



Plant Diversity of a Coffee-Based Agroforestry System in La Union, Philippines

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Abstract: Evaluating plant diversity in an agroforestry site is crucial for understanding the system, as vegetation is crucial for sustaining natural ecological processes and serves as a valuable resource for human consumption. This study aims to determine the tree species diversity of a coffee-based agroforestry system in a state university in La Union, Philippines. This research determined the species composition, density, frequency, dominance, importance value, and conservation status of the plant species, and also their richness, diversity, and evenness. A stratified sampling design was used in establishing quadrats. The study identified a total of 108 individuals across different vegetation layers, including 26 trees (16 species, 10 families), 38 saplings (12 species, 10 families), and 44 non-tree flora (14 species, 9 families), with Rain Tree (*Samanea saman*) and Coffee species (*Coffea canephora* and *Coffea liberica*) being the most dominant, highlighting a mixed native and introduced species composition within a coffee-based agroforestry system. The diversity is low ($H' = 1.79$) for the saplings, while the non-tree and tree species are both categorized as moderate, with H' of 2.15 and 2.65, respectively. However, there is a very high species evenness for tree species of (0.96) indicating extremely balanced community, while moderate evenness for saplings and non-tree species showed well-balanced community at a high evenness with a value of 0.72 and 0.83 respectively. This study offers valuable insights into the plant diversity of a managed coffee-based agroforestry system. Future studies may explore the implementation of strategies aimed at enhancing biodiversity within the coffee-based agroforestry system.

Keywords: Agroforestry; Biodiversity Conservation; Coffee.

INTRODUCTION

The Philippines is among the world's most significant countries for biodiversity conservation and is recognized as a megadiverse nation. Numerous life forms inhabit this area across both aquatic and terrestrial ecosystems and is

considered a biodiversity hotspot with a high concentration of endemic species. However, the country faces ongoing and severe habitat loss. Furthermore, evaluating tree diversity in a given area is crucial for assessing stand conditions, as trees play essential roles for sustaining natural ecological

processes and serving as vital resources for human use (Coracero and Malabrigo, Jr. 2020).

Climate change presents a significant risk for developing nations, impacting both directly and indirectly the ability for natural ecosystems to sustain food production and provide essential goods and services. Rural communities depend on natural forests for sustenance and livelihoods, contributing to forest deterioration. Many have also relocated to marginal, high-risk areas prone to land degradation, drought, pest infestations, and disease outbreaks (Manaye et al. 2021).

Agroforestry provides a viable path to mitigate the issues of biodiversity loss, habitat degradation, and climate change impacts, particularly in megadiverse yet vulnerable countries like the Philippines. Agroforestry, which integrates trees and shrubs with crops and/or livestock, is a land-use management approach that is essential for promoting biodiversity, enhancing soil health, and supporting sustainable agricultural practices. By promoting ecological balance and providing alternative sources of food and income, agroforestry helps mitigate habitat destruction while supporting the resilience of rural communities against climate-related challenges such as land degradation, drought, and pest outbreaks (Nair & Garraty, 2012).

Tree species diversity is critical in agroforestry systems, influencing ecosystem functions, including nutrient cycling, habitat provision, and resilience to environmental changes, are strengthened by higher diversity, which frequently leads to increased ecological stability and productivity. Studies have shown that diverse tree species can positively affect coffee yield and quality by providing shade, improving microclimate, and enhancing soil fertility (Nesper et al. 2017).

Tree species diversity in agroforestry systems is highly influenced by environmental factors like climate, soil type, and management practices (Sileshi et al. 2010). Research indicates that diverse tree species compositions enhance ecosystem stability, pest regulation, and overall productivity (Zhao et al. 2022)

While there are many studies of tree species diversity assessment in an agroforestry system, there is scant information, and the gap in the study is still significant. Thus, the goal of this study is to assess tree species diversity of the coffee-based agroforestry systems in a state university in the province of La Union, in the Philippines. Specifically, its goals are to: a) determine the different tree species in terms of the following taxa i) species, ii) genus, and iii) family; b) assess the endemism of the species found in the study area; c) classify the tree species found according to diameter sizes; d) assess the importance value of each species based on the following parameters: i) relative density; ii) relative frequency; and iii) relative dominance; and e) assess the abundance of species in terms of i) species diversity (H); ii) species richness, and iii) species evenness.

MATERIALS AND METHODS

Location of the Study Area

The study examines tree species diversity within a coffee-based agroforestry system at Don Mariano Marcos Memorial State University (DMMMSU) in Bacnotan, La Union, Philippines. This region characterized by diverse ecosystems that support various agricultural practices, including coffee cultivation.

Establishment of Sample Plots

Establishing sample plots was based on the quadrat method employed in Technical Bulletin No. 16 by the Department of Environment and Natural Resources (DENR) -Forest Management Bureau Technical Bulletin No. 16-A of 2019. This method was considered a standard floral inventory technique in assessing terrestrial ecosystems. At each representative sample site, a baseline transect was set up parallel to the existing trail, with transect lines positioned perpendicular to the baseline at 50-meter intervals. The length of the transect lines was 250 meters quadrat-to-quadrat distance on the 15,000 square meters extent of agroforestry land. Within the transect line, a 20m x 20m quadrat with a nested plots measuring 5 m×5 m and 1 m×1 m sub-plots were established at a 50 m interval between sectioning in the transect lines. All trees measuring 10 cm in diameter at breast height (DBH) of 10 cm or more were located and measured within 20m × 20m quadrats. Meanwhile, smaller trees classified as saplings (DBH <10 cm) were counted within the 5m × 5m plots, while non-tree flora, including shrubs, vines, and herbs, were identified and recorded within the 1m × 1m subplots.

For effective plot establishment, we set up 5 transects, each laid out 50 meters apart, resulting in a total coverage of 250 meters. In actual conduct, transect 1, quadrats were placed at 50, 100, and so forth, up to 250m. Overall, this methodology involved setting up the baseline transect along a determined line, marking transect lines every 50 meters, establishing quadrats at specified intervals, and systematically collecting data on tree species and other flora according to the established criteria (Fig. 1).

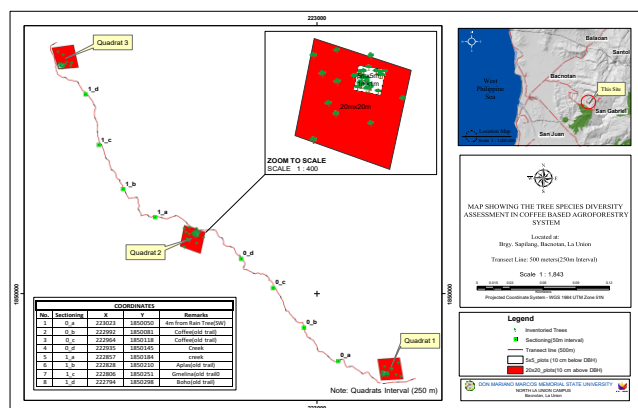


Figure 1. Map showing the established 500-meter transect line at the Coffee-based Agroforestry System in DMMMSU-NLUC, Bacnotan, La Union.

Measurement of Macrofloral Attributes/Characteristics

In each plot, the following parameters were determined or measured:

Plot and tree coordinates: The geographical location of the center of each plot, as well as all the sampled trees, the locations were identified using a handheld GPS receiver. Alternatively, case of unavailability of a hand-held GPS receiver, a mobile phone with a geo-tagging application will be used for tree mapping.

Species identification and individual count: All macroflora found inside the sample plots were identified up to species level, along with individuals for each species was counted and recorded. For documentation and further verifications of the species' correct names, photographs of samples of each species, a full tree, and a close-up of the leaves and flowers/fruits, if available, were taken. Species were identified on-site and classified taxonomically whenever possible. For species that were challenging to identify in the field, sample specimens were collected and assigned unique identifiers. These specimens were then processed at the end of each survey day to ensure proper preservation before final identification at the conclusion of the survey period. The identification of the species was verified using Co's Digital Flora of the Philippines (Pelsner et al. 2011).

Diameter measurement: The DBH of the trees was measured at 1.3 meters above the ground using either a diameter tape or tree caliper. These were recorded on prepared data sheets.

Data Analysis

The different parameters for assessing the floral diversity in the study area include the following: a) relative density, b) relative frequency, c) relative dominance, d) species importance value, e) general index of diversity (H), and f) species richness.

Relative Density

Individual count per species was recorded, and density values were calculated following the formula used by Curtis & McIntosh (1951) as cited by Terbio et al. (2022).

$$Density = \frac{Number\ of\ individuals}{Area\ sampled}$$

$$Relative\ Density = \frac{Density\ of\ species}{Total\ density\ of\ species} \times 100$$

Relative Frequency (F)

The number of plots where each species was present was recorded, and frequency values were calculated using the

formula from Curtis & McIntosh (1951) as cited by Terbio et al. (2022).

$$Frequency = \frac{Number\ of\ plot\ species\ occur}{Total\ number\ of\ plots\ sampled}$$

$$Relative\ frequency = \frac{Frequency\ value\ of\ species}{Total\ frequency\ for\ all\ species} \times 100$$

Relative Dominance (cover)

The relative dominance was computed using the formula used by Curtis & McIntosh (1951) as cited by Terbio et al. (2022).

$$Dominance = \frac{basal\ area\ of\ a\ species}{Area\ sampled}$$

$$Where\ basal\ area = \frac{\pi}{4} d^2$$

d = diameter at breast height

$$Relative\ Dominance\ (Rdom) = \frac{Dominance\ for\ a\ species}{Total\ dominance\ for\ all\ of\ species} \times 100$$

Importance Value (IV)

The Importance Value (IV) provides a general estimate of a plant species' overall influence and significance within a community. The IV was computed using the following formula of Curtis & McIntosh (1951) as cited by Terbio et al. (2022).

$$Importance\ Value = RD + RF + Rdom$$

where:

RD stand for Relative Density; *RF* = Relative Frequency; and *Rdom* = Relative Dominance

Index of Diversity (H)

Shannon Diversity Index (H') was employed for evaluating overall floral variety in the study area, considering both species abundance and evenness. A higher H value indicates a diverse and well-distributed community, while lower values suggest reduced diversity. A value of 0 signifies the presence of only one species. Typically, Shannon diversity values range between 1.5 and 3.5, seldom going beyond 4.5.

This index of diversity was computed using the following formula indicated below (Fernando et al. 2008; Baliton et al. 2020).

$$H' = \sum (pi) (ln pi)$$

Where: H' = Diversity of species

ln = natural logarithm

pi = relative abundance of species

Table 1. Shannon diversity index category based on Fernando et al. (2008) and Baliton et al. (2020).

Shannon Index	Category
0-1.0	Very low
1.1-2.0	Low
2.1-3.0	Moderate
3.1-3.5	High
3.6-4.0	Very high
4.1-4.5	Extremely high

Species Richness

Species richness is a diversity measure based on the total number of species present, giving equal importance to both rare and abundant species.

Species richness was computed by counting the total number of distinct species observed in each category:

$$\text{Species Richness } (S) = \text{Number of unique species}$$

No weighting was applied for species abundance—only presence was considered. Separate richness values were determined for Trees, Saplings and Non-tree species. Total species richness was obtained by summing across the three categories, excluding duplicate species if they appeared in more than one group.

Species Evenness

The Pielou's Evenness Index (J') was calculated to assess the distribution of species within the community. The J' value is categorized into five values as presented in Table 2. The Pielou's Evenness Index (J') measures the evenness of species distribution within a community. The Pielou index ranges from 0 to 1. A value of 1 indicates perfect evenness within a community, while values closer to zero signify increasing unevenness as species' relative abundances become more disparate. Index was computed using the formula from Feest et al., (2010).

Pielou's Evenness Index (also known as the Shannon Equitability Index) helps ecologists measure and understand these distribution patterns, revealing how equitably species share their habitat.

$$J = \frac{H'}{\ln(S)}$$

Where: H' = Shannon Diversity Index

S = total number of species

$\ln(S)$ = natural logarithm of S

Table 2. Pielou's Evenness values indicators:

PIELOU (J) Value	Result
0.90-1.00	Very high evenness
0.70-0.89	High evenness
0.50-0.69	Moderate evenness
0.25-0.49	Low evenness
0.00-0.24	Extremely low evenness

Conservation Status

The conservation status of each species at the study site was determined using two key references: the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2025) and the DENR Administrative Order (DAO) 11-2017 (DENR, 2017). The documented species were classified and organized into a table according to their respective conservation status.

GIS Mapping of the Trees in the Agroforest

The mapping was able to accurately identify and visualize the location of each individual tree, understand and show distribution, and assess the floral diversity in each site. Geographical coordinates of each tree were used to come up with a GIS map indicating the spatial locations of the trees in the study area. Individuals were tagged using mobile phones with a GPS tracking application.

RESULTS AND DISCUSSIONS

Floristic Composition

The study area recorded a total of 108 individual plants, comprising 26 trees, 38 saplings, and 44 non-tree flora. Among the identified species, coffee varieties exhibited the highest percentage occurrence (37.59%) in both subplots measuring 5 m×5 m and 1 m×1 m 5 m × 5 m and 1 m × 1 m, indicating the dominance of coffee in the agroforestry system.

The 20 m×20 m quadrats were used to assess tree species (Table 3) revealed a total of 26 individuals representing 16 species from 10 families. The most frequently recorded tree species included Rain Tree (*Samanea saman*) and Bolong-eta (*Diospyros pilosanthera*). Both native and introduced species were present suggests a mixed composition of naturally occurring and cultivated trees. Notably, 13 of the 16 tree species identified were endemic, while the remaining three species were non-endemic (Table 3). Most tree species were classified as Least Concern on the IUCN Red List, except for Bolong-eta (*Diospyros pilosanthera*), which is categorized as Vulnerable (IUCN, 2025).

The sapling layer, assessed within the 5 m × 5 m subplots, consisted of 38 individuals belonging to 12 species from 10 families. Coffee species dominated this category, with Coffee robusta (*Coffea canephora*) and Coffee excelsa (*Coffea liberica*) exhibiting the highest relative densities (Table 4). The prevalence of coffee in the sapling layer suggests that the study area is primarily managed as a coffee-based agroforestry system, where natural regeneration may be influenced by cultivation practices.

Non-tree flora recorded in the 1 m × 1 m subplots accounted for 44 individuals representing 14 species from nine families. The dominant non-tree species included Chinese evergreen (*Aglaonema commutatum*), basket grass (*Oplismenus hirtellus*), and carpet grass *Axonopus fissifolius*) (Table 5). The presence of groundcover species reflects the site's microhabitats and disturbances, with some species, such as Bamboo (*Bambusa vulgaris*) and Pasture

grass (*Pennisetum purpureum*), indicating adaptation to disturbed environments.

The recorded 38 species from 23 families in this study are comparatively lower than the 139 morpho-species identified by Coracero and Malabrigo Jr. (2020) in a diversity assessment conducted in Sitio Dicasalarin in Barangay Zabali, Baler, Aurora. The discrepancy may be attributed to differences in sampling effort, as their study utilized three 2-km transects, whereas this study employed a quadrat based sampling approach. In contrast, the findings of this study are comparable to those of Reyes Jr. and Sarnowski (2020) in a the one-hectare Indigenous Tree Farm located at Bohol Island State University-Bilar, where only 44 species were recorded. The lower species diversity observed in this study may be due to the dominance of cultivated coffee species, which could suppress the natural regeneration of other native species.

Table 3. List of tree species found in the 20mx20m quadrat.

Species	Frequency	Endemicity	Conservation Status
Raintree (<i>Samanea saman</i>)	4	NE	LC
Bolong-eta (<i>Diospyrus pilosanthera</i>)	3	E	V
Kupang (<i>Parkia timorensis</i>)	2	E	LC
Kalios (<i>Streblus asper</i>)	2	E	LC
Alim (<i>Melanolepis multiglandulosa</i>)	2	E	LC
Malapapaya (<i>Polyscias nodosa</i>)	2	E	LC
Lubeg (<i>Syzygium lineatum</i>)	2	E	LC
Dao (<i>Dracontomelon dao</i>)	1	E	LC
Anubing (<i>Artocarpus ovatus</i>)	1	E	LC
Pamaklaten (<i>Palaquium philippense</i>)	1	E	LC
Dita (<i>Alstonia scholaris</i>)	1	NE	LC
Rambutan (<i>Nephelium lappaceum</i>)	1	E	LC
Mango (<i>Mangifera indica</i>)	1	E	DD
Takip-asin (<i>Syzygium nitidum</i>)	1	E	LC
Aplas (<i>Ficus irisana</i>)	1	NE	LC
Binunga (<i>Macaranga tanarius</i>)	1	E	LC
Total	26		

Legend: LC - Least Concern; V - Vulnerable; NE - Not Endemic; E - Endemic; DD - Deficient Data

Table 4. List of saplings found in the 5mx5m nested plots.

Species	Frequency	Endemicity	Conservation Status
Coffee robusta (<i>Coffea canephora</i>)	15	NE	LC
Coffee excelsa (<i>Coffea liberica</i>)	12	NE	LC
Banato (<i>Mallotus philippinensis</i>)	2	E	LC
Malakamias (<i>Ailanthus triphysa</i>)	1	NE	LC
Anubing (<i>Artocarpus ovatus</i>)	1	E	LC
Bolong-eta (<i>Diospyros philippinensis</i>)	1	E	V
Malapapaya (<i>Polyscias nodosa</i>)	1	E	LC
Anonang (<i>Cordia dichotoma</i>)	1	NE	LC
Kalios (<i>Streblus asper</i>)	1	E	LC
Alder (<i>Alnus glutinosa</i>)	1	NE	LC
Is-is (<i>Morus alba</i>)	1	NE	LC
Lansones (<i>Lansium domesticum</i>)	1	NE	LC
Total	38		

Legend: LC - Least Concern; V - Vulnerable; NE - Not Endemic; E - Endemic

Table 5. List of non-tree flora found in the 1mx1m sub-plots.

Species	Frequency	Endemicity	Conservation Status
Chinese evergreen (<i>Aglaonema commutatum</i>)	11	NE	LC
Bow grass (<i>Elymus repens</i>)	8	NE	LC
Basket grass (<i>Oplismenus hirtellus</i>)	7	NE	LC
Carpet grass (<i>Axonopus fissifolius</i>)	6	NE	LC
Small leaf spiderwort (<i>Tradescantia fluminensis</i>)	3	NE	LC
Bamboo (biket) (<i>Bambusa vulgaris</i>)	1	NE	LC
Malabalatong (<i>Flemingia macrophylla</i>)	1	NE	LC
Pugahan (<i>Caryota mitis</i>)	1	NE	LC
Dieffenbachia (<i>Dieffenbachia sequin</i>)	1	NE	LC
Chinese burr (<i>Triumfetta rhomboidea</i>)	1	NE	LC
Purple scalystem (<i>Elytraria imbricata</i>)	1	NE	LC
Pepper elder (<i>Peperomia pellucida</i>)	1	NE	LC
Pasture grass (<i>Pennisetum purpureum</i>)	1	NE	LC
Lepidagathis (<i>Lepidagathis formosensis</i>)	1	E	LC
Total	44		

Legend: LC - Least Concern; V - Vulnerable; NE - Not Endemic; E - Endemic

Diameter Size Classification

The data in Table 6 classifies tree species based on their DBH into three size categories: small (10–30 cm), medium (31–60 cm), and large (≥61 cm). The majority of the trees (61.54%) fall within the small-size category, indicating a prevalence of younger or slower-growing species in the agroforestry system. Medium-sized trees make up a smaller proportion (11.54%), suggesting that fewer trees are in the intermediate growth stage. Meanwhile, large-sized trees account for 26.92% of the total, reflecting the presence of well-established, mature trees that contribute significantly to the system’s canopy structure and ecological stability. The dominance of small-sized trees may indicate ongoing regeneration, while the lower percentage of medium-sized trees suggests a gap in tree succession. This distribution pattern underscores the necessity of enrichment planting long with management strategies designed to ensure a balanced and sustainable tree population in the agroforestry system. Jose et al. (2009) stated that agroforestry systems that incorporate a variety of tree species offer several socio-ecological advantages. Agroforestry improves pollinator populations, creates habitats for wildlife, and helps residents maintain their standard of living. Additionally, diverse agroforestry systems can also support initiatives for mitigating and adapting to climate change.

Table 6. Tree species classification based on Diameter at Breast Height (DBH).

Diameter class	Diameter at breast height	Frequency	%
Small size	10-30	16	61.54
medium size	31-60	3	11.54
large size	≥61	7	26.92

Relative Density (RD)

The RD values obtained in the study provide information on the dominance of some species within the different vegetation layers and their ecological importance (Fig. 2). In the 20 x 20 m quadrat, the high value of RD for Rain tree

(*Samanea saman*) reflects its abundant distribution, which determines the structure of the forest canopy. In addition, Bolong-eta (*Diospyrus pilosanthera*) and other tree species contribute to structural and functional diversity in the forest. Within the 5m x 5m sub-plots, the dominance of Coffee Robusta (*Coffea canephora*) (38.5%) and Coffee Excelsa (*Coffea liberica*) (30.8%) reflects a strong regenerative capacity and ecological adaptability of these species, probably as a result of their commercial and ecological importance in the region. The most dominant non-tree flora was Chinese evergreen (*Aglaonema commutatum*) and Bao grass (*Elymus repens*) found in the 1m x 1m sub-plots, which are considered important as a ground cover to stabilize the soil. Besides that, basket grass (*Oplismenus hirtellus*) and Carpet grass (*Axonopus fissifolius*) present a considerable number of RD values; therefore, these plants help biodiversity and ecosystem functionality by avoiding soil erosion and ensuring the stabilization of ground-level vegetation.

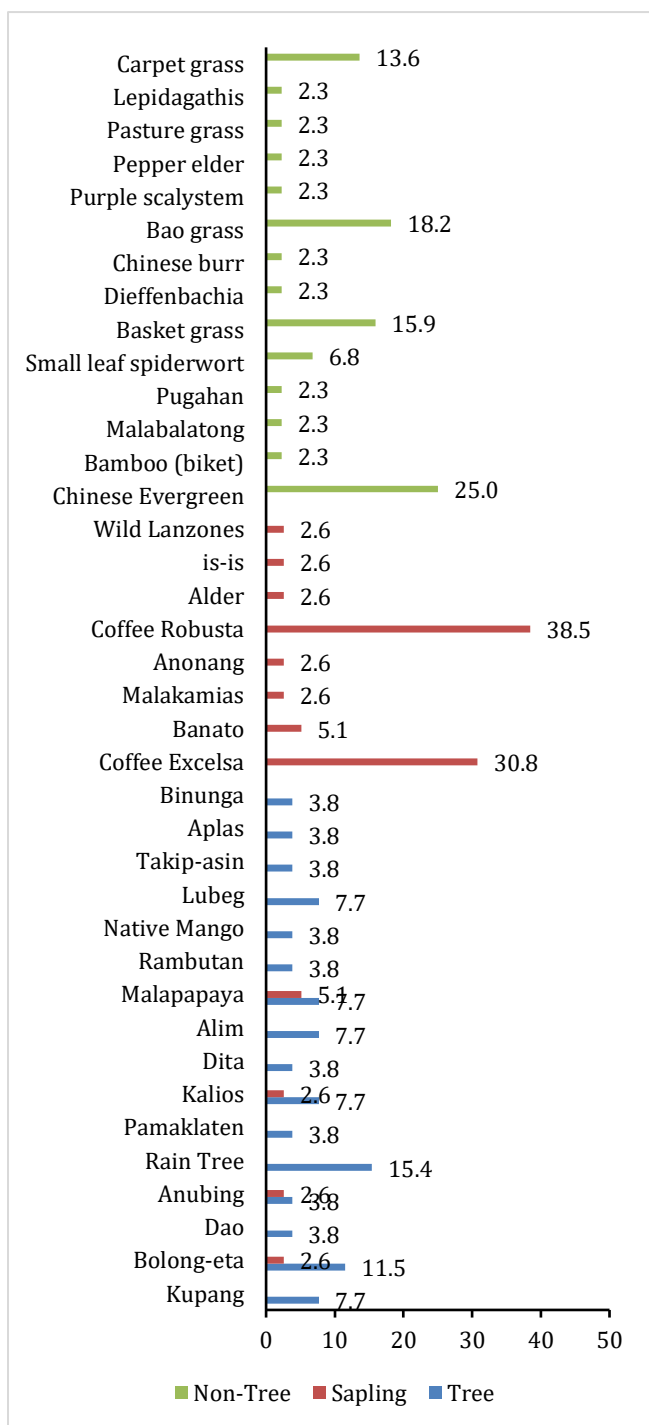


Figure 2. Relative Density of trees, saplings, and non-tree flora.

Relative Dominance (R Dom)

The findings of this study reveal in (Fig. 3) among the **tree species found in the area**, Rain Tree (*Samanea saman*) exhibits the highest RDom at 73.0, significantly surpassing other species. Kupang (*Parkia timoriana*) follows with 7.6, Alim (*Melanolepis multiglandulosa*) with 4.4, Dita (*Alstonia scholaris*) with 3.8, and Native Mango (*Mangifera indica*)

with 3.4, Malapapaya (*Polyscias nodosa*) with 2.2, Dao (*Dracontomelon dao*) and Bolong eta (*Diospyrus pilosanthera*) with 1.7 and 1.6, Kalios (*Parkia timorensis*) with 0.8, Aplas (*Ficus irisana*), Rambutan (*Nephelium lappaceum*) and Lubeg (*Syzygium lineatum*) with 0.4 while Pamaklaten (*Palaquium philippense*), Takip asin (*Syzygium nitidum*), Binuga (*Macaranga tanarius*) show considerably lower values of 0.1. Among saplings, Coffee Robusta (*Coffea canephora*) displays the highest RDom (93.3), followed by Coffee Excelsa (*Coffea liberica*) (4.0). These findings suggest that coffee species are crucial for maintaining the structural integrity of regenerating forests, particularly in areas affected by human activities. Studies on coffee-based agroforestry systems have demonstrated their ability to enhance biodiversity, promote carbon sequestration, and help conserve the soil (de Souza et al. 2012; Vaast et al. 2016).

The dominance of Rain Tree highlights its ecological significance within the study site, likely influencing essential ecosystem processes such as canopy closure, nutrient cycling, and understory dynamics. This is consistent with previous findings that emphasize Rain Tree's ability to improve soil fertility through nitrogen fixation, enhance organic matter accumulation, and support diverse understory vegetation (Nyeko, 2012; Arévalo et al. 2020). Its adaptability and widespread presence suggest it plays a major role in shaping forest composition and function, similar to its role observed in secondary and managed forests (Chazdon, 2014). Although species like Alim and Dita have relatively low RDom values, their presence contributes to forest biodiversity and ecosystem functionality, though less significantly than the dominant species. These species represent diversity in functional roles, supporting pollinators and acting as intermediate successional species, as observed in tropical and subtropical ecosystems (Lugo & Helmer, 2004).

One limitation of this study is the exclusion of non-tree flora from the RDom assessment due to the absence of measurable DBH. While these species were not quantified in this metric, they remain essential components of the ecosystem, contributing to ground cover, soil stabilization, and nutrient cycling (Jose, 2009). Future studies may consider integrating additional ecological parameters, such as belowground biomass contributions and microbial interactions, to offer a more thorough assessment of vegetation dynamics in the study area

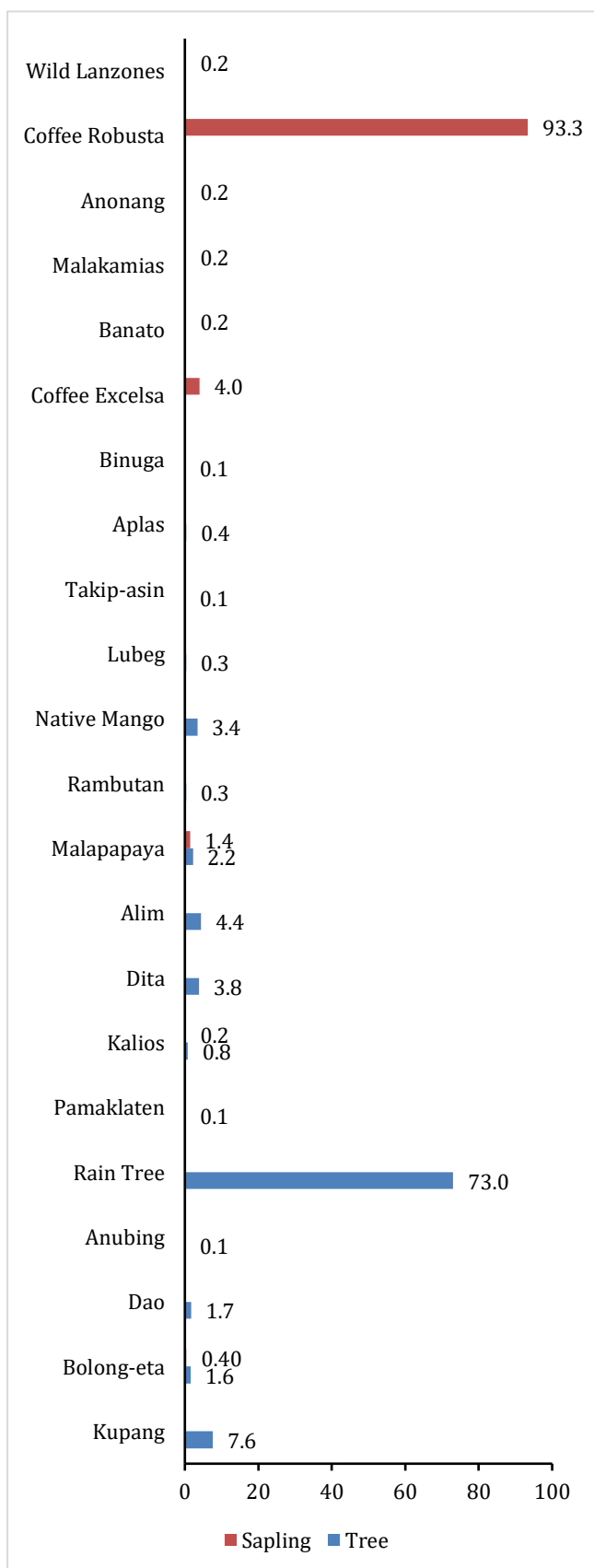


Figure 3. Relative Dominance of trees and saplings.

Importance Value (IV)

The highest IV among the tree species found in the study area was the Rain Tree (*Samanea saman*) (Fig. 4). This may be because this species recorded the greatest frequency in the study area. On the other hand, lower IV were recorded by Kupang (*Parkia timorensis*), Bolong-eta (*Diospyrus pilosanthera*), Kalios (*Streblus asper*), and Alim (*Melanolepis multiglandulosa*) in the agroforestry site.

Among the saplings, *Coffea robusta* (*Coffea canephora*) has the highest IV of 147.2%, followed by *Coffea excelsa* (*Coffea liberica*) with 42.4%. These values indicate a strong presence of these species in the understory and their potential contribution to the process of regeneration. The high values of importance for the coffee species may further suggest their commercial importance in the region, as well as their suitability to the local environmental conditions. *Coffea* spp. was also recorded by Lozano et al. 2024 to have the highest IV, density, and relative density in the DMMMSU forest reserve, where the present study was adjacent to. They have mentioned that the abundance of *Coffea* spp. around the forest reserve was due to the suitability of the area for growing coffee, the conducive microclimatic condition due to the presence of shade trees and the economic importance of coffee species to local farmers. Present study would further provide evidence of the dominance of coffee and reinforce the continued influence of coffee cultivation practices in the region, which strengthens its ecological and economic importance. The Banato (*Mallotus philippinensis*), Bolong-eta (*Diospyros philippinensis*), and Malapapaya (*Polyscias nodosa*) were recorded to have significantly lower IV, suggesting they play a less dominant role in terms of regeneration.

In the category of non-trees, the Basket grass recorded the highest IV. This was followed by Chinese evergreen (*Aglaonema commutatum*), Bao grass (*Elymus repens*), and Carpet grass (*Axonopus fissifolius*). These are species that most likely would cover the ground in large quantities to stabilize soil and perhaps promote the integrity of the forest floor ecosystem. All these species are categorized as Least Concern regarding their conservation status on the IUCN Red List (IUCN, 2025).

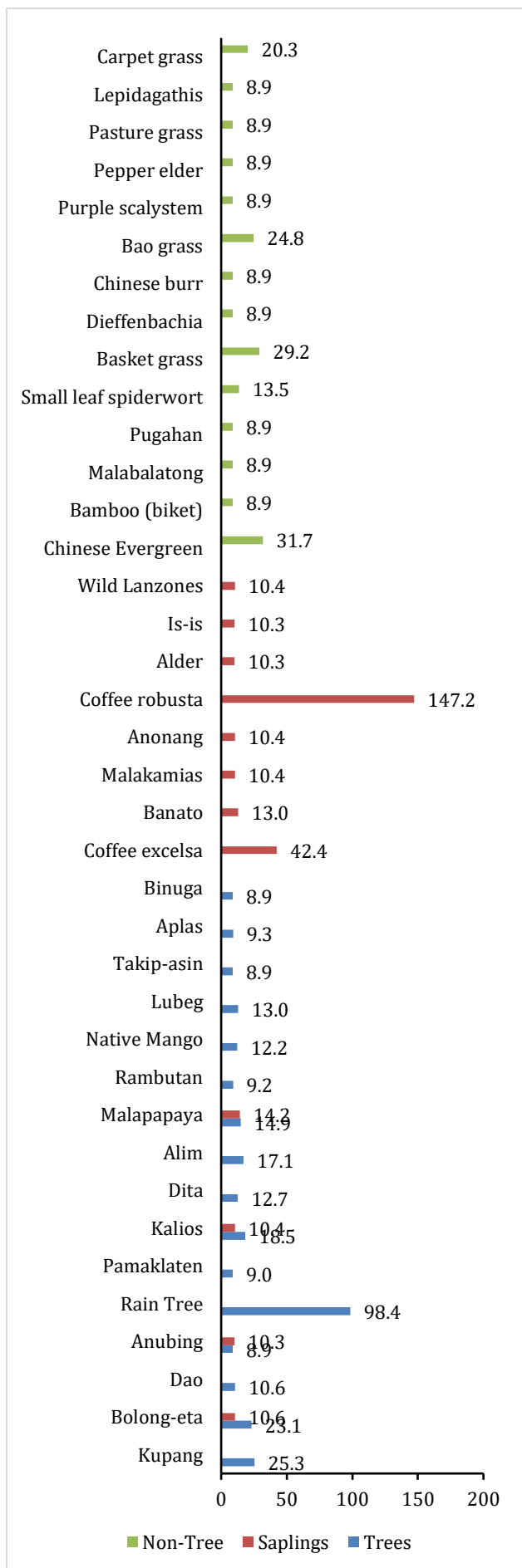


Figure 4. Importance Value of trees, saplings, and non-tree flora.

Species Diversity

In the agroforestry site, the Shannon Diversity Index (SDI) indicates both moderate diversity in trees (2.65) and non-tree species (2.15). On the other hand, the diversity of saplings was categorized as low (1.79) (Fig. 5). The results indicate that sapling diversity is lower compared to tree and non-tree species. Similarly, a study by Lozano *et al.* (2024) regarding the diversity of fruit-bearing tree species in the forest reserve adjacent to the site of the present study also reported moderate fruit tree diversity, supporting the findings of this research. Given the overall decline in forest cover across the Philippines, the study site's diversity may be in a relatively better condition.

By boosting habitat and landscape variability and structural complexity, multistorey agroforestry systems have the potential to aid in the conservation of biodiversity in agricultural and forest landscapes (Haggar *et al.* 2019).

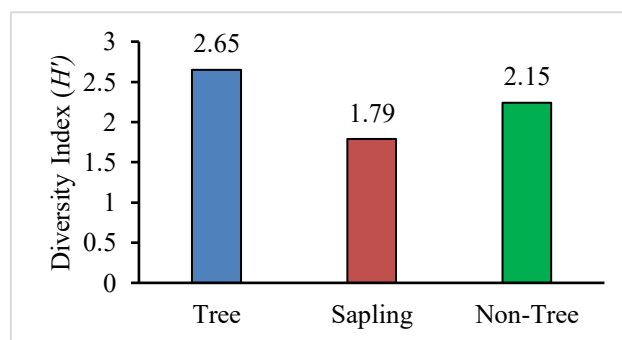


Figure 5. Species diversity of trees, saplings, and non-tree flora.

The diversity of trees and non-tree species in the study area was categorized as being at a moderate level, while the saplings were at a low level of diversity (Figure 5). Only minimal disturbances were observed on the site, suggesting a potentially low effect on diversity; this study was comparatively lower than the diversity assessment conducted by Coracero and Malabrigo Jr. (2020) from their 3 2 - km transects in Aurora, Philippines. However, this study may still be comparable with the diversity study of Reyes, Jr. and Sarnowski (2020) in a one-hectare Indigenous Bohol Island State University-Bilar's Tree Farm, where they recorded a total of 44 species.

Species Richness

The species richness in the observed ecosystem or study area is reflected in the presence of three distinct groups of vegetations: 16 tree species, 12 saplings and 14 non-tree flora. These numbers give a total species richness of 42, assuming there is no overlap among the categories (Figure

6). A combined richness of 42 species suggests that the ecosystem is diverse and potentially stable. Tree species contribute to structural diversity and long-term habitat formation. Saplings indicate successful regeneration, while non-tree species support ecological interactions like pollination, soil cover, and food web dynamics.

The richness of mature tree species (16) is essential for canopy structure, carbon sequestration, and long-term habitat provision. It reflects past and ongoing ecological processes and land-use history. However, the presence of 12 sapling species indicates active regeneration and recruitment potential. In a coffee-based agroforestry system, saplings are essential not just for regeneration, but for creating a resilient, diverse, and productive farming ecosystem. Their strategic management ensures long-term shade stability, soil improvement, biodiversity conservation, and income diversification, all key to sustainable coffee production. According to Poorter *et al.* (2010), regeneration layers, such as saplings are particularly sensitive to microhabitat conditions and anthropogenic impacts, which can significantly influence their diversity and abundance.

Additionally, the species richness index for non-tree flora (14) indicates the presence of specialized microhabitats, particularly in disturbed areas where certain species have adapted to cope with environmental stress. Their presence increases functional diversity and resilience to disturbances.

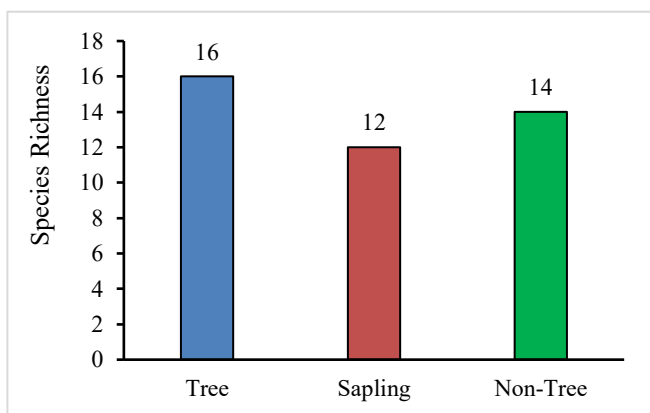


Figure 6. Species richness of trees, saplings, and non-tree flora.

Species Evenness

The species evenness index values in the study were 0.96 for trees, 0.72 and 0.83 for saplings and non-tree flora respectively. (Figure 7). Based on the classification by Feest *et al.*, (2010), tree and non-tree species fall under very high evenness value (0.90-1.00) while saplings are categorized as high evenness (0.70-0.89).

The very high evenness value for tree (0.96) and non-tree flora (0.83) indicates extremely balanced community and the species are evenly distributed across the study site, with no single species overwhelmingly dominating. This indicates a

balanced species composition, contributing to overall ecosystem stability. Ecologically, very high evenness is resilient to disturbances due to the quick recovery of the community from natural disasters, climate change, or human interference. On the other hand, the high evenness values for saplings (0.72) indicates a well-suggest that certain species within this category are more dominant than others, leading to a less uniform distribution. The relatively lower evenness among saplings may be attributed to the prevalence of coffee species, which are heavily cultivated in the area.

The evenness values observed in this study provide insight into the distribution patterns of species across different plant life forms. The very high evenness value for trees (0.96) and non-tree species (0.83) indicates a relatively uniform distribution of individuals among different tree species, with no single species exerting dominant control over the community (Whittaker, 1972; Tilman, 1999). On the other hand, saplings vegetation showed low evenness values of 0.49. indicates that although there may be high species richness (many different species), their abundance is uneven. This trend is especially evident among saplings, where the low evenness may result from the widespread cultivation of coffee (*Coffea spp.*), a common crop grown beneath forest canopies in agroforestry systems. The concentration of one or a few dominant species during this growth stage can hinder overall species diversity and potentially compromise the long-term ecological stability of the regenerating plant community (Chazdon, 2003; Perfecto and Vandermeer, 2010). Furthermore, the tree and non-tree flora’s evenness value of 0.96 and 0.83 respectively suggests a somewhat more balanced species composition than saplings, though still indicative of partial dominance by specific species. This could be influenced by factors like light availability, soil conditions, and land-use practices, which can affect the growth of understory vegetation (Gilliam, 2007).

These findings indicate that the coffee-based agroforestry system remains largely coffee-centric, with other species serving as either canopy or understory components. While tree species are relatively well-distributed, the dominance of coffee among saplings and non-tree flora suggests the potential need for diversification strategies to enhance species distribution and ecological balance within the agroforestry system.

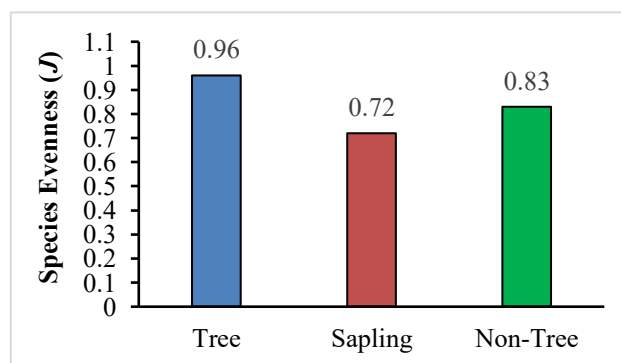


Figure 7. Species evenness of trees, saplings, and non-tree flora.

CONCLUSION

Tree species, saplings, and non-tree flora identified belong to 29 families with 42 species that are composed of 108 individuals. The most dominant family was Rubiaceae, due to the extensive presence of coffee in the area. The species diversity of the coffee-based agroforestry system is low for the saplings, while non-tree and tree species are both categorized as moderate. However, there is a high species evenness for tree species while moderate evenness for saplings and non-tree species.

The diversity and abundance of tree species are crucial for overall forest biodiversity. Data on these aspects will provide baseline information on the status of tree species in the study area. This is essential for understanding regeneration processes like tree growth, mortality, understory development, and the spread of disturbances (Ati and Kungo, 2023).

The area's relatively high plant diversity and even distribution suggest a healthy ecosystem (Llait, 2024). Given the lack of existing data, this study offers a significant contribution to tree assessment research in the region. The findings indicate that the area merits protection and conservation to ensure the long-term survival of these vital species for future generations (Lleno *et al.*, 2023).

Therefore, we recommend creating conservation management plans for the diverse plant species in the area and ensuring periodic biodiversity monitoring in the coffee-based agroforestry plantation. Enrichment planting of the area may be considered to enhance the diversity and explore greater livelihood opportunities for the community. This might also involve introducing a wider variety of native tree species that can coexist with coffee plants, further enriching the ecosystem. Overall, implementing strategies aimed at enhancing biodiversity within the coffee-based agroforestry system may be explored.

A scheduled regular monitoring and assessment of tree species diversity using the quadrat method will help in understanding changes over time, allowing for timely interventions if species loss or ecological imbalances are detected. Further, conduct of studies on the impact of agroforestry practices, particularly the interaction between coffee cultivation and various tree species is recommended. Understanding these dynamics can aid in developing best practices for sustainable agroforestry management.

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Conflict of Interest

The authors declared no conflicts of interest.

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