Floristic Composition, Structural Analysis and Socio-economic Importance of Legume Flora of the Commune of Mayahi, Niger, West Africa

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Abstract— Floristic assessment plays a crucial role in managing and conserving phytodiversity. This study tried to determine the floristic composition, woody structure and socio-economic importance of the legume flora in the commune of Mayahi. We used plot method based on systematic sampling approach to inventory legume species within the parklands in September 2012. We recorded 55 legume species belonging to 24 genera in 56 relevés. Fabaceae is the dominant family among the legume botanical families in the parklands of the commune of Mayahi. The average woody legume density is 62 individuals per hectare in the commune of Mayahi. The woody legume species of highest average density are Faidherbia albida and Piliostigma reticulatum. While the total basal area of legumes of the commune is 1.12m² / ha in the Mayahi commune. The crown cover varies according to the vegetation types but it is higher in the Goulbi N’kaba forest reserve. Legume flora provides a myriad of benefits to the people of Mayahi. The present study recommends further research that examines the impact of human activities on the legume flora of the parklands in the commune of Mayahi.

Keywords— Legume flora, Dendrometry, Socio-economic importance, Commune of Mayahi, Niger.

I. INTRODUCTION

Niger has four climatic zones climatic zones that have contributed to the formation of the Sudanian and Sahelo-Saharan environments characterized by a great biodiversity of both animals and plants. Niger covers a surface area of 1,267,000 sq km. It is located between the longitude 0°16’ and 16° East and the latitude 11°1’ and 23°17’ North. Niger human population was estimated at 19.8 million people and a population growth rate at 3.9 % (World Bank, 2016). About 80% of its human population lives in rural areas where it derives various ecosystem services (INS, 2011). Indeed, vegetation changes is one of the greatest ecological problems in Niger. Niger’s ecosystems are prone to the high pressure due to the high population expansion that exercises great demand such us the firewood, absence of fallow and expansion of agricultural lands to forest areas. In addition, the climate vagaries has also huge impact of vegetation in Niger. Added to that, ecosystems of Niger are prone to unsustainable management due to such as inappropriate agricultural practices, illegal and unsustainable logging activities and unsustainable pastoral activities (CNEDD, 2006). Such practices lead to compositional and structural changes of vegetation and biodiversity loss, which would have huge impacts on the environment and socio-economic setup of the Niger communities.

Legume species are known to be critically important in an ecosystem in terms of building and conserving soil fertility. Most legume species have nodules on the root systems, which enable them to absorb the atmospheric nitrogen and convert it into the nitrogen the plant needs for its development. Therefore, legume flora plays a crucial role in the ecological systems. For instance, in Niger, legume flora provides a myriad of benefits such as firewood, timber, fodder, melliferous, gun and food species, traditional medicine for human and animal (Hamidou et al., 2015 and Soulé et al., 2017). Legume species belong to the order of leguminosae that comprises three main botanical families such as Caesalpiniiaceae, Fabaceae or Papilionaceae and Mimosaceae. Leguminosae is one of the largest and most useful orders in the world. For instance, Bellefontaine (2005) stated that Faidherbia albida is very important pastoral woody species in the Sudano-Sahelian areas. Further, Ouedraogo-Kone et al., 2008 found out that Faidherbia albida has the strongest use indices and it is very good nutritious pastoral woody plant. Furthermore, Cassia
obtusifolia (Cassia tora) is a wild legume specie cultivated in Niger for its leaves as food in dry and rainy season in Aguíé, Maradi region (Soulé et al, 2017)

Botanical evaluation such as floristic composition, dendrometric analysis studies are important for providing information on species richness of the ecosystems, useful for the ecosystem management goal and help in apprehending ecology and functions of ecosystem (Pappoe et al., 2010). Data on the floristic composition and structure of ecosystem is also useful in managing sustainably the ecosystem (Addo-Fordjour et al., 2009). The aim of this study was therefore, to list the floristic composition and make structural analysis of the legume flora of the commune of Mayahi in Niger.

II. MATERIALS AND METHODS

1.1 Study area

The commune of Mayahi is located in Maradi region of Niger republic. The commune of Mayahi has an estimated population of 94,160 inhabitants in 2011 (PDC, 2011). The commune of Mayahi has fifty nine (59) administrative villages and tribes. The capital of the commune is Mayahi. Agriculture is the principal economic activity of the people of the commune of Mayahi. Vigna unguiculata (cowpea) and Arachis hypogaea (peanut) constitute the cash legume crops. Animal husbandry is the second economic activity of the people of the commune of Mayahi. One of the major vegetation types of the commune of Mayahi is parklands that consists of croplands and pasturelands with the scattered woody species. The people of the commune of Mayahi exploit many parklands services such as firewood, forage for livestock, food (fruits, leaves). They exploit the parklands for medicinal purposes. The climate of the commune of Mayahi is the Sahelian type, characterized by a short rainy season usually three to four months from June to September. The total amount of rainfall estimated in 2015 was 380.9 mm (DDA, 2015). The study sites were Mayahi urban commune, Digaba, Guidan Sani, Guidan Alou, Koren Habjia, Loda, Dan Amaria, Achalou, Kotaré, they were randomly selected.

1.2 Inventory Sampling design

The survey took place in September 2012, which is the period of the maturity of herbaceous species in Sahel (Saadou, 1990). A systematic sampling technique was used due to the homogeneity of the landscape to collect vegetation data. Plots of size 50m x 50m (2500m²) were used for woody species, one subplots of 100 m² (10 mx 10 m) at one corner of the main plot and subplots of 1m x1 m for herbaceous density at the four corners and one at the centre of the large plot. We constructed also five subplots at the angle and one at the centre of the large 5 m x 5 m for recording the seedlings. Plots were laid systematically at every 500m along transect lines, which were 500m apart from each other. Ringing pole, tape meter and GPS were used the fieldwork. All the plot sizes used correspond to the minimum areas for agroforestry systems and steppe (Mahamane & Saadou, 2008). The plots were shown in Figure 1.

1.3 Data collection

We did first Systematic counting of all the plant species in the subplot of 100m² and secondly in the large plot. Thirdly, we used destructive method for the herbaceous biomass; we removed all the herbaceous species within the five subplots in each large plot. Nevertheless, we separated only the herbaceous legume within the five sub plots in each large plot. We counted the fresh herbaceous legume manually. If there were some woody species within the large plot, we took some dendrometric variables such as height; circumference at 1.30 m for the tree and 20 cm for the shrubs and crown cover were measured. We considered tree as any woody plant superior to 7 m of height and less than 7 m was considered as shrub. We used ringing pole and tape meter for the dendrometric variables measurement. We also measured the widest diameter and perpendicular diameter of the woody crown by using tape meter. Furthermore, the seedling were recorded. These seedling refers to any woody plant, which is diameter is less than 2 cm and the height less than 1.3 m. Additional plant species occurring outside plots but were also recorded only as present and were added to the final legume floristic list. Finally, we used ethnobotanical questionnaire to collect the socio-economic data about the importance of legume flora to the people of the commune of Mayahi. We took some pictures that explain the use of legume flora in the commune of Mayahi. We used two approaches for specie identification. Firstly, we have identified the majority of the species in the field. Further,
we used also some books for the identification in field such as the flora of Hutchinson (1972), Adventrop (1995) and Michel Arbonnier (2002). For the unknown species, we produced the herbarium and submit to the Department of biology University Dan Dicko Dan Koulodo of Maradi for the species identification.

1.4 Data analysis
All the collected vegetation data were taped in Excel. After the legume vegetation data were extracted from the entire data. For the description of legume structure, woody species density, height, diameter at breast height (DBH), basal area, crown cover and regeneration rate were used. We analysed the data with Excel for following information about the legume flora of the vegetation of the Mayahi commune. We calculated:

- **Density (N)** of a specie or group of species is the number of individuals per unit of (nb/ha). Further, the average woody species density was the ratio of the total number of individuals to the total survey area, and then reported to the hectare. 
  \[ D = \frac{10000 \times N}{S} \]

- **Crown Cover (R)** is the area of the woody crown on soil. It is calculated by the following formula: Crown cover = (Average crown diameter) \( \frac{2 \times \pi}{4} \), where Average crown diameter is equal to the sum of the diameter South-North and West-East of the woody crown divide by two. Further the total woody species crown cover was expressed using \[ R = \frac{100n}{45} \sum_{i=1}^{N} D_{i}^{2} \] where \( R \) (\%) = total crown cover, \( S \) = total survey area, \( D_{i} \) is the average diameter of the individual crowns, and \( N \) is the total number of individuals. The crown cover is expressed in percentage of plot area. However, as we measured the circumference, we used the formula circumference (\( C \)) = diameter \( \times \pi = d \pi \), so you get a diameter = Circumference(\( C \)) divide by \( \pi \). Where the value of \( \pi \) = 3.14.

- **Basal area (G)** is the area of a given section of land that is occupied by the cross-section of woody species trunks and stems at the base. The basal area is calculated based on trunk diameter and expressed in \( m^{2} \) per hectare. It is obtained by the following formula: 
  \[ G = \frac{\pi D^{2}}{4} \] , where \( D \) is diameter at breast height for the trees (1.3 m) and 2 cm for the shrubs. 
  \[ G = \frac{10000n}{45} \sum_{i=1}^{N} d_{i}^{2} \] where \( G \) (\( m^{2} \) / ha) = Total basal area, \( S \) = total survey area, \( d_{i} \) diameter of individuals and \( N \) total number of individuals.

- **Rate of regeneration (Rr)** is defined as the ratio of the total number of sapling/seedlings counted over the total plot area per hectare. \( Rr = \frac{N}{S} \), where \( N \) = Total number of seedlings/ Area (ha). Descriptive statistic was used for analysing the questionnaire data.

### III. RESULTS AND DISCUSSION

#### 3.1 Floristic Composition
A total of 55 legume species belonging to 24 genera and 3 families were identified from the agroforestry systems of the commune of Mayahi. Fabaceae and Caesalpiniaceae were found to be the dominant families in the inventoried legume flora of the commune of Mayahi represented by 12 (50 %) genera and 28 species (51 %) and 14 species (25%) respectively in table 1. The Caesalpiniaceae and Mimosaceae have equal number of the genera. Our findings confirm that Fabaceae is the first botanical families of leguminosae order (Burju et al., 2013 & Soulé et al.,2016) who found respectively that the Fabaceae was the first families among the leguminosae in Jibat Humid Afromontane Forest of Ethiopia and the of parklands of commune of Mayahi. *Pterocarpusserinaceus* was not recorded at all during the inventory. This confirms also the result of Boubacar (2010) who found out that *Pterocarpusserinaceus* has disappeared from the department of Mayahi. This was also supported during our interview with the villagers of the commune of Mayahi that *Pterocarpusserinaceus* from their commune. The absence of *Pterocarpusserinaceus* in the inventoried flora of the commune of Mayahi confirms the findings of Arbonnier (2004) who reported that the specimen of the *Pterocarpusserinaceus* decrease and tend towards extinction in Niger. Furthermore, Sokpon et al. (2006) stated that *Pterocarpusserinaceus* has disappeared from many sites in Niger. Moreover, Rabiou et al. (2015) found out that in the Sahelian zone and even Niger W Park there were lack of seedling of *Pterocarpusserinaceus* indicating that the specie faces a problem of regeneration. Added to that *Parkiabiglobosa* was not also inventoried during our fieldwork in the commune of Mayahi. From the interview with the people of the commune of Mayahi, *Parkiabiglobosa* has also disappeared from their commune. In addition, the specie *Prosopis africana* is also rare in the commune of Mayahi because during all our prospect, only three individuals have been obtained and the population of the commune among the threatened species classifies this specie.

### Table 1: Legume floristic composition

| Families       | No. of Genera | %  | No. of Species | %  |
|----------------|---------------|----|---------------|----|
| Fabaceae       | 14            | 25 | 28            | 51 |
| Caesalpiniaceae| 12            | 50 | 28            | 51 |
| Mimosaceae     | 12            | 25 | 28            | 51 |

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3.2 Structural Analysis

- **Legume woody species density**
  The average woody legume density is 62 individuals per hectare in the commune of Mayahi. The woody legume species of highest average density are *Faidherbia albida* and *Piliostigma reticulatum* (Table 2). The dominance of the two woody legume species in the agroforestry systems of the commune of Mayahi is an indicator of selective farmers Managed Natural Regeneration (FMNR). This means the farmers select the two species because of their importance in their farmlands. Our results corroborate the findings of Savadogo et al. (2015) who stated that *Piliostigma reticulatum* and *Faidherbia albida* are predominant in the degradation zone of their study area in Mayahi department. The three dominant legume species are *Faidherbia albida* (122 individuals), *Piliostigma reticulatum* (64), and *Acacia tortilis* (49).

| Woody Legume Species | Relative Density (hectare) |
|----------------------|----------------------------|
| *Acacia nilotica*    | 2                          |
| *Faidherbia albida*  | 22                         |
| *Piliostigma reticulatum* | 15                     |

- **Crown Cover**
  The woody crown cover of the commune of Mayahi varies according to the land use and land cover types. It is higher in the Goulbi N’kaba valley (table 3), because Goulbi N’kaba forest is an environment highly protected by the foresters of the commune of Mayahi. Added to that Goulbi N’kaba vegetation belongs wetlands vegetation. The high crown cover observed in the forest of Goulbi N’kaba valley may be due the level of environmental perception of the surrounding population of forest degradation consequences. On the other hand, it is less elevated in farmlands, which explains the protection of woody plant by the principle of tree tenure and ownership. In addition, this may be due to the practice of natural assisted regeneration. The crown cover is lower in the fallow lands, which may be due the pastoral pressure as there is scarcity of pastoral land in the commune and illegal logging.

| Crown Cover | Farmlands | Fallow land | Goulbi Kaba forest |
|-------------|-----------|-------------|--------------------|
| %           | 4.40      | 3.45        | 9.90               |

- **Basal area**
  The total basal area of legumes of the commune is the sum of all the basal areas of legume species on the inventoried area. It is 1.12m² / ha in the Mayahi commune. The analysis of these two table shows that the basal area is large for *Faidherbia albida*and *Acacia tortilis*.

| Woody Legume Species | Basal area(m² / ha) |
|----------------------|---------------------|
| *Acacia tortilis*    | 0.034               |
| *Faidherbia albida*  | 0.065               |
| *Piliostigma reticulatum* | 0.028            |

- **Regeneration rate and Legume herbaceous density**
  There are 25 seedlings of legume per hectare in the commune of Mayahi. The herbaceous legume of high average density were *Zornia glochidiata* (89.02 individuals / m²) and *Alysicarpus ovalifolius* (40.34 individuals / m²). The two herbaceous legume species are the pastoral species. The average density of each species
was determined in order to assess their contribution to biomass.

- **Diameter and Height of Some woody legume species distribution in three geomorphological units**: Plain, Valley and Plateau

Analysis of the figure 2 shows that *Faidherbia albida* is distributed in all geomorphological units, with greater density at the plain. The diameter and height all have a symmetrical structure at plateau and plain. The high density in these units is due to large *Faidherbia albida* Parklands we meet at some locations such as Guidan Alou Guidan Sani, etc.

![Fig.2: diameter distribution (a) and height distribution (b) of Faidherbia albida](image)

The structure of diameter and height of *Piliostigma reticulatum* shows a predominance of young individuals at the level of the plain whereas the aged individuals are totally absent (Fig3). This can be explained by the exploitation of individuals with large diameter in agroforestry systems. Moreover, the species is represented on the plateau only by individuals with an average diameter and at the level of the valley, this class is absent.

![Fig.3: diameter distribution (a) and height distribution (b) of Piliostigma reticulatum](image)

The analysis of the graph 4 shows that *Acacia tortilis* well distributed in the plain and in the valley than in the plateau. Both parameters have a bell structure, which means that the specie recovers well in these units. Indeed, this specie dominates the physiognomy of the vegetation of Goulbi N’kaba, which is a protected area. This also supports the high crown cover we observed in the Goulbi N’kaba forest. In short based on the height distribution of the three legume woody plants, the woody legume flora of the commune of Mayahi has two strata such as tree stratum and shrub stratum.
3.3 Socio-economic Importance
The questionnaire data analysis from 52 people reveal that the legume species provides a diversity of services to the population of Mayahi commune. They are source of medicines, fodder, firewood, human food and they protect their croplands against wind and water erosion. *Faidherbia albida* and *Acacia tortilis* constitutes the main fodder woody legume plant in the commune. They are also source of firewood and timber. *Acacia senegal* and *Acacia seyal* provides natural gum to the commune. For instance, the leaves of *Vignaunguiculata* are consumed as salad in the commune. *Arachis hypogaea* and *Vignaunguiculata* are the main cash legume crops in the commune.

IV. CONCLUSION
The parklands of the commune of Mayahi are floristically diverse in legume species. The inventoried flora has 55 legume species belonging to 24 genera and 3 legume botanical families Fabaceae are the best represented among the legume botanical families in the parklands of the commune of Mayahi. Structural analysis revealed that the woody legume flora health is good state but the woody legume flora is under pressure due to human activities. The socio-economic analysis showed that the legume flora provides a myriad of services to the people of Mayahi.

The study recommends further study that will examine the impact of anthropogenic activities on the legume flora of the commune of Mayahi.

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| LEGUME FLORISTIC LIST |
|------------------------|
| **Species**            | **Families** |
| 1. Crotalaria podocarpa DC. | Fabaceae |
| 2. Aeschynomene indica L. | Fabaceae |
| 3. Alysicarpus ovalifolius (Schum. Et Thonn.) | Fabaceae |
| 4. Arachis hypogaea L. | Fabaceae |
| 5. Canavalia rosea (L.) DC. | Fabaceae |
| 6. Crotalaria goreensis Guill. & Perr. | Fabaceae |
| 7. Crotalaria retusa L. | Fabaceae |
| 8. Crotalaria senegalensis (Pers.) Bak. Ex.DC. | Fabaceae |
| 9. Indigofera astragalina Dc. | Fabaceae |
| 10 | Indigofera berhautiana Gillet. | Fabaceae |
| 11 | Indigofera bracteolata DC. | Fabaceae |
| 12 | Indigofera dendroides Jacq. | Fabaceae |
| 13 | Indigofera diphylla Vent. | Fabaceae |
| 14 | Indigofera hirsuta Var.hirsuta | Fabaceae |
| 15 | Indigofera nummularifolia (L.) Liv. ex Alston | Fabaceae |
| 16 | Indigofera pilosaPoir. | Fabaceae |
| 17 | Indigofera stenophylla Guill. & Perr. | Fabaceae |
| 18 | Indigofera tinctoria L. | Fabaceae |
| 19 | Sesbania pachycarpa DC. | Fabaceae |
| 20 | Stylosanthes erectaP.Beauv. | Fabaceae |
| 21 | Tephrosia bracteolata Guill. & Perr. | Fabaceae |
| 22 | Tephrosia linearis (Willd.) Pers. | Fabaceae |
| 23 | Tephrosia lupinifolia DC. | Fabaceae |
| 24 | Tephrosia obcordata (Lam.exPoir.) | Fabaceae |
| 25 | Tephrosia purpurea (L.) Pers.ssp. Leptostachya | Fabaceae |
| 26 | Vigna unguiculata (L.) Walp. | Fabaceae |
| 27 | Voandzeia subterranea ( Thouars (L.)) Verdec. | Fabaceae |
| 28 | Zornia glochidiataReichb.ex DC. | Fabaceae |
| 29 | Bauhinia rufescens Lam. | Caesalpiniaceae |
| 30 | Cassia absus L. | Caesalpiniaceae |
| 31 | Cassia italica (Mill.) Lam. Ex Fw.Andr | Caesalpiniaceae |
| 32 | Cassia mimosoides L. | Caesalpiniaceae |
| 33 | Cassia nigricansVahl. | Caesalpiniaceae |
| 34 | Cassia obtusifolia L. | Caesalpiniaceae |
| 35 | Cassia occidentalis L. | Caesalpiniaceae |
| 36 | Cassia siamea L. | Caesalpiniaceae |
| 37 | Cassia sieberiana DC. | Caesalpiniaceae |
| 38 | Cassia singueana Del. | Caesalpiniaceae |
| 39 | Delonix regia (Hook.) Raf. | Caesalpiniaceae |
| 40 | Parkinsonia aculeata L. | Caesalpiniaceae |
| 41 | Pilostigma reticulatum (DC.) Hochst | Caesalpiniaceae |
| 42 | Tamarindus indica L. | Caesalpiniaceae |
| 43 | Acacia ataxacantha DC. | Mimosaceae |
| 44 | Acacia nilotica (L.) Willd. Ex Del.subsp.nilotica | Mimosaceae |
| 45 | Acacia senegal (L.) Willd. | Mimosaceae |
| 46 | Acacia seyal Del. | Mimosaceae |
| 47 | Acacia sieberiana DC. | Mimosaceae |
| 48 | Acacia tortilis Subsp.raddiana | Mimosaceae |
| 49 | Albizia chevalieri Harms. | Mimosaceae |
| 50 | Albizia lebbeck (L.) Benth. | Mimosaceae |
| 51 | Dichrostachys cinerea (L.) Wight &Arn. | Mimosaceae |
| 52 | Faidherbia albida Del. | Mimosaceae |
53 Prosopis africana (Guill. & Perr.) Taub. Mimosaceae
54 Prosopis juliflora (SW) DC. Mimosaceae
55 Entada africana Guill. & Perr. Mimosaceae

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