ISSN 2201-2796

Diversity and Structure of Woody Species in parts of Sahelian dryland of Maradi Region, Niger Republic.

Mamane Abdourahamane[1], Maharazu A. Yusuf [2] and Moussa Massaoudou [3]

[1&2]Centre for Dryland Agriculture, Bayero University of Kano, Nigeria

[2]Department of Geography, Bayero University of Kano, Nigeria

[3]Université Dan Diko Dankoulodo Maradi, Niger Republic

Corresponding Author**:** **mamanedourahmane@gmail.com**

DOI: 10.31364/SCIRJ/v12.i04.2024.P0424980
http://dx.doi.org/10.31364/SCIRJ/v12.i04.2024.P0424980

Abstract: Changes in woody vegetation cover and woody biomass have been at the center of discussions of environmental trends in Sahel. Understanding woody vegetation diversity and structure is important for guiding management decisions. In Niger Republic, many studies highlighted several threats on Sahelian ecosystems. Therefore, it is useful to further make based field investigations on tree cover in terms of vegetation structure and woody species composition. This study aimed to identify the diversity and structure of woody species in part of Sahelian dryland of Maradi Region, Niger Republic. Transect method was used to collect quantitative data. From the central village, the transects followed the four geographical directions with quadrat (plots) of 50 m x 50 m every 500 m interval were used to measure dendrometric parameters. Fabaceae (70.81%), Balanitaceae (9.85%) and Combretaceae (2.70%) have a high frequency and abundance in this area with Sudanian (S), Sudano-Zambezian (SZ) and Sahelo-Saharan (SS) as dominant phytogeographical classes. *Faidherbia albida*, *Piliostigma reticulatum, Acacia tortilis subsp raddiana* and *Balanites aegyptiaca* are the dominant woody species. This implies the better adaptation of these species to climatic conditions added to the preservation from local communities. The southern part of the study area has the higher woody species diversity which is decreasing from South to Northern part. The phenology of vegetation is an important measure of terrestrial ecosystem processes and an indicator of climate change.
Keywords: Diversity, Structure, Woody species, Transect method, Sahelian dryland.

1. INTRODUCTION

Woody vegetation management is carried out with varying objectives like biodiversity conservation. Changes in woody plant cover and woody biomass have been at the center of discussions of environmental trends in Sahel since the severe droughts of the 1970s and 1980s (Martin et al., 2016). Investment in woody vegetation can contribute to counter land degradation and improve populations' livelihoods (Hanna & Line, 2015; Bargués et al., 2020) by providing several advantages (Larwanou et al., 2010; Steven et al., 2013; Badamasi, 2014). In Sahelian area trees and shrubs play a major role in peoples' daily life besides being the main source for firewood (Abdou et al., 2014; Martin et al., 2014; Raphael et al., 2014).

In addition, many researchers reported a number of ecosystem services through densities of woody species in Sahel help farmers in reducing their vulnerability and provide advantages soil cover and buffers the effects of climate change (Bayala et al., 2014; Kapoury et al., 2016; Wafa et al., 2016; Asako et al., 2017). The interactions between trees and crops represents a key element determining the management options applied by farmers in West African Sahel (Bayala et al., 2014). Woody species conservation is imperative since the ecological treats are still persistent.

Climate change has not spared the conservation of woody species because the Sahelian zone was characterized by a significant vegetation response to rainfall (Zhou et al., 2021). Previous studies showed that change in climate is expected to affect general patterns of vegetation such as a decrease in tree density and diversity (Ali et al., 2007; Martin et al., 2014; Jordi & Francisco, 2016; Stefanos et al., 2017). Some results underlined that degradation of woody vegetation cover and trees declining in the Sahel zones were due to human high pressure (Martin et al., 2016; Paxie et al., 2017). The human disturbances on woody species in Sahel and its negative impact on the dynamics of woody species was also demonstrated by Sambo et al. (2019); Habou et al. (2019); Balima et al. (2019).

Recent findings based on satellite images analysis revealed an increasing trend of woody species biomass in some Sahelian areas (Louise et al., 2017; Martin et al., 2019; Mohamed et al., 2020), but this cannot be generalized to the Sahelian scale. This implies an increase in woody species density, in total contrast with the general narration of the persistence of ecosystem degradation.

Understanding woody vegetation diversity and structure is important for guiding management decisions in Sahelian vulnerable zones. Vegetation cover play an important role in the functioning of terrestrial ecosystem (Feng et al., 2018) and represent a key indicator in environment change (Akila et al., 2008). In addition to this, the knowledge on current woody species represents another challenge especially that Martin et al. (2017) recommended that, increase of vegetation and dying of some species in the Sahel demonstrate the need for more detailed and dynamic analysis at local scale.

Niger Republic is a Sahelian country and most populations live in the southern area where natural resources like woody species are important in populations' livelihoods. In Niger Republic, many studies highlighted several threats on Sahelian ecosystems. Therefore, it is useful to further make based field investigations on tree cover in terms of vegetation structure and woody species composition, in order to contribute to biodiversity conservation. This study aimed to identify the diversity and structure of woody species in part of Sahelian dryland of Maradi Region, Niger Republic.

2. STUDY AREA

Maradi Region (Figure 1) is located in the south-central part of Niger Republic, between 13° and 15°26' North latitude and 6°16' and 8°36' East longitude. Maradi Region is located in arid climate with three (3) agroecological zones differentiated based on average annual precipitation (Sécretariat Exécutif du Commité Interministériel pour la Stratégie de Développement Rural, 2022): (i) ***Saharo Sahelian zone***, precipitation varies from 200 to 300 mm. It concerns the northern part of Maradi Region including Northern part of Dakoro and Bermo departments. The woody vegetation cover is dominated by shrub tree with a dominance of thorns species; (ii) ***Sahelian zone*** receives total precipitations between 300 and 400 mm and is located in the central part of Maradi Region. The woody vegetation cover is dominated by trees and shrubs which are located in both agricultural farms and pastoral areas. There are pastoral enclaves and passage corridors that allow animals to reach the southern part of the region after the harvest period and during the dry period. The two (2) agroecological zones of the study area (Mayahi and Korahane) are located respectively in the Southern and Northern parts of the Sahelian zone of Maradi Region; (iii) **Sahelo Sudanian zone** (400 to 600 mm) which is located in a small part of the south of Maradi Region. The woody vegetation cover is dominated by trees with a low representation of shrubs. The third agroecological zone (Hawandawaki) of the study area is located in this zone. Rainfall in the Maradi Region is characterized by great variability from north to south with irregular and poorly distributed rainfall. The average duration of rainfall is four (4) months (Secrétariat Permanent Régional du Code Rural, 2019). The relief of the Maradi Region is characterized by a slight inclination from south to north (550 to 400 m altitude), and

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does not present mountains, hills or pit. The large sets of relief in the Region are made up of valleys, sandy spreading glacis, dune and lateritic plateaus (Secrétariat Permanent Régional Code Rural, 2019).

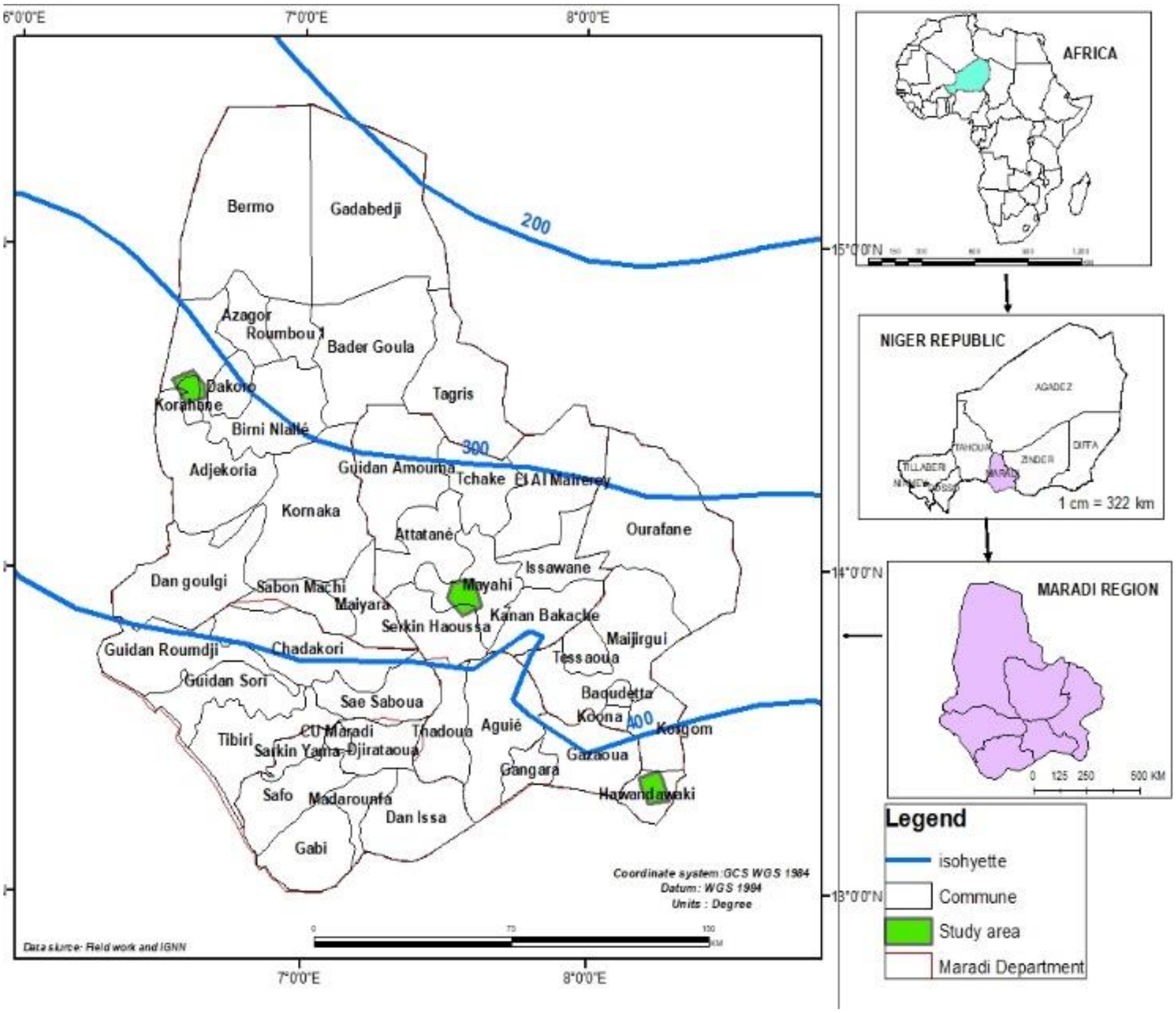

Figure 1: Maradi Region and the Study Area, Niger Republic

3. METHODOLOGY

Quantitative data were used in this study. The selected villages are located in the three communes (Hawandawaki, Mayahi and Korahane) and constitute a cluster of 5 villages located in an area of 5 km by 5 km in each agroecological zone. Four (4) transects were drawn in each agroecological zone to measure dendrometric parameters (Figure 2). From the central village, the transects followed the four geographical directions (East, West, North and South) with quadrats (plots) of 50 m x 50 m (2500 m^2) every 500 m interval. These quadrats were used in order to have maximum of environmental heterogeneity. The transect method (Thiombiano et al., 2016, Issoufou et al., 2020) and the plot size (2500 m^2) correspond to the minimal area needed for study of woody vegetation in Sahel. In each quadrat,

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woody species were enumerated by direct counting and the local names of these trees are identified. The dendrometric parameters measured in each plot were diameter at breast height (1.30 meters) and total height of tree.

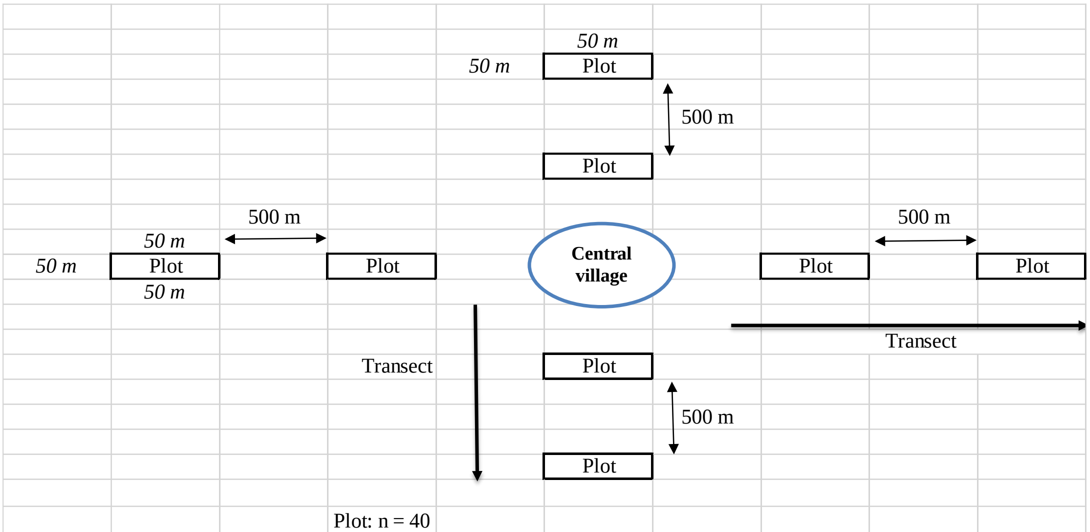

Figure 2: Transect Method and Plots for Vegetation Inventory

The software MINITAB 14 and Excel were used to analysis the woody species data. The information related to biological and phytogeographic classes of species, woody species diversity, structural analysis of diameter and total height were calculated.

(i) Woody species names and families

The list of woody species was drawn up using the document entitled «*Lexique des plantes du Niger, noms scientifiques - noms vernaculaires, Juin 1979*», and the Angiosperm Phylogeny Group (APG III) classification for the orders and families was used to establish the name of different families.

(ii) Biological and phytogeographical classes of woody species

The biological classes represent the overall adaptation of the plant to the environment. It is the set of morpho-physiological particularities during a climate, especially the unfavorable season. Phanerophytes are woody plants whose buds are located more than 50 cm above the soil surface (Saadou, 1990). According to the author, there are:

- ✓ Nanophanerophytes (nPh) from 0.5 to 2 m;
- ✓ Microphanerophytes (mPh) from 2 to 8 m;
- ✓ Mesophanerophytes (MesoPh) from 8 to 30 m;
- ✓ Megaphanerophytes (MPh) > 30 m;
- ✓ Liana microphanerophytes (LmPh).

The phytogeographical classes are adapted from the chorological subdivisions generally accepted for Africa and already used by Mahamane (2005); Morou (2010) and Rabiou (2016). There are:

(iii) Wide-range species

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- ✓ Cosmopolitan (Cos): species distributed in tropical and temperate regions of the world;
- ✓ Afro-American (AA): species widespread in Africa and America;
- ✓ Pantropicales (Pan): species widespread in Africa, America and tropical Asia;
- ✓ Paleotropical (Pal): species distributed in tropical Africa, tropical Asia, Madagascar and Australia.

(iv) Species with a distribution restricted to the African continent

- ✓ Tropical Afro-Malagasy (AM): species distributed in Africa and Madagascar;
- ✓ Afro-Tropicals (AT): species widespread in tropical Africa;
- ✓ Pluri-regional (PA): species whose range extends to several regional centers of endemism;
- ✓ Sudano-Zambezian (SZ): species distributed in both Sudanian and Zambezian regional centers of endemism;
- ✓ Guinean-Congolese (GC): species distributed in the Guinean region;
- ✓ Sahelo-Saharan (SS): species in arid and semi-arid zones.
- ✓ Sudanian (S): species widely distributed in the Sudanian regional center of endemism.

(v) Woody species relative frequency (Fr)

The woody species relative frequency was calculated using the following formula:

$$Fr = \frac{ni}{N} \times 100$$

With **ni** number of woody specie **i** and **N** total number of woody species of the area.

(vi) Woody species diversity

The diversity of agroecological zones was assessed using Shannon-Weaver Diversity Index (H') and Equitability of Pielou (E).

(vii) Shannon-Weaver diversity index (H')

This index calculated in bits per individual and ranges from lowest diversity (0 bit) to (4.5 bits). $H' < 2.5$: low diversity; $2.5 \leq H' < 4$: medium diversity; and $H' \geq 4$: high diversity. The Shannon-Weaver Diversity Index is calculated using the following formula:

$$H' = -\sum F_i \times \text{Log2}(F_i)$$

with Fi: relative frequency.

Consequently, it is calculated the *maximum theoretical Shannon-Weaver diversity index* with the formula: **Hmax = Log2 (S)**, with S is the total number of woody species at each agro ecological zone.

***(viii) Equitability of Pielou* (E)**

The Equitability of Pielou corresponds to the ratio between the diversity obtained and the theoretical maximum diversity of the number of woody species. This Equitability shows the regularity and the distribution of individual trees within species. It is near to 0 when there is dominance, and 1 when the distribution of individuals between species is regular.

$$E = H'/Hmax$$

With **H'** Shannon-Weaver Diversity Index and **Hmax** maximum theoretical Shannon-Weaver diversity index.

(ix) Structural analysis of woody species

A diameter class structure analysis was done with 5 cm amplitude and the smallest value of the diameter at breast height considered is 2 cm. The theoretical three-parameters model of Weibull distribution were used to characterize the structure of woody species. The parameter (a) corresponds to the threshold value (smallest value of diameter or height) and the parameter (b) is related to the central

http://dx.doi.org/10.31364/SCIRJ/v12.i04.2024.P0424980

ISSN 2201-2796

value of the distribution of the diameter or height classes. Finally, the parameter (c) is linked to the observed structure and depending on its value, it allows Weibull distribution to take several forms (Houètchégnon et al., 2015; Rabiou, 2016):

- ✓ $c < 1$: inverted "J" distribution describing groups of multispecific woody species;
- ✓ $c = 1$: exponentially decreasing distribution, describing woody populations in extinction;
- ✓ $1 < c < 3.6$: Asymmetric positive or asymmetric right distribution, describing monospecific groups of trees of small diameter;
- ✓ $c = 3.6$: Bell-shaped distribution describing monospecific groups or plantation species;
- ✓ $c > 3.6$ Positive distribution describing groups of monospecific trees of large diameters.

The same approach was applied for the total height class structure, with 2 m amplitude and 0 m is the smallest value considered.

4. RESULTS AND DISCUSSION

4.1. Biological and Phytogeographical Classes of Woody Species

Results of this study revealed that one hundred and twenty (120) plots (quadrats) were inventoried in the three (3) agroecological zones, representing a total of 300,000 m². Eight hundred and fifty-six (856) trees were inventoried in the study area, which correspond to two hundred and ninety-one (291) in Sahelo Sudanian Zone (SS-Z), three hundred and twenty-five (325) in Sahelian Zone South (SZ-South) and two hundred and forty (240) in Sahelian Zone North (SZ-North). Fifty-three (53) woody species have been identified, including twenty-five (25) in the Sahelo Sudanian Zone, seventeen (17) in Sahelian Zone South and eleven (11) in the Sahelian Zone North.

In the three agroecological zones, Microphanerophytes (mPh) dominates the biological type (Table 1) with 95% in SZ-North, 94.2% in SS-Z and 88.9% in SZ-South. The least represented types are Megaphanerophytes (MPh) with 0.7% in SS-Z, Nanophanerophytes (nPh) with 11.1% in SZ-South and Mesophanerophytes (MesoPh) in SZ-North with 5%.

Table 1: Biological classes of Woody species of the Agroecological Zones

Biological Classes	Sahelo Sudanian Zone	Sahelian Zone South	Sahelian Zone North
mPh	94,2	88,9	95
MPh	0,7	-	-
nPh	2,7	11,1	-
MesoPh	2,4	-	5
Total	100	100	100

The Microphanerophytes (mPh) is the predominant biological type in the study area. These results corroborate those found by Laminou et al. (2017) in Guidan Roumdji (Maradi Region) where Microphanerophytes represent 67.39% of the flora. In addition to this, Amadou et al. (2017) showed that the flora of the Maggia watershed (Tahoua Region, Niger) is dominated by Microphanerophytes with 95.45%. The dominance of Microphanerophytes corroborate the nature of woody stands which is shrub stand in the study area. This confirms the most common physiognomic type in the Maradi Region reported by Saadou (1990) and Mahamane et al. (2007) which is dominated by shrub woody species.

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The analysis of phytogeographical classes (Table 2) shows that Sudanian (S) and Sudano-Zambezian (SZ) species present the highest percentage respectively 43% and 37.5% in SS-Z. In SZ-South, Sudano-Zambezian (SZ) types are largely dominant (57.5%) while in SZ-North, Sahelo-Saharan (SS) and Sudano-Zambezian (SZ) types are the most dominant. The Afro-tropical (AT) and Paleotropical (Pal) types are the least represented types in the study areas.

Table 2: Phytogeographical Classes of Woody Species of the Agroecological Zones

Phytogeographical classes	Sahelo Sudanian Zone	Sahelian Zone South	Sahelian Zone North
SS	7.6	10.5	51.60
SZ	37.5	57.5	40.0
S	43.0	29.8	5.8
Pal	8.2	0.9	1.3
AT	3.7	0.9	1.3
MesoPh	-	-	-
AM	-	0.4	-
Total	**100**	**100**	**100**

The Sudanian (S) and Sudano-Zambezian (SZ) species present the highest percentage in Sahelo Sudanian Zone and Sahelian Zone South while Sahelo-Saharan (SS) type and Sudano-Zambezian (SZ) types are the most dominant in Sahelian Zone North. The dominance of Sudanian (S) and Sudano-Zambian (SZ) species was mentioned by Laminou et al. (2017) in Guidan Roumdji (Southern center of Niger), while Rabiou (2016) reported on the dominance of Sahelo-Saharan species in the Sahelian zone of Tamou (South Est of Niger). The dominance of these phytogeographical classes in the three agroecological zones can be explained by the maintenance of indigenous woody species which are easy to grow and resistant to local environmental conditions.

4.2. Woody Species Families

The analysis of inventory results' shows overall sixteen (16) families dominated by Fabaceae with 70.81% followed by Balanitaceae family 9.85% and Meliaceae 2.93% (Table 3). The least represented families are the Burseraceae with 0.12% followed by the Lamiaceae (0.23%), Loganiaceae (0.23%) and Malvaceae (0.23%).

Table 3: Woody Species Families

Family	Sahelo Sudanian Zone (%)	Sahelian Zone South (%)	Sahelian Zone North (%)	Overall (%)
Anacardiaceae	4.81	0.92	1.25	2.34
Annonaceae	2.06	0.61	-	0.94
Arecaceae	4.81	4.29	-	3.28
Balanitaceae	-	8.28	23.75	9.85
Burseraceae	-	0.31	-	0.12
Capparaceae	0.69	1.23	-	0.70
Combretaceae	2.75	-	6.25	2.70
Cucurbitaceae	-	-	6.25	1.76
Ebenaceae	1.72	-	-	0.59
Fabaceae	68.04	80.67	61.25	70.81
Lamiaceae	0.69	-	-	0.23
Loganiaceae	-	0.61	-	0.23
Malvaceae	0.69	-	-	0.23
Meliaceae	7.90	0.61	-	2.93
Rhamnaceae	1.03	2.45	1.25	1.64

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Zygophyllaceae	4.81	-	-	1.64

The woody species families in the three agroecological zones are dominated by Fabaceae. The family Fabaceae includes many woody species that are common in agriculture. This is consistent with results of Abdel Nassirou & Moussa (2022) who reported the dominance of Fabaceae family (43.48% in Dan Saga and 58.34% in Sekoukou) in Niger Republic.

4.3. Frequency Distribution of Woody Species

Faidherbia albida and *Piliostigma reticulatum* are the two (2) woody species with the highest relative frequency in Sahelo Sudanian Zone (SS-Z) and Sahelian Zone South (SZ-South). However, in Sahelian Zone North (SZ-North), *Acacia tortilis subsp raddiana* and *Balanites aegyptiaca* have the highest relative frequencies. Table 4 presents the relative frequency in the agroecological zones.

Table 4: Frequency Classes

Family	**Specie**	**Frequency (%)**			
		SS-Z	**SZ-South**	**SZ-North**	**Overall**
Fabaceae	*Acacia nilotica* (L) WILLD. Ex Del.	6.19	0.92	1.67	2.92
Fabaceae	*Acacia senegal* (L) Willd.	1.03	2.15	8.75	3.62
Fabaceae	*Acacia tortilis subsp raddiana* (Savi) Brenan	-	6.15	35	12.15
Malvaceae	*Adansonia digitata* L,	0.69	-	-	0.23
Fabaceae	*Albizzia chevalieri* Harms	2.06	-	-	0.70
Annonaceae	*Annona senegalensis* Pers.	2.06	0.62	-	0.93
Meliaceae	*Azadirachta indica* A. Juss.	7.90	0.62	-	2.92
Zygophyllaceae	*Balanites aegyptiaca* (L.) Del.	4.81	8.31	23.75	11.45
Fabaceae	*Bauhinia rufescens* Lam.	1.03	0.31	0.83	0.70
Capparaceae	*Boscia salicifolia* (Pers.) Lam. ex Poir.	0.34	-	-	0.12
Fabaceae	*Cassia sieberiana* DC.	0.69	-	-	0.23
Combretaceae	*Combretum glutinosum* Perr. Ex DC.	1.03	16.31	1.25	6.89
Burseraceae	*Commiphora africana* (A. Rich.) Engl.	-	0.31	-	0.12
Combretaceae	*Combretum micranthum* g. Don.	1.03	-	-	0.35
Ebenaceae	*Diospyros mespiliformis* hochst. Ex A. DC.	1.72	-	-	0.58
Fabaceae	*Faidherbia albida* Del	13.06	26.15	15	18.57
Combretaceae	*Guiera senegalensis* J.F. Gmel.	0.69	10.46	5	5.61
Arecaceae	*Hyphaene thebaica* (L.) Mart.	4.81	4.31	-	3.27
Anacardiaceae	*Lannea microcarpa* Engl.Et K. Krause	2.41	-	-	0.82
Capparaceae	*Maerua crasssifolia* Forsk.	0.34	1.23	6.25	2.34
Fabaceae	*Parkia africana r.* Br.	2.06	-	-	0.70
Fabaceae	*Piliostigma reticulatum (*dC.) Hochst.	35.74	18.46	-	19.16
Fabaceae	*Prosopis africana* (Guill. et Perr.) Taub.	6.19	-	-	2.10
Anacardiaceae	*Sclerocarya birrea*	2.41	0.92	1.25	1.52
Loganiaceae	*Strychnos spinosa* Lam.	-	0.31	-	0.12
Lamiaceae	*Vitex doniana* sweet.	0.69	-	-	0.23
Rhamnaceae	*Ziziphus mauritiana* Lam.	0.34	-	1.25	0.47

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Rhamnaceae	*Ziziphus spina-christi (*L.) Desf.	0.69	2.46	-	1.17
	Total général	**100**	**100**	**100**	**100**

Faidherbia albida, Piliostigma reticulatum, Acacia tortilis subsp raddiana and *Balanites aegyptiaca* are important woody species which are maintained and protected in the study area.

4.4. Woody Species Diversity

The diversity was assessed using Shannon-Weaver Diversity Index (H') and Equitability of Pielou (E). In Sahelo Sudanian Zone, H' index is 4.5 while in the SZ-South and the SZ-North are respectively 1.62 and 1.37 (Table 5). The Equitability value of the study area varies from 0.73 to 0.75 depending on the agroecological zone.

Table 5: Shannon-weaver Index and Pielou Equitability of the Agroecological Zones

	Shannon-weaver Index (Bits per individual)			**Pielou Equitability**		
	SS-Z	**SZ-South**	**SZ-North**	**SS-Z**	**SZ-South**	**SZ-North**
Value	4.5	1.62	1.37	0.73	0.75	0.74

The value of specific diversity of Sahelo Sudanian Zone (4.5) demonstrates that the woody vegetation cover is characterized by a high diversity compared to the Sahelian Zone South and North where the diversity is low (1.62 and 1.37). The southern part of the study area has the higher woody species diversity which is decreasing through the gradient South to North. The Pielou Equitability varies from 0.73 to 0.75 (near to 1) and demonstrated the distribution of individuals between species is regular which means there is not dominance of only of one woody specie compare to others species.

4.5. Diameter and Height Classes Structure of Woody Species

The structures in diameter and height classes were adjusted to the Weibull model and the different values of "c" allowed to determine the type of woody vegetation.

4.5.1. Diameter classes structure of woody species

The results of diameter classes structure of Sahelo Sudanian Zone (Figure 3) show a dominance of trees species with diameters between [15 - 20[; [10 - 15[; and [20 - 25[. The structure of the woody vegetation presents asymmetric right distribution, describing trees with small diameter (c = 1.541).

In Sahelian Zone South the dominants diameters (Figure 4) are [2 - 5[with 6.10 tree ha^{-1}; [15 - 20[; and [20 - 25[with respectively 4.9 tree ha^{-1} and 4.6 tree ha^{-1}. The structure of the woody vegetation presents asymmetric right distribution, describing trees with small diameter (c = 1.225).

In Sahelian Zone North trees with diameter [15 - 20[and [25 - 30[are the dominants species with 4.5 and 4.2 tree ha^{-1} (Figure 5). The structure of the woody vegetation describes trees with small diameter (c = 1.911).

4.5.2. Height classes structure of woody species

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The height classes structure of the woody vegetation in Sahelo Sudanian Zone is an asymmetric positive distribution ($1< c < 3.6$), describing trees with small height (Figure 6). The most dominants height classes are [4 - 6[with 11.9 tree ha^{-1} and [2 - 4[with 6.9 tree ha^{-1}.

The height classes structure of Sahelian Zone South presents asymmetric right distribution, describing monospecific groups of trees of small height ($1< c < 3.6$). The trees with height between 2 and 4 m are the majority with 10.2 tree ha^{-1} followed by the height class between 4 and 6 m with 9.5 tree/ha (Figure 7).

In the Sahelian Zone North, trees have small heights and weakly represented by the intervals 2 to 4 m and 4 to 6 m with respectively 1.14 tree ha^{-1} and 1.77 tree ha^{-1}. The ‘’c” value is 3.101 ($1< c < 3.6$) describing asymmetric right distribution with small height (Figure 8).

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ISSN 2201-2796

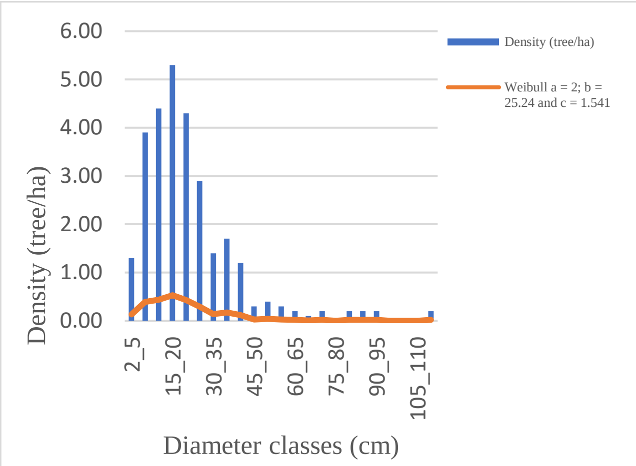

Figure 3: Diameter classes structure of Sahelo Sudanian Zone

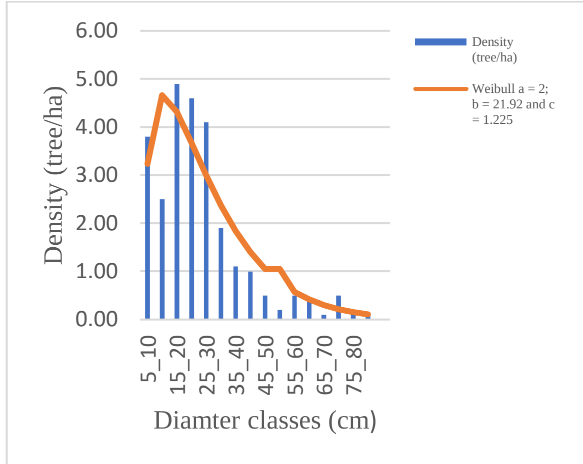

Figure 4: Diameter Classes Structure of Sahelian Zone South

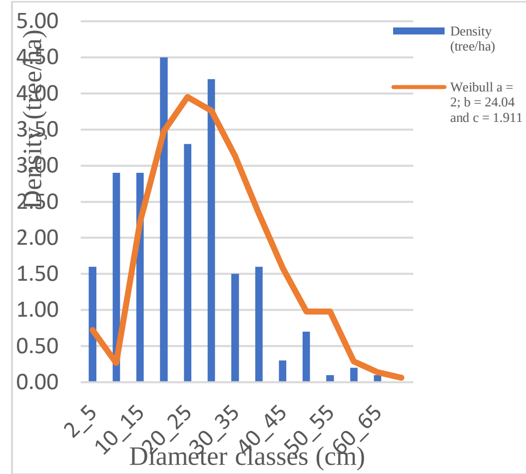

Figure 5: Diameter Classes Structure of Sahelian Zone North

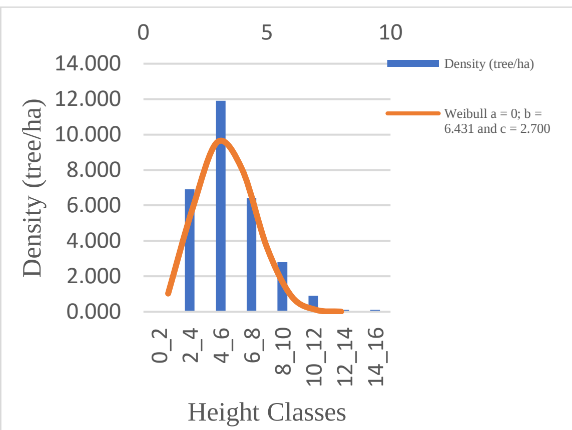

Figure 6: Height Classes Structure of Sahelo Sudanian Zone

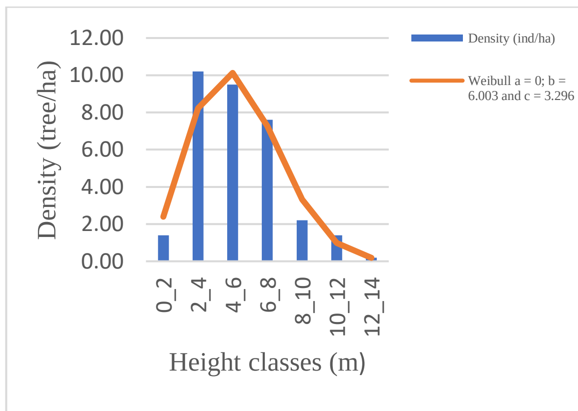

Figure 7: Height Classes Structure of Sahelian Zone South

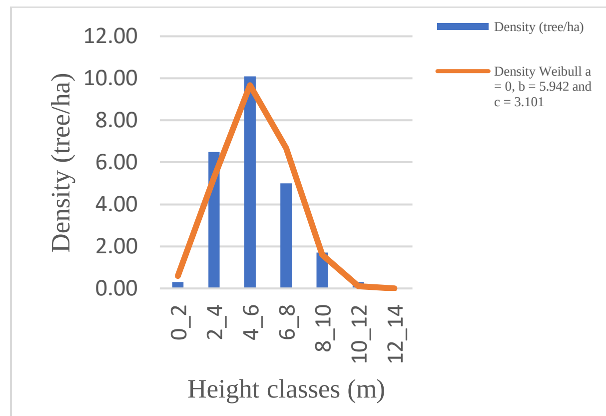

Figure 8: Height Classes Structure of Sahelian Zone North

http://dx.doi.org/10.31364/SCIRJ/v12.i04.2024.P0424980

The diameter class distribution is used to understand tree dynamics and can be used to assess the impact of anthropogenic pressure on the woody species density. The structure of the woody vegetation in the three (3) agroecological zones describes groups of trees with small diameter. This value demonstrated that the woody vegetation of the study area is characterized by trees with small diameter. These results are comparable to those found by Amadou et al. (2017) in the Maggia watershed (Tahoua) and Dan Guimbo (2010) in the Dosso Region. They reported that their study areas are dominated by trees with small diameter. In addition to this, Hamidou et al. (2013) found that the diameter classes structure of woody trees in the Dan Kada Dodo and Dan Gado classified forest complex (Aguié, Maradi Region) is characteristics of young trees or small diameters.

The height classes structure of the study area demonstrated also the impact of anthropogenic pressure on the woody species density. This is consistent with the results of Soumana (2015) and Laouali (2008) respectively on *Faidherbia albida* and *Prosopis africana* parklands where they reported height classes structure dominated by individuals of lower classes in the agrosystems of Aguié (Niger). The dominance of woody tree species with small diameter and height indicated that trees in farmlands face to human pressure particularly by cutting tree for several reasons.

5. CONCLUSION

This work presented evidence that Fabaceae, Balanitaceae and Combretaceae have a high frequency and abundance in Sahelian zones of Maradi Region with Sudanian (S), Sudano-Zambezian (SZ) and Sahelo-Saharan (SS) as dominant phytogeographical classes. *Faidherbia albida*, *Piliostigma reticulatum, Acacia tortilis subsp raddiana* and *Balanites aegyptiaca* are the dominant woody species in this area. This implies the better adaptation of these species to the climatic conditions added to the preservation from local communities. The southern part of the study area has the higher woody species diversity which is decreasing from South to Northern part of Maradi Region. The local communities' preferences and conservation priorities on woody species can help policy makers or development agencies in their sustainable development activities. The connection between local knowledge in woody species conservation, scientists and policy makers can improve resilience of Sahelian population in the climate change context. The phenology of vegetation is an important measure of terrestrial ecosystem processes and an indicator of climate change.

COMPETING INTERESTS

The authors declare that they have no competing interests.

ACKNOWLEDGMENTS

The authors would like to acknowledge the Centre for Dryland Agriculture (CDA) which is an Africa Centre of Excellence in Bayero University, Kano (Federal Republic of Nigeria), for providing financial assistance for this research in the Ph.D. Program (Natural Resource Management and Climate Change). The authors also extend gratitude to all people who contributed to data collection.

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