followed by Sudano-Zambezian-Saharo-Sindian species in the Tahoua region.

Table 3 : Phytogeographic type

Area	**Dakoro**		**Guidan Roumdji**		**Madarounfa**	
Phytogeographic type	**Gross**	**Weighted**	**Gross**	**Weighted**	**Gross**	**Weighted**
SZ-Sah.S	88,72	91,94	78,91	77,45	39,85	46,14
SZ	11,28	8,06	13,28	10,65	46,62	38,78
I			4,69	4,45	9,02	10,31
GC-SZ			2,34	4,57	3,01	3,72
GC-SZ-Sah.S			0,78	2,88	1,50	1,06

3.5. Density of regeneration of species by area

The regeneration density of all woody species in all zones is presented in Table 4. The results show that 34 regenerating plant species were found in all sites, with the highest number of species in Madarounfa (24 species), followed by Dakoro (22 species) and finally Guidan Roumdji (21 species). The dominance of species depends on the zone. Nevertheless, the Guidan Roumdji zone has the highest regeneration density compared to the other two zones with the species Hyphaene thebaica (822.85 trees/ha) followed by *Piliostigma reticulatum* (555.76 trees/ha) and *Guiera senegalensis* (478.12 trees/ha). According to the criteria for assessing regeneration, with the exception of the Dakoro zone, all the study areas show good regeneration with density values between $1000 < NP \leq 10000$. This could be due to the favorable soil and climatic conditions for the development of woody species. Also, [43] reported that variations in juvenile density could be related to the complex interaction between factors involving species characteristics, soil types, as well as the capacity of the species to dispose of stump offsets.

Table 4: Density of regeneration of all species by area

	Regeneration density (trees /ha)			
Species	**Dakoro**	**Guidan Roumdji**	**Madarounfa**	**Total**
Acacia laeta	1,94	-	-	0,73
Acacia nilotica	0,69	2,42	0,78	1,33
Acacia radiana	-	-	0,55	0,15
Adansonia digitata	-	-	0,39	0,11
Albizia chevalieri	1,20	3,94	17,80	6,70
Annona senegalensis	10,40	9,88	17,18	12,06
Azadirachta indica	0,46	20,48	111,53	37,82
Balanites aegyptiaca	19,60	7,70	8,31	12,32
Bauhinia rufexens	9,83	9,09	-	6,89
Boscia salicifolia	0,00	0,48	-	0,17
Boscia senegalensis	178,74	-	9,10	69,39
Calotropis procera	7,89	2,91	20,71	9,63
Cassia singueana	0,34	-	-	0,13
Combretum glutinosum	24,17	21,33	-	16,58
Combretum micranthum	17,49	0,91	-	6,87
Commiphora africana	0,11	-	11,76	3,25
Dichrostachys cinerea	-	51,58	4,71	19,49
Diospiros mespiliformis	-	-	3,14	0,86
Euphorbia Balsamifera	-	0,85	11,37	3,40
Faidherbia albida	22,97	39,27	70,59	41,71
Ficus thonningii	-	-	1,57	0,43
Guiera senegalensis	354,40	478,12	119,61	334,03
Hyphaene thebaica	7,14	822,85	321,88	380,88
Lannea frutisoca	-	0,61	-	0,21
Maerua angolensis	0,06	-	-	0,02
Maerua crassifolia	5,60	3,52	-	3,34
Moinga oleifera	-	-	0,94	0,26
Piliostigma reticulatum	19,54	555,76	181,33	252,92
Sclerocarya birrea	10,63	7,76	4,16	7,85
Sterculia setigera	-	-	0,08	0,02
Stereospermum kunthianum	-	2,12	-	0,75
Tamarindus indica	-	-	2,82	0,77
Vitex doniana	-	-	3,92	1,07
Ziziphus mauritiana	48,91	94,18	91,61	76,53
Total	747,31	2135,76	1017,65	1311,08

3.6. Density of individuals per hectare

The density of individuals per hectare of all the species by zone is represented in table (5). The results show that the Madarounfa zone has the highest density (10.43 individuals/ha) followed by the Guidan Roumdji zone (7.76 individuals/ha) and finally the Dakoro zone (7.6 individuals/ha).

Table 5: Density of individuals per hectare

		Density (individuals/hectare)			
Scientific names	**Famillies**	**Dakoro**	**Guidan Roumdji**	**Madarounfa**	**Total**
Acacia laeta	Fabaceae	0,23	-	-	0,09
Acacia nilotica	Fabaceae	0,34	-	0,08	0,15
Adansonia digitata	Malvaceae	-	0,06	0,94	0,28
Albizia chevalieri	Fabaceae	-	0,06	0,31	0,11
Annona senegalensis	Fabaceae	-	0,06	0,16	0,06
Azadirachta indica	Meliaceae	-	0,36	0,94	0,39
Balanites aegyptiaca	Zygophyllaceae	1,14	-	0,39	0,53
Bauhinia rufexens	Fabaceae	0,06	-	-	0,02
Bombax castatum	Malvaceae	-	-	0,16	0,04
Combretum glutinosum	Combretaceae	0,34	0,12	-	0,17
Detarium microcapum	Fabaceae	-	0,06	-	0,02
Diospyros mespiliformis	Ebenaceae	-	0,18	0,24	0,13
Entada africana	Fabaceae	-	-	0,08	0,02
Faidherbia albida	Fabaceae	4,23	0,36	0,63	1,88
Ficus thonningii	Moraceae	-	0,06	-	0,02
Guiera senegalensis	Combretaceae	0,11	0,06	-	0,06
Hyphaene thebaica	Arecaceae	0,06	0,12	2,98	0,88
Lannea fruticosa	Anacardiaceae	-	0,30	0,08	0,13
Maerua crassifolia	Capparaceae	0,06	0,06	-	0,04
Piliostigma reticulatum	Fabaceae	0,51	5,70	2,90	2,99
Prosopis africaina	Fabaceae	-	0,06	-	0,02
Sclerocarya birrea	Anacardiaceae	0,17	0,12	0,24	0,17
Stereospernum kunthianum	Bignoniaceae	-	-	0,08	0,02
Tamarindus indica	Caesalpiniaceae	-	-	0,16	0,04
Vitex doniana	Lamiaceae	-	-	0,08	0,02
Ziziphus mauritiana	Rhamnaceae	0,34	-	-	0,13
Total		7,60	7,76	10,43	8,43

3.7. Distribution of woody species by area

The 26 species found in 187 plots were subjected to a factorial correspondence analysis (FCA). Factor axes 1 and 2 explained 100% of the total variance, with contributions of 66.9% and 33.1% respectively (Figure 3). The hierarchical ascending classification (HAC) at 50% similarity had identified three plant groupings which are G1, G2 and G3 as shown in the dendrogram in Figure (4). The species of the G1 grouping characterize the Guidan Roumdji area. This zone includes the following species: *Piliostigma reticulatum, Lannea fructicosa, Detarium microcarpum, Diospyros mespiliformis, Ficus thonningii, Prosopis africana.*

The G2 grouping characterizes the Dakoro zone, it is constituted in majority of thorny species which are: *Faiderbia albida, Balanites aegyptiaca, Combretum glutinosum, Sclerocarya birrea, Acacia nilotica, Ziziphus mauritiana, Acacia laeta, Guiera senegalensis, Maerua crassifolia, Bauhinia rufescens*.

The G3 grouping represents that of the Madarounfa zone, made up of species such as *Hyphaene thebaica, Azadirachta indica, Diospyros mespiliformis, Albizzia chevalieri, Annona senegalensis, Bombax costatum,*

Tamarindus indica, Entada africana, Stereospernum kunthianum, Vitex doniana.

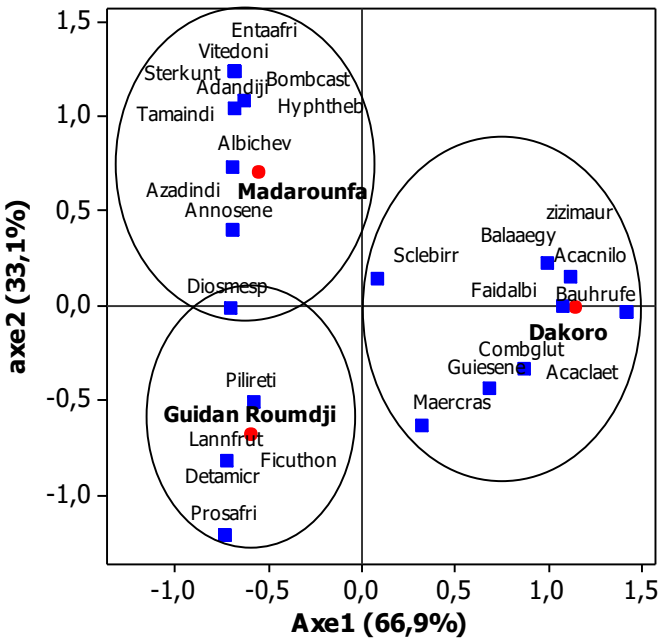

Figure 3: Correspondence factor analysis of woody species, frequency by zone Dendrogram readings

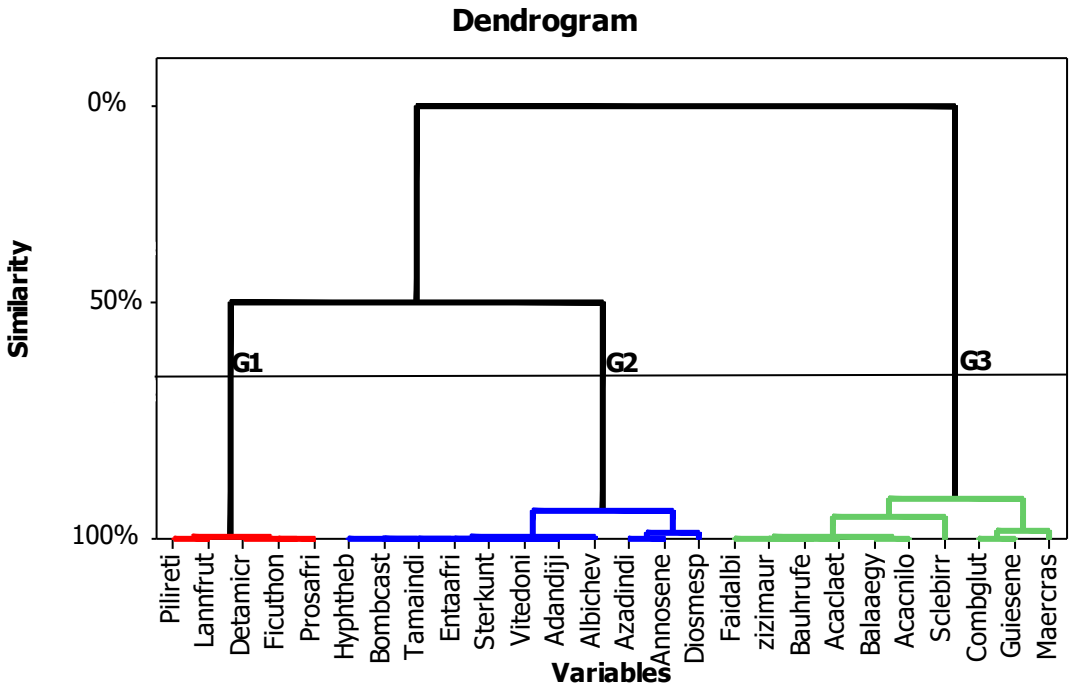

Figure 4: Hierarchical bottom-up classification of plant groupings across area.

4. CONCLUSION

The study of the floristic diversity of the Maradi region according to the North-Central-South gradient allowed the identification of 32 families. Indeed, the Madarounfa zone

abounds in the greatest number of species, followed by Guidan Roumdji and Dakoro. The Fabaceae families are the most dominant in all zones. The most represented biological types are microphanerophytes in Guidan Roumdji followed by Mesophanerophytes in Dakoro and Madarounfa, but for phytogeographic types, Sudano-Zambezian-Saharan-Sindian species are the most dominant, followed by Sudano-Zambezian species on all sites. Thus, we note a re-greening through young shoots in the whole region. In order to safeguard the woody species identified in the agroforestry parks, the village committees for monitoring assisted natural regeneration must be strengthened in order to perpetuate this already threatened woody resource.

References

1. Abasse T., Rabiou H., Moussa M., Soumana I., Kouyate A. and Mahamane A. Influence of the agroecological gradient on the diversity and distribution of ligneous resources in the Sahelian and Sudanian zones of Niger. Africa science. 2019; 15(6) 335 – 348.
2. Alhassane A., Chaibou I., Karim S., Soumana I., Mahamane A. and Saadou M. Flora and structure of woody populations in natural pastures in the Maradi region, Niger. Africa Science. 2018; 14(5) 171 – 189.
3. Ali A., Morou B, Inoussa M M., Abdourahamane S., Mahamane A. and Saadou M. Characterization of woody stands in Diospyros mespiliformis agroforestry parks in central Niger. Africa Science .2017;13(2) 87 – 100.
4. BAKHOUM A. Dynamics of fodder resources: resilience indicator of community rangelands from Téssékéré to Ferlo (North-Senegal). Unique doctoral thesis in Biology, Animal Production and Pathology, Option Pastoral Ecology, FST-UCAD. 2013.
5. Baggnian I. Resilience of agroecosystems in the Sahel: analysis of regreening in the Center South of Niger. Thesis from the Abdou Moumouni University of Niamey, Faculty of Agronomy, Plant Production Laboratory. 2014 ; 152p.
6. Bechir A. B., Kabore-Zoungrana C. Woody fodder in the savannahs of Chad: demographic structure and pastoral exploitations, Cameroon Journal of Experimental Biology. 2012; Flight. 8, No. 1. 35-46.
7. Bonou W., Glèlè Kakaï, R., Assogbadjo, A. E., Fonton, H. N. and Sinsin, B. Characterization of Afzelia africana Sm. Habitat in the Lama forest reserve of Benin. Forest Ecology and Management. 2009; 258.1084–1092.
8. César J. The evaluation of natural fodder resources. Animal production in West Africa. CIRDES and CIRAD. 2005; sheet n°17, p 12.
9. National Institute of Statistics. Statistical Yearbook 20015-2019, Ministry of Planning, Regional Planning and Community Development, Edition 2020, Republic of Niger.2020; 257p.
10. Issa, Y. and Oumarou, I. The food crisis in Guidan Roumdji 2004-2005. Studies and Works n°65. Laboratory for Studies and Research on Social Dynamics and Local Development (LASDEL), Niamey, Niger. 2006; 37p.
11. Dan Lamso N., Guéro Y., Tankari Dan-Badjo A., Rabah L., André BB., Patrice D., Tidjani AD., Ado Maman N. and Ambouta JM. Textural and chemical variations around soil clumps of Hyphaene thebaica (MART) in the Maradi region (Niger). Algerian Journal of Arid Environment. 2015 5(1): 40-55.
12. Dramé Y. and Berti F. Socio-economic issues around village agroforestry in Aguié (Niger). Tropicultura. 2008, 26: 141-149.
13. Dupouey J L. and Bodin J.. Already observed movements of plant species: a few emblematic cases, but no massive migrations", ONF Technical Meetings, special issue no 3, "Forests and natural environments facing climatic changes. 2007; 34-39 p.
14. Garba A., djima I T., Abdou A and Mahamane A. Characterization of woody vegetation in the Maggia watershed in the rural commune of Bagaroua (Tahoua region); International Journal Biological Chemical Sciences. 2017; 11 (2): 571-584.
15. GNING O. N., SARR O., GUEYE M., AKPO L.E., NDIAYE P.M. Socio-economic value of trees in a Malinke environment (Khossanto, Senegal), Journal of Applied Biosciences. 2013;70. 5617 – 5631.
16. Gounot M. Method for the quantitative study of vegetation. Masson et al., Paris VIe. 1969; 303p.
17. HOUNTONDJI Y-C. H. Environmental dynamics in the Sahelian and Sudanian zones of West Africa: Analysis of the modifications and evaluation of the degradation of the vegetation cover. Doctoral thesis, University of Liège, Belgium. 2008; 153p.
18. Howden M., Soussana J.F., Tubiello F.N., Chtetri N., Dunlop M., Aggarwal P.K. Adapting

agriculture to climate change, PNAS.2007; 104;19691 – 19696.
19. Kaou A K., Manzo O L., Dan Guimbo I., Karim S., Habou R., Paul R. Floristic diversity and vegetation structure in the dune zone of south-eastern Niger: Case of Mainé soroa . J.Appl. Biosci. 2017. 120: 12053-12066.
20. Larwanou M., Saadou M. and Hamadou S. Trees in agrarian systems in the Sahelian zone of Niger: management method, advantages and constraints. Tropicultura. 2006; 24, 1, 14-18.
21. Larwanou M., Oumarou I., Laura S., Danguimbo I. Eyog-Matig O. Silvicultural and cropping practices in agroforestry parklands following a north-south rainfall gradient in the Maradi region of Niger; Tropicultura. 2010; 28, 2, 115-122p.
22. Larwanou M, Saadou M. Biodiversity of ligneous species in semi-arid to arid zones of southwestern Niger according to anthropogenic and natural factors. Agriculture, Ecosystems and Environment. 2005; 105: 267-271.
23. Larwanou M. and Saadou M. The role of human interventions in tree dynamics and environmental rehabilitation in the Sahel zone of Niger; Journal of Arid Environments. 2011; 75: 194-200.
24. Legay M., Mortier F., Menginlecreulx P., Cordonnier T. La forest management in the face of climate change: let's learn the first lessons. ONF Technical Meetings, special issue No. 3, “Forests and natural environments in the face of climate change. 2007; 95 – 102.
25. Maazou R., Rabiou H., Issiaka Y., Abdou L., Saidou S I. and Mahamane A. Influence of land occupation on the dynamics of plant communities in the Sahelian zone: case of the rural commune of Dantchandou (Niger). International Journal Biological Chemical Sciences. 2017; 11 (1): 79-92.
26. Mahamane A., Saadou M., Bakasso Y., Abassa I., Ichaou A., Karim S. Diachronic analysis of land use and vegetation characteristics in the commune of Gabi (Maradi region, Niger) ; Drought, October-November-December.2007, Vol. 18, No. 4, 9 p.
27. Mahamane A., Saadou M., Danjimo M. B., Saley K., Yacoubou B., Diouf A., Morou B., Mamane Maarouhi I., Soumana I. and Tanimoune A. Plant biodiversity in Niger: state of current knowledge . Annals of the University of Lomé (Togo), Sciences series, Volume XVIII .2009: 81-93
28. Mahamane A. Floristic, phytosociological and phytogeographical studies of the vegetation of the W Niger Regional Park. Doctoral Thesis in Agronomic Sciences and Biological Engineering. Free University of Brussels. 2005, 536 p.
29. Mahamat-Saleh M., Diallo A., Ousmane N., Faye M. N., Guisse A., Characterization of woody populations in the Cayor Baol zone (Thiès-Senegal), Int. J. Biol. Chem. Sci.2013; 7(5); 2117 – 2132
30. Manzo O. L., Oumarou B. G., Morou B., Karim S., Mahamane A. State of woody vegetation in the Sahel: Case of Guidan Roumdji in the central Sahel of Niger, Journal of Animal & Plant Sciences.2017; Flight. 31, Issue 3, 5033–5049.
31. Melom S., Mbayngone E., Bechir A. B., Ratnan N. and Mapongmetsem P. M. Floristic and ecological characteristics of the plant formations of Massenya in Chad (Central Africa), Journal of Animal & Plant Sciences. 2015 ; Vol.25, Issue 1: 3799-3813
32. Morou B. Impacts of land use on giraffe habitat in Niger and issues for safeguarding the last herd of giraffes in West Africa. Doctoral thesis, Abdou Moumouni University of Niamey. 2010; 198p.
33. Nacoulma B. Dynamics and conservation strategy of the vegetation and phytodiversity of the ecological complex of the W National Park of Burkina-Faso. Single Thesis, Univ. Ouagadougou. 2012,153p
34.Ozer,A. and Ozer, P. Desertification in the Sahel: climatic or anthropogenic crisis? Bulletin of the Sessions of the Royal Academy of Overseas Sciences. 2005; 51:395-423.
35. Communal Development Plan (PDC). Municipality of Dakoro, Region of Maradi. 2013; 54p.
36. Communal Development Plan (PDC). Urban Commune of Guidan Roumdji, Maradi Region. 2013; 130p.
37. Raunkiaer C., The life forms of plants and statistical plant geography. Clarendon, Oxford. 1934; 632 p.
38. Rondeux J. Measurement of forest stands. Presses agronomiques de Gembloux, Gembloux, edition 2, (1999) 544 p.
39. Sarr O., Diatta S., Gueye M., Ndiaye P.M., Guisse A., Akpo L. E. Importance of woody fodder in an agropastoral system in Senegal (West Africa), Revue Med. Vet., 164 (1); 2013; 2 - 8
40. Sinsin B., Oumorou M., Ogoubiyi V. The Andropogon pseudapricus facies of post-cultivation groups and shrubby avannas in northern Benin: floristic dissimilarity and common characters.: Van Der Maesen, L. J. G, X. M. Van Der Burgt And J. M. Van Medenbach De Rooy (ed.), The biodiversity of

African plants. Proceeding XIVth AETFAT Congress. 1996; 231-238. Kluwer Academic Publishers.
41. Thiombiano A. The Combretaceae of Burkina-Faso: taxonomy, ecology, dynamics and regeneration of species. State thesis, Univ. Ouagadougou. 2005; 290 pages
42. Traoré S.A. and Toé P. Status of a village forest in the province of Nayala; study of rehabilitation strategies. Man, plants and environment in the western Sahel, proceedings of the Fada N'Gourma workshop. 2004 ; 115-126.
43. Traoré L. Influence of climate and protection on woody vegetation in the western part of Burkina Faso. Single doctoral thesis, University of Ouagadougou. 2012; 228p.
44. White F. The vegetation of Africa. Memoir accompanying the vegetation map of Africa. Unesco / AETFAT / UNSO, ORSTOM / UNESC. 1986; 384p.
45. ICHAOU, A. Conduct test of the regional protocol for monitoring the environmental impacts of the exploitation of forest resources in the sandy plains of Banban Rafi, PREDAS Regional Coordination Unit (CRC/PREDAS) Final report, INRAN.2009, 88 p.
46. Larwanou M. Vegetation dynamics in the Sahelian domain of western Niger following an aridity gradient: roles of ecological, social and economic factors; Doctoral thesis, University of Niamey.2005; 186p.
47. Saadou M., The vegetation of drained environments in Niger to the east of the Niger River. Doctoral Thesis - Natural Sciences, University of Niamey. 1990, 395 p.