
**Journal of Environment, Climate, and Ecology (JECE)**

ISSN: 3079-255X (Online)

Volume 2 Issue 1, (2025)

https://doi.org/10.69739/jece.v2i1.493

https://journals.stecab.com/jece

Published by
**Stecab Publishing**

*Research Article*

# Floristic Diversity of Community Forests in Togo's Maritime Region

*[1]Akpakpah Jean-Luc Ayéfouni, [1]Agbodan Kodjovi Mawuégnigan Léonard, [1]Akpavi Sêmihinva, [1]Batawila Komlan, [1]Akpagana Koffi

## About Article

**Article History**

**Submission**: April 18, 2025
**Acceptance** : May 20, 2025
**Publication** : June 17, 2025

**Keywords**

*Anthropic Pressure, Community Forests, Floristic Diversity, Forest Conservation, Togo*

**About Author**

[1] Laboratory of Botany and Plant Ecology (LBEV), University of Lomé, Togo

Contact @ Akpakpah Jean-Luc Ayéfouni
jeanlucakpakpah@gmail.com

## ABSTRACT

In the context of increasing land-use change, tropical forests are increasingly subjected to anthropogenic pressure, which is impacting their floristic composition. This study was conducted in community forests in the Maritime Region of Togo to assess their floristic diversity. Data were collected from 92 vegetation plots (30 m × 30 m each), arranged along linear transects following an altitudinal gradient. In each plot, ecological variables (e.g., location, geographic coordinates, vegetation type, canopy cover, and management practices) and floristic data (i.e., all plant species present) were recorded. Floristic and ecological data were analyzed using diversity indices (Shannon, Simpson) and spectrum analyses (biological and phytogeographic types). A total of 211 plant species were recorded, belonging to 175 genera and 65 families. The Fabaceae family was the most represented with 44 species (21%), followed by Euphorbiaceae (12 species, 6%) and Poaceae (9 species, 4%). The biological spectrum was dominated by mesophanerophytes and nanophanerophytes. In terms of phytogeographic distribution, GC-SZ and GC types were the most prevalent. The floristic composition and diversity of these community forests appear to be significantly influenced by various anthropogenic pressures, particularly agricultural expansion, urban encroachment, and illegal harvesting. The findings provide valuable insights for developing sustainable forest management strategies and guiding conservation planning and research in the Maritime Region.

**Citation Style:**

Akpakpah, J.-L. A., Agbodan, K. M. L., Akpavi, S., Batawila, K., & Akpagana, K. (2025). Floristic Diversity of Community Forests in Togo's Maritime Region. *Journal of Environment, Climate, and Ecology, 2*(1), 68-76. https://doi.org/10.69739/jece.v2i1.493

## 1. INTRODUCTION

Tropical forests are among the most biologically rich and ecologically important ecosystems on Earth. They host not only the majority of terrestrial biodiversity but also provide vital services to humanity, including carbon sequestration, water regulation, soil protection, and cultural values (Slik *et al.*, 2015; Edwards *et al.*, 2014). Beyond their ecological functions, tropical forests support millions of people by supplying timber, non-timber forest products (NTFPs), and essential resources for rural livelihoods. However, tropical forests are increasingly subjected to pressures from human activities such as agricultural expansion, illegal logging, mining, and urban development. These activities lead to habitat fragmentation, biodiversity loss, and the degradation of ecosystem services (Asner, 2009). Forest degradation not only alters their physical structure but also affects their floristic composition and overall resilience. Understanding floristic diversity, the variety and distribution of plant species within forests is therefore crucial for developing effective conservation strategies and sustainable management practices (Slik *et al.*, 2015).

In West Africa, forest ecosystems have been particularly vulnerable to anthropogenic pressures over the past decades. In Togo, especially in the Maritime Region, rapid population growth combined with increasing socio-economic demands has resulted in significant deforestation and degradation of natural habitats (Bigma *et al.*, 2021). Despite these pressures, relatively intact forest areas persist, particularly within community-managed forest zones. These community forests serve as essential refuges for native biodiversity, providing critical ecosystem services to local populations and contributing to regional ecological stability.

## 2. LITERATURE REVIEW

Previous research on floristic diversity in Togo (Bigma *et al.*, 2022; Kombate *et al.*, 2020; Seou *et al.*, 2022; Kokou *et al.*, 2010; Folega *et al.*, 2017; Atakpama *et al.*, 2022) has highlighted trends of increasing species richness in certain areas, suggesting that traditional practices and community-based conservation may play a role in maintaining biodiversity. However, community forests remain considerably threatened by daily human activities, including agricultural encroachment, firewood collection, and uncontrolled grazing. Their proximity to villages facilitates resource extraction and land-use changes, impacting floristic composition and the integrity of forest ecosystems.

Despite the recognized importance of these forests, detailed studies specifically focusing on floristic diversity within community forests in the Maritime Region remain limited. Moreover, the influence of various anthropogenic pressures on species composition and richness is still poorly understood. In the context of accelerating climate change, there is an urgent need to fill these knowledge gaps in order to inform sustainable management strategies capable of reconciling biodiversity conservation with local development needs.

Thus, the present study aims to contribute to the understanding of plant diversity and the condition of community forests in Togo's Maritime Region. Specifically, the objectives are: (i) to assess the floristic composition and species diversity of selected community forests; (ii) to identify the main forms of anthropogenic pressure affecting these forests.

The results of this study are expected to provide a scientific basis for the development of improved management plans and to guide conservation efforts aimed at safeguarding biodiversity and ecosystem services in Togo's Maritime Region.

## 3. METHODOLOGY

### 3.1. Study area

The study was conducted in the Maritime Region of Togo, located between 1°20′ West and 1°50′ East longitude, and between 6°10′ and 6°60′ North latitude. It covers an area of approximately 6,300 km² (Figure 1). Phytogeographically, this region belongs to ecological zone V of Togo, as defined by Ern (Ern, 1979). The population is predominantly composed of indigenous ethnic groups such as the Ewé, Mina, and Ouatchi, alongside non-indigenous communities including the Akposso, Ifè, Kabyè, Kotokoli, Bassar, and Moba (Gayibor, 2006). Although it accounts for only 10.8% of the national territory, the Maritime Region is home to approximately 42.3% of the country's total population, with a slight female majority (51.3%) (INSEED, 2010, 2022). The region's climate is hot and humid, classified as subtropical, and supports a relatively long growing season. The topography is composed of three main geomorphological units: the coastal strip, the continental plateau, and the Precambrian peneplain (Affaton, 1987). In terms of vegetation, the region is characterized by a fragmented cover due to widespread agricultural and anthropogenic activities. Four main vegetation types can be identified: riparian formations, remnant forest islands, herbaceous savannas, and heavily anthropized formations.

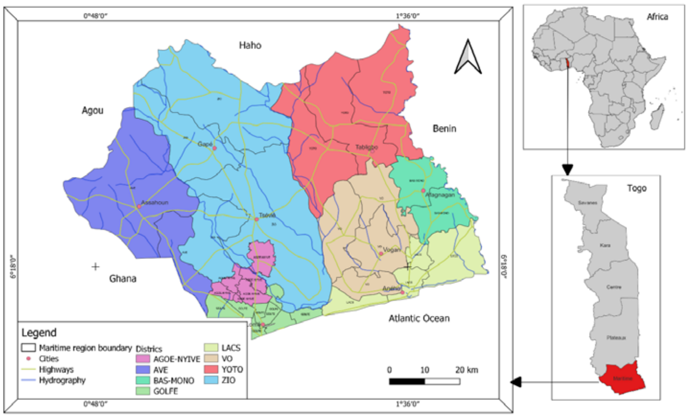


**Figure 1.** Map of the study area

### 3.2. Data collection

To estimate the biological diversity of plant formations, 92 phytosociological surveys were carried out using the sigmatist method of (Braun-Blanquet, 1932). Rectangular plots measuring 30 m × 30 m were established for data collection. In each plot, the information collected concerned ecological parameters (location, geographical coordinates, type of plant formation, degree of cover, management method, etc.) and floristic parameters (noting all the species in the plot). These parameters are those taken into account for the floristic and structural study at the scale of plant communities and species by various authors, including (Awokou *et al.*, 2009; Adjonou *et* *al.*, 2010, 2016). A total of 12 community forests were selected for this study. Given the high number of community forests in the Maritime Region, only forests with an area greater than or equal to 10 hectares were retained to ensure representativeness and ecological relevance. A GPS Garmin eTrex 10 is used for recording the geographic coordinates of inventory locations. In addition to the KoboCollect tool, data sheets were used for recording field measurements. The nomenclature used is that of (Brunel *et al.*, 1984). All plant species present were listed and each assigned an abundance-dominance coefficient following the scale below based on the average coverage (MR) proposed by Braun-Blanquet (1932):

- 5: species covering 75 to 100% of the survey surface, i.e., an RM of 87.5%;
- 4: species covering 50 to 75% of the survey area, i.e., an RM of 62.5%;
- 3: species covering 25 to 50% of the survey surface, i.e,. an RM of 37.5%;
- 2: species covering 5 to 25% of the survey surface, i.e., an RM of 15%;
- 1: species covering 1 to 5% of the survey surface, i.e,. an RM of 3% and;
- +: species covering less than 1% of the survey surface, i.e., an RM of 0.5%

Species not identified in the field were collected and later identified at the national herbarium. The nomenclatures used for flora and plant formations are, respectively, those of Akoègninou *et al.* (2006) and Brunel *et al.* (1984).

**Table 1.** Forests investigated and areas

| N° | Community forests | Area (ha) |
|---|---|---|
| 1 | Godjé-Godjin forest | 61.98 |
| 2 | Togodo forest | 12404.86 |
| 3 | Ando Bedo forest | 60.94 |
| 4 | Edzi-Hado forest | 89.91 |
| 5 | Sétékpé forest | 32.16 |
| 6 | Havé forest | 11.20 |
| 7 | Ando-Kpomey forest | 127.40 |
| 8 | Nyamessiva forest | 65.83 |
| 9 | forest of Eklobavé | 16.24 |
| 10 | Fialalonou forest | 14.31 |
| 11 | Fokpodoé forest | 23.03 |
| 12 | Zikpé forest | 29.26 |

### 3.3. Data processing

The species recorded are classified according to their families (APG III, 2009), biological form (Raunkiaer, 1934), and phytogeographic type (White, 1986) taking into account the type of ecosystem (Fallow land, Cropland and Plantations, Dense Forests, and Open Forests). This method has already been used by several authors (Sinsin, 1993; Mahamane, 2006). To take into account the weight of species for a character, the comparison was made by analyzing the raw spectra (RS) and the weighted spectra (WS) of biological types and phytogeographic types.

The raw spectrum is given by the following formula:

$$RS = \frac{\text{Number of the trait considered}}{\text{Total number of all identified traits}} \times 100$$

The weighted spectrum is given by the following formula:

$$WS = \frac{\Sigma\text{average coverage of the line considered}}{\Sigma\text{coverage of all identified traits}} \times 100$$

A "surveys x species" matrix is produced based on the presence/absence of species. The determination of alpha diversity is made by calculating the specific richness (Rs), the Shannon diversity index (ISH), and the Pielou's evenness index (E) (Magurran, 2004). The abundance of each species was taken into account to measure the equivalence of given areas of richness.

**i. Shannon's diversity index:** Shannon's diversity index (H') is used to measure both species richness and evenness (Kent, 2012).

It is given as follows: $H'=\sum_{i=\Lambda}^{s} (ni/n) \log2 (ni/n)$

With ni = sum of abundances/dominances of species i, and n = sum of abundances/dominances of all species.

**ii. Simpson's diversity index:**

$D = \Sigma_{i=1}^{s} (Pi)^2$

Pi = proportion of individuals of species i (pi = ni/N); ni = number of individuals of species i

N = total number of individuals; S = total number of the list of species present

**iii. Pielou's evenness index (E):** He was determined according to (Krebs, 1989).

$E = H'/\log2n$

Where n = sum of abundances/dominances of all species

## 4. RESULTS AND DISCUSSION

### 4.1. Species composition and diversity

The community forests investigated (12) in the maritime region are home to 211 plant species belonging to 65 families and 175 genera. Of all woody plants recorded in the study quadrats, 4 species (4.6%) are shrubs, and 87 species (95.4%) are trees. Diversity indices (Shannon, Simpson, and Pielou) varied across the different ecosystem types and are represented in the table below (Table 2).

### 4.2. Spectrum of families

Fabaceae (Figure 2) are the most represented family with 44 species (21%); followed by Euphorbiaceae 12 species (6%), Poaceae 9 species (4%), Moraceae 7 species (3%), Combretaceae

**Table 2.** Summary of species composition and diversity

| | Open Forests | Dense Forests | Cropland and Plantations | Fallow land | Maritime Region |
|---|---|---|---|---|---|
| H' (Shannon Diversity Index) | 6.75 | 6.26 | 5.73 | 5.61 | 6.87 |
| Pielou's Evenness (E) | 0.92 | 0.91 | 0.97 | 0.95 | 0.89 |
| Simpson | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 |
| Standard deviation | 0.03 | 0.04 | 0.04 | 0.05 | 0.03 |
| Species Richness | 166 | 118 | 61 | 59 | 211 |
| Families | 56 | 47 | 27 | 32 | 65 |
| Genera | 139 | 104 | 58 | 58 | 175 |

6 species (3%), Rubiaceae 6 species (3%) and Sterculiaceae 6 species (3%). Similarly, four families (Anacardiaceae, Asteraceae, Cyperaceae, and Tiliaceae) are represented by 5 species each, while 9 families are represented by 4 species, 2 families are represented by 3 species, 16 families are represented by 2 species, and the remaining 27 families are represented by one species.

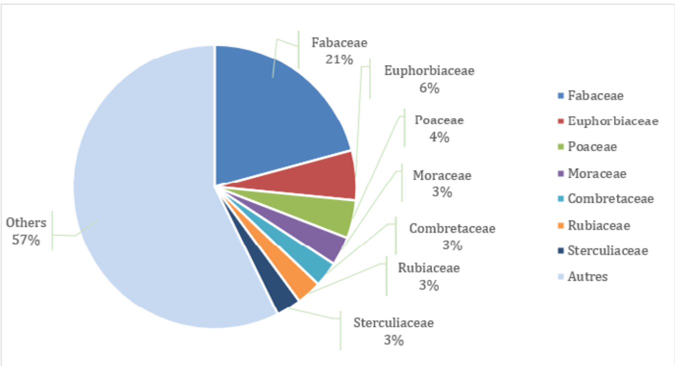


**Figure 2.** Family spectrum

### 4.3. Spectrum of biological types

Analysis of biological types (Figure 3) shows a clear predominance of mesophanerophytes and nanophanerophytes, with a particularly high frequency for mesophanerophytes. Mesophanerophytic lianas (Lmp) are also well represented. Grasses (Gr) and parasites (Par) have very low frequencies.

At the scale of land use units, the same trends are observed. We note a predominance of mesophanerophytes and nanophanerophytes with higher frequencies in light and dense forests than in fields and fallows. As for light and dense forests, this is characteristic of relatively closed and stable ecosystems. We also note a high proportion of therophytes and hemicryptophytes in fields and fallows, and this is explained by the fact that these areas are home to more small species adapted to disturbance. This situation could show the selective effect of anthropogenic activities (agricultural practices and logging,) favoring certain species to imprint a physiognomy on the vegetation.

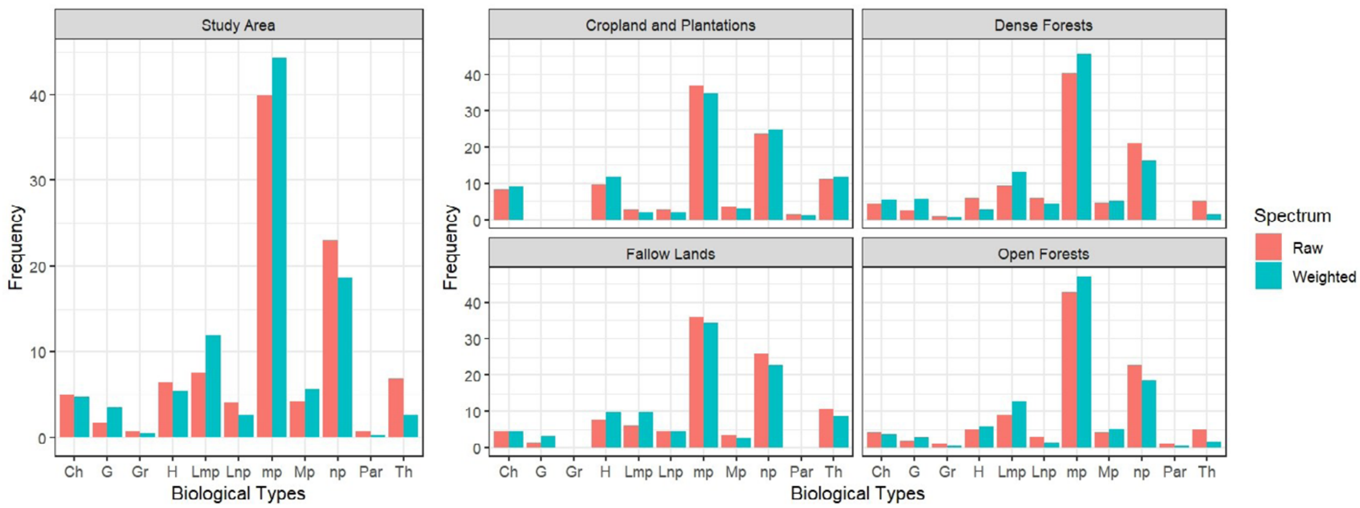


**Figure 3.** Raw and weighted spectrum of biological types

Ch = Chamaephytes, G = Geophytes, Gr = Grasses, H = Hemicryptophytes, Lmp = Mesophanerophytic lianas, Lnp = Nanophanerophytic lianas, mp = Mesophanerophytes, Mp = Megaphanerophytes, np = Nanophanerophytes, Par = Parasitic plants, Th = Therophytes.

### 4.4. Spectrum of phytogeographic types

Phytogeographic types are good indicators of the dynamism or stability of plant communities (Sinsin, 1993). In the study area (Figure 4), species with GC-SZ distribution (approximately 46%

and 45% raw and weighted spectrum) and GC (approximately 25% and 28% raw and weighted spectrum) are dominant. Regarding land occupation units, the same trends are observed. According to Sinsin (1993), the high proportion of widely distributed species is an indicator of disturbance and indicates that the flora is losing its specificity.

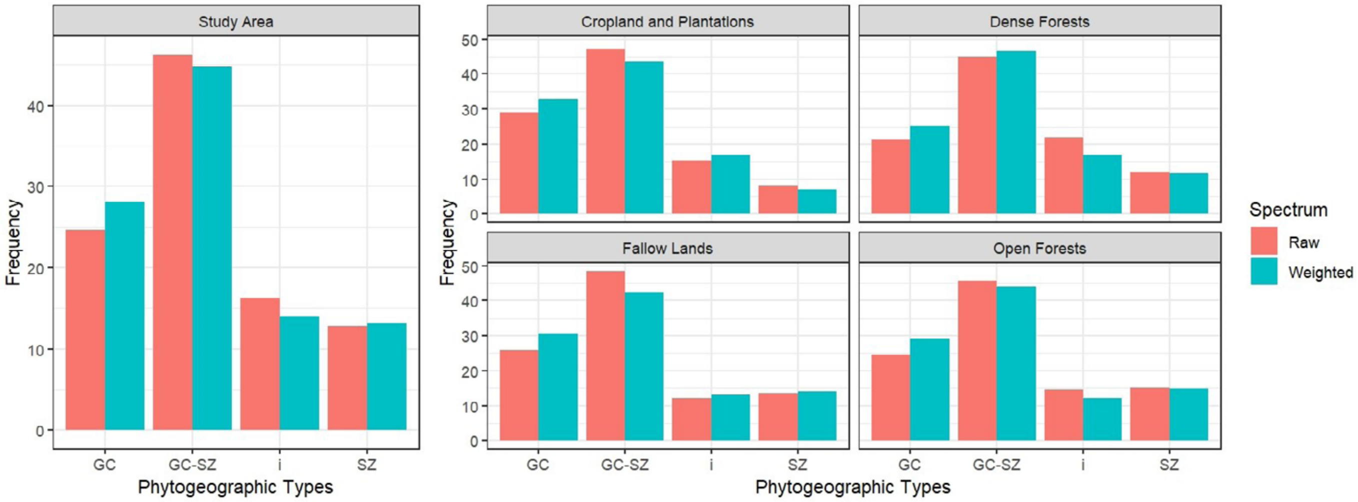


**Figure 4.** Raw and weighted spectrum of Phytogeographic Types

GC = Guinea-Congolese, SZ = Sudanese-Zambezians, GC-SZ = species found in both zones, I = introduced.

### 4.5. Rank-frequency curve

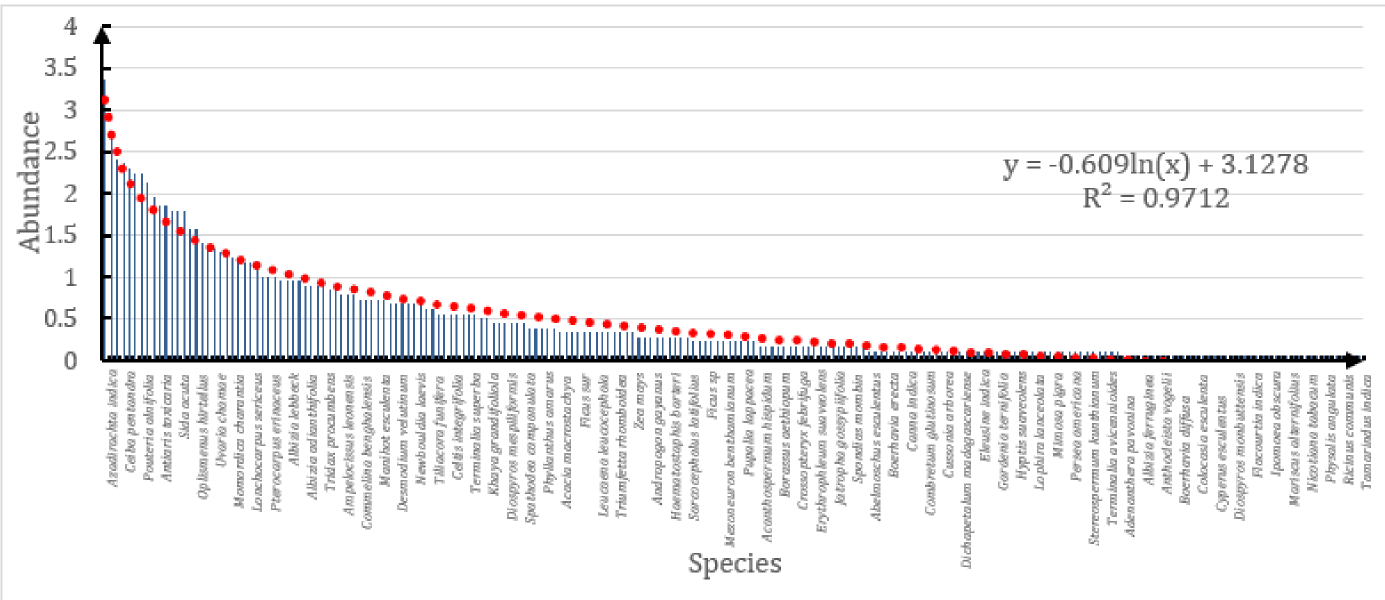


**Figure 5.** Rank-abundance curve

The rank-frequency curve (Figure 5) shows that the distribution of species according to their frequencies follows a logarithmic regression with the equation $y = -0.609\ln(x) + 3.1278$ with a very high correlation coefficient ($R^2 = 0.9712$). The most frequent species included Azadirachta indica A. Juss. (3.37%), Anogeissus leiocarpa (DC.) Guill. & Perr. (2.67%), Chromolaena odorata (L.) R.M.King, (2.41%), Ceiba pentandra (L.) Gaertn. (2.36%), et Pouteria alnifolia (Baker) Roberty var. alnifolia, (2.25%).

### 4.6. Relationship between floristic groups and vegetation types (Ecosystems)

Figure 6 (A) presents a biplot of the Principal Component Analysis (PCA), in which species distributions are projected onto a two-dimensional space defined by Axis 1 and Axis 2. Plot grouping is colour-coded by vegetation type, revealing a clear differentiation among dense forests, open forests, and habitats influenced by anthropogenic activities. Axis 1 accounts for 5.9% of the total variance and separates forest formations from cropland and fallow lands, suggesting a strong influence

of disturbance gradients. Axis 2, which explains 4.7%, appears to reflect differences related to soil moisture and elevation.
Figure 6 (B) shows the species contributions to the PCA. Only the 30 species with the highest contributions to the ordination were retained. Notably, Cussonia arborea, Andropogon gayanus, Combretum glutinosum, and Abelmoschus esculentus make substantial contributions to the structure of Axis 1, indicating their role as key discriminant species. Conversely, Delonix regia and Ficus spp. contribute less, owing to their widespread occurrence or weak association with any specific vegetation type. The PCA thus confirms a floristic gradient extending from minimally disturbed forest formations toward more anthropogenic landscapes, reflecting both ecological turnover and species adaptation to land-use intensity.

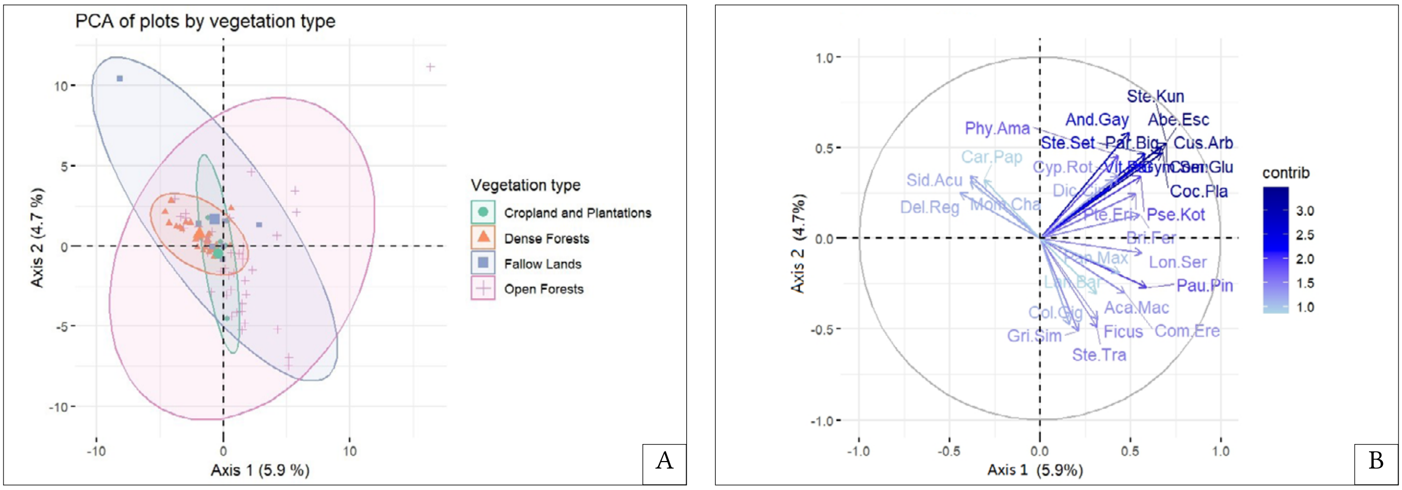


**Figure 6.** Biplot of floristic groups by vegetation type

### 4.7. Different types of pressure on community forests

Fig 7 highlights the various anthropogenic pressures exerted by local communities on forest ecosystems. The most frequently reported pressures include crop expansion (29.72%), proximity to agglomerations (22.29%), and resource harvesting (10.84%). In contrast, hunting (0.31%), illegal logging (4.95%), and charcoal production (4.95%) were less frequently cited.

When these pressures are spatially compared with alpha diversity indices (e.g., Shannon, Simpson), a clear inverse relationship emerges: areas subjected to high agricultural pressure and intensive land use, such as fallow lands and open forests, exhibit reduced species richness and lower evenness. This suggests a degradation of floristic structure and a shift toward generalist or pioneer species in disturbed plots.

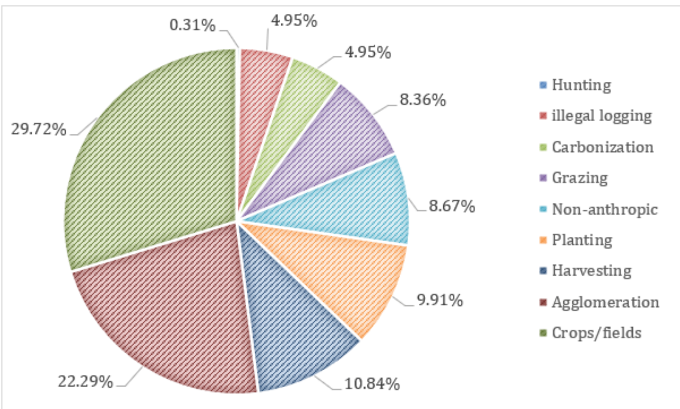


**Figure 7.** Types of FCs anthropization

### 4.8. Discussion

#### 4.8.1. Floristic diversity

The floristic inventory of community forests in the maritime region made it possible to identify 211 species of plants divided into 65 families and 175 genera. According to the different categories of land use, open forests have 166 species, grouped into 56 families and 139 genera; dense forests are home to 118 species in 47 families and 104 genera; fields and plantations contain 61 species belonging to 27 families and 58 genera and fallows contain 59 species, divided into 32 families and 58 genera. More recent work in the maritime region of Samarou *et al.* (2023) identified 55 species divided into 45 genera and 23 families in the production units of this same region. For their part, Gadikou *et al.* (2022) inventoried 164 medicinal plants, divided into 148 genera and 67 families, while Effoe *et al.* (2020) identified 86 plant species, grouped into 72 genera and 36 families. This reduction in floristic diversity reflects increasing anthropogenic pressure and a decline in plant resources. Note also that the intensity of human activities (deforestation, agriculture) has an impact on floral diversity.

At the local scale (AVE prefecture), Bigma *et al.* (2021) identified 158 woody species divided into 129 genera and 43 families. The Togodo forest, for its part, is home to 201 species, divided into 156 genera and 56 families, according to (Folega *et al.*, 2023). Local floristic variation is explained by local ecological factors, such as soil types, local climate, and the level of forest protection, but also by the influence of local forest management practices.

The Shannon diversity index (H') in the study area was 6.87, while Pielou's evenness index (J') was 0.89, indicating high species richness and relatively uniform distribution. This shows that the area is rich in flora diversity and almost uniformly distributed. Despite the good records of diversity and uniformity of the region's forests, there are various anthropogenic challenges such as illegal logging, agricultural expansion, and grazing in the areas. These results are different from those of (Kokou *et al.*, 2005), where the Shannon diversity index (H') was 7.28 and that of Pielou's evenness was 0.94. According to Legendre and Legendre (1998), cited by (Mahamane, 2006), the Shannon index has high values for species with overlaps of the same importance, and it takes low values when a few species have high overlaps.

### 4.8.2. Family spectrum, biological and phytogeographic types

It appears from our analysis that Fabaceae is the richest family, and therefore represented with 44 species (21%); followed by Euphorbiaceae 12 species (6%), Poaceae 9 species (4%), Moraceae 7 species (3%), and Combretaceae with 6 species (3%). This dominance of Fabaceae could be attributed to the potential adaptation of legume species (Fabaceae) to the diverse ecologies of the country (Atsbha *et al.*, 2019). Other studies have also reported the dominance of Fabaceae in plant populations, including (Kokou *et al.*, 2005; Samarou *et al.*, 2023).

Regarding biological and phytogeographic types, the maritime region shows a clear predominance of mesophanerophytes and nanophanerophytes for TB; and a GC-SZ (Guineo-Congolese/ Sudanese-Zambézian) and GC (Guineo-Congolese) distribution for TP. Gadikou *et al.* (2022) made the same observations with a dominance of widely distributed species from both Guinean-Congolese/Sudanese-Zambézian (61%). The latter are seconded by Guinean-Congolese species (27%). The presence of Guinean-Congolese/Sudanese-Zambézian and Guinean-Congolese species is due to the humid nature of the area studied, favorable to the development of relatively more hydrophilic flora (Atakpama *et al.*, 2017). For the biological spectrum, they found a dominance of microphanerophytes (27%), therophytes (22%), and nanophanerophytes (16%). The predominance of phanerophytes highlights the wooded character of the vegetation of the reserve (Woegan *et al.*, 2013). According to Insist (1993), the high proportion of widely distributed species is an indicator of disturbance and indicates that the flora is losing its specificity.

### 4.8.3. Impact of anthropogenic pressure

The populations of the study area, with a majority of farmers, practice agricultural activities. Always in search of fertile land, they are forced to move in search of new land. Also, they degrade or destroy natural spaces to settle, thus causing biodiversity to disappear or be lost. In areas of high demographic pressure such as the maritime region, the humanization of the landscape is almost total, with encroachments into community forests. Most old or recent studies show that clearing of African forests leads to a reduction in the density of woody cover (Pourtier *et al.*, 1992) in connection with a modification of its floristic composition (Nault, 1996) and sometimes leads to savannahization.

## 5. CONCLUSION

The study of the floristic diversity of community forests in the maritime region, in southern Togo, highlighted the importance of community forests for plant conservation. Two hundred and eleven (211) species with a diversity index varying from 0.89 to 6.87 were recorded. The Fabaceae were represented by the greatest number of species (44 species). Woody plants are the dominant life forms, representing approximately 95.4% of the species. Although human activities are gradually altering the floristic composition, these forests still maintain high species richness and diversity.

The results of this study serve as an essential database for biodiversity conservation strategies in southern Togo. In line with Togo's national biodiversity targets, such as increasing forest cover to 26%, community forests play an essential role in supporting native plant diversity and ecosystem resilience. Monitoring the floristic composition of these forests and identifying priority areas for restoration can directly support national commitments to reforestation and biodiversity. In addition, integrating local communities into forest governance, ecological restoration and biodiversity monitoring will enhance the effectiveness and sustainability of these efforts. Future studies should take into account the recovery dynamics of species under various disturbance and management scenarios.

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