Species Diversity and Community Structure of Riparian Forest in Mau-It-Tipuluan River: Implications for Reforestation and Disaster Risk

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ABSTRACT

This study examines the structural characteristics and species composition of the riparian forest along the Maui-it-Tipuluan River, Sibalom, Antique, 2024, as inputs for reforestation and disaster risk reduction strategies. Conducted across three sampling stations—Igpanolong, Salvacion, and Iglanot—the research assessed species diversity and community structure of the riparian forest using standardized methods. It was found that the forest hosts 65 species across 23 families, with Euphorbiaceae, Leguminosae, and Moraceae being the most represented. Key species such as Mahogany Swietenia macrophyla, Bangkal Nauclea orientalis, and Rain Tree/Acacia Samanea Samman showed high importance values, indicating their dominant ecological roles. Despite very low diversity indices (H') across all stations—Igpanolong at 1.09, Salvacion at 0.94, and Iglanot at 0.79—high seedling densities suggest strong regenerative potential. Species evenness (J') varied, with Igpanolong at 0.75, Salvacion at 0.70, and Iglanot at 0.82, indicating varying levels of distribution balance among species. The findings emphasize the importance of planting native species like Anagas Semecarpus cuneiformis, Malapaho Mangifera altissima, Salong Canarium aspeirum, Talisay Terminalia catappa, and Narra Pterocarpus indicus to enhance biodiversity and establish natural flood buffers. Prioritizing these species in reforestation efforts will ensure the long-term sustainability and resilience of the riparian forest ecosystem, thereby reducing flood risks and protecting local communities.

Keywords: Riparian Forest, Species Diversity, Community Structure, Reforestation, Disaster Risk Reduction, Mau-it-Tipuluan River

INTRODUCTION

Riparian zones are essential for maintaining watershed health, biodiversity, and water quality. Trees in these areas stabilize stream banks, prevent erosion, filter pollutants, and regulate water temperatures, which support aquatic life. These zones also provide recreational and economic benefits by promoting tourism and conservation efforts [8],[12],[22],[3]. Beyond these ecological functions, riparian forests mitigate flooding by absorbing stormwater and sustaining stream flows, reducing the need for costly flood control structures [9] [4]. However, deforestation, urbanization, and agricultural activities pose significant threats to these ecosystems, impairing their capacity to perform these critical roles [15].

In the province of Antique, several municipalities, including Sibalom, have been identified as highly susceptible to flooding. During Typhoon Ruby in 2014, accumulated rainfall exceeded 100 mm within 24 hours, leading to severe flooding in parts of the province [13]. The Mines and Geosciences Bureau (MGB) identified Sibalom as one of the nine critical flood-prone areas due to its vulnerability to rain-induced landslides and flooding [19]. LiDAR Survey and Flood Mapping found that the Sibalom River Basin, with a floodplain and drainage area of 153.78 km² and 130.473 km², respectively, poses a flooding threat to nearby municipalities, including San Remigio, Belison, San Jose, and Patnongon [16]. Furthermore, the study assessed the flood vulnerability of 100 educational institutions in Sibalom's floodplain under different flooding scenarios, with several schools exposed to low, medium, and high levels of flooding over 5-year, 25-year, and 100-year projections [16].

The Mau-it-Tipuluan River, a tributary of the Sibalom River, is part of the Tipulu-an-Mau-it River Watershed Forest Reserve, established under Proclamation No. 605 series of 1990 to protect water yield and prevent forest exploitation and disruptive land use. It was later identified as a priority watershed by the Department of Environment and Natural Resources (DENR) (Philippine Master Plan for Climate Resilient Forestry Development, 2015).

Structural flood control measures such as dams, levees, and dikes were historically emphasized but have proven costly and, in some cases, ineffective, with unforeseen environmental consequences and over-reliance on physical defenses [6],[21].

In contrast, natural solutions like reforestation of degraded riparian forests have been found to be ecologically sound and cost-effective in reducing flood impacts, especially in the face of climate change [17]. This study aims to assess the present condition of the riparian forest along the Mau-it-Tipuluan River to generate baseline information on species richness and diversity, guiding planners and decision-makers in selecting appropriate species for effective reforestation, conservation, and flood mitigation.

Objectives of the Study

This study aims to determine the species diversity and community structure of riparian tree species along Mau-it-Tipuluan river.

Specifically, this study aim to (a)Determine the tree species present in the riparian zones at selected barangays along Mau-it-Tipuluan River, and (b) Determine the community structure of riparian forest in terms of species composition, stand basal area, dominance, tree density, sapling density, seedling density, importance value, index of diversity, and species evenness of tree species present on the area.

Significance of the Study

The study will provide valuable insights into riparian tree species diversity and community structure, benefiting key stakeholders such as the Local Government Unit (LGU) of Sibalom, the Department of Environment and Natural Resources (DENR), and the Disaster Risk Reduction Council. The LGU can utilize the findings to develop science-based policies for riparian zone conservation and flood mitigation, ensuring that natural flood control mechanisms are preserved and integrated into land-use planning.

Similarly, the DENR can use the data to enhance riparian forest management, support biodiversity conservation, and monitor the effectiveness of reforestation programs. The Disaster Risk Reduction Council will gain critical information to strengthen flood risk assessments, early warning systems, and preparedness strategies, contributing to the safety and resilience of flood-prone communities along the Mau-it-Tipuluan River.

The research will also benefit the local community, schools, students, and teachers by promoting environmental awareness and fostering participation in conservation initiatives. Understanding the role of riparian forests in flood control and water quality improvement will empower the community to engage in sustainable practices and reduce activities that threaten ecosystem health.

Furthermore, schools, particularly those in flood-prone areas, can incorporate the study into their environmental education programs, encouraging students and teachers to explore riparian ecosystems, participate in tree planting, and advocate for green spaces. This hands-on learning approach will inspire future generations to prioritize ecological protection and contribute to climate resilience in their communities.

Scope and Limitations

This study will find out the existing tree species and describe the community structure of riparian forests along

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the riparian zones of barangay Igpanolong, Salvacion, and Iglanot. Three (3) 20 m x 20 m plots transect line with 100 m length will be established in the selected barangays. Only tree species will be identified and measured as basis for determining the community structure of the area. The data will be gathered using standard procedures and will be analyzed using prescribed formula for community structure assessment of forests [5],[14].

MATERIALS AND METHODS

Procedure

Scoping and Ocular Survey:

Scoping was done to substantiate the evidence to conduct the study through literature survey, information gathering, and initial visit to the location. An ocular survey was done to validate the data gathered during scoping and to have an initial view of the location and the current situation along the riverbanks, identify existing species, determine coverage of riparian forests, and for the selection of the area for transect establishment. Also, the ocular survey was done to record human settlement and activities in the riparian area.

Preparation of Materials:

A 100-meter fiber tape measure and standard tape measure were used to establish sampling plots and measure distances along transects, ensuring precision in plot layout and data recording. A 100-meter straw lace was employed to mark plot boundaries and create straight lines for proper alignment during sampling.

Additionally, a meter stick was used to measure the diameter at breast height (DBH) of trees and assess plant heights, providing standardized measurements critical for analyzing species composition and community structure. Supporting tools such as masking tape and marking pens were essential for labeling trees and plot markers, enabling easy identification and accurate data tracking during fieldwork.

Lastly, the Haribon Foundation Technical Report (2004) served as a field guide, assisting in the identification of tree species and offering relevant ecological information, which ensured the reliability and accuracy of species identification throughout the study.

Identification of the sampling sites and coordination with local officials:

After scoping, it was found that the barangays Igpanolong with coordinates- 10°46'29''N 122°05'40''E at 118 meters above sea level, Salvacion with coordinates at 10°46'45''N 122°04'30''E at 52 meters above sea level and Iglanot with the coordiantes 10°47'13''N 122°02'04''E at 28 meters above the sea level had the highest potential to be the sampling sites due to the ideal location of lush vegetation. Also, the distance between each sampling station were found to be ideal.

Figure 1 shows the map of the municipality of Sibalom where the sampling stations are located.

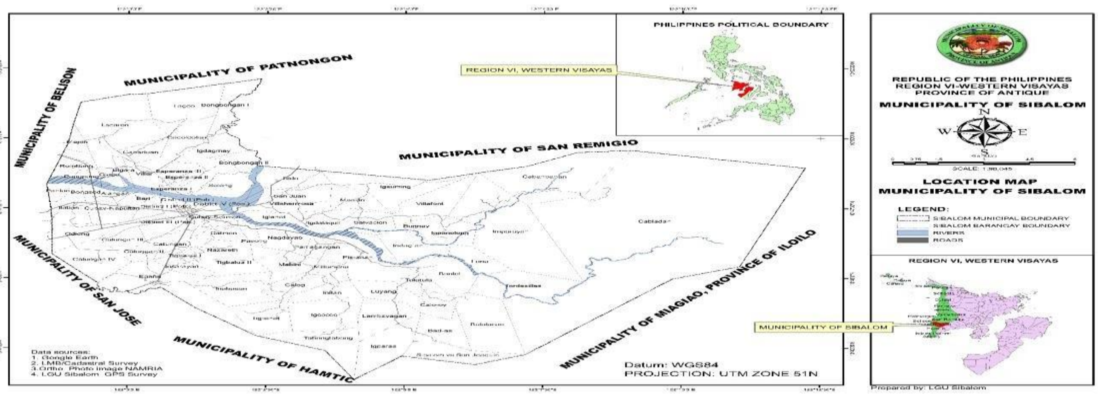

Fig 1. Map of Municipality of Sibalom.

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Establishing Transects and Sampling Plots:

Sampling plots were established in the identified area at the selected barangays along Sibalom River as shown in Figure 2. A transect line was established in the area with dense trees to represent the general area. Transect line plots method adopted from English et al. (1994) in assessing selected sites was utilized with 100 m in length, constituting three (3) 20 m x 20 m plots. The seedling and sapling profile of every species was considered.

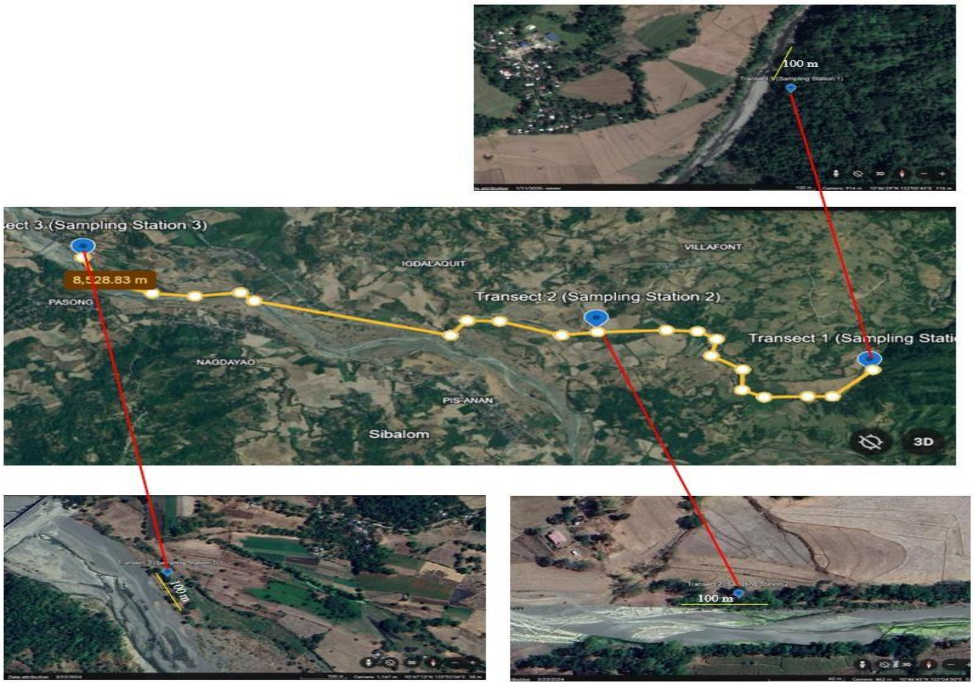

Fig. 2. Map showing the location of Transect Lines in each sampling station

Data Collection:

The following procedure were followed in collecting data:

Identification of Species

Riparian forest species were identified by their local names with the help of two foresters who assisted in the conduct of the study for species identification. Scientific names were identified using the List of Floral Species in Sibalom, Antique from Haribon Foundation's Rapid Site Assessment and Full Biological Survey (2004). All species were photographed for verification, identification, and documentation.

The International Union for Conservation of Nature (IUCN) classification if plant species were identified through Co's Digital Flora of the Philippines [18].

Measurement of DBH

Using the technique prescribed by English et al. (1994), diameter at breast height (DBH) was determined. This was measured in centimeters using a tape measure. The tree DBH was measured at 1.3 meters from the ground. For trees that had grown irregularly, specific measurements were applied.

When a stem forked below breast height or sprouted from a single base close to the ground or above, each branch was measured as a separate stem. When the stem forked at breast height or slightly above it, the diameter at breast height or below the swelling caused by the fork was measured. When the stem had prop roots or a fluted lower trunk, diameter was measured 20 cm above the root collar. Finally, when the stem had swelling, branches, or abnormalities at the point of measurement, the diameter was measured slightly above or below the irregularity.

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Data Analysis

Riparian forest community structure was calculated using the formulas adopted from English et al. (1994) and Odum and Barrett (2005). Data were processed using Microsoft Excel program with the following formulas:

a. Basal Area

BA (in cm²) = $\frac{\pi DBH^2}{4}$

b. Stand Basal Area

Stand BA (in m²ha²) $\frac{\Sigma BA}{\text{Area of the plot}}$ =

c. Stems per Hectare

Stems/ha = $\frac{\text{No. of stems per plot x 10,000}}{\text{Area of the plot}}$

d. Relative Density

Rel. Density = $\frac{\text{No. of individuals of species x 100}}{\text{Total no. of individuals (all}}$

e. Frequency $\frac{\text{number of plots were species occur x100}}{\text{Total number of plots}}$

Frequency =

f. Relative Dominance

Rel. Dominance = $\frac{\text{Total BA of species x 100}}{\text{BA of all species}}$

g. Importance value

Imp. Value = (R. Density) + (R. Freq.) + (Rel. Dominance)

h. Shannon Index of Diversity

$$H = -\sum_{i=1}^{s} \frac{n_i}{N} \log_2\left(\frac{n_i}{N}\right)$$

where:

n_i= importance value of a species i

N= sum of importance values for all species

s = total # of species in the sample

i. Evenness Index

E = $\frac{H}{\ln S}$

where: H = Shannon-Weiner Index

S = total number of species in the sample

ln = natural logarithm

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In interpreting the biodiversity index, [7], [1], [2] the value of H can be interpreted within specific ranges:

Value	Description	Interpretation
$H \leq 1.99$	Very Low Diversity	Indicates a community dominated by a few species, suggesting low biodiversity.
$2.0 \leq H < 2.49$	Low Diversity	Reflects a community with some diversity but still dominated by certain species.
$2.50 \leq H < 2.99$	Moderate Diversity	Suggests a balanced community where no single species dominates significantly.
$3.00 \leq H < 3.49$	High Diversity	Indicates a rich community with a good balance of species.
$H \geq 3.50$	Very High Diversity	Reflects a highly diverse community with many species and a relatively even distribution of individuals among them.

For the interpretation of species evenness, the value of J was based on a range from 0 to 1, with higher values indicating greater evenness in species distribution [20]. Specifically, $J = 1$ represented maximum evenness, where all species had an equal number of individuals, while $J < 1$ indicated varying levels of evenness, with lower values suggesting a more uneven distribution of individuals among species.

Ethical Issues

This study, at all costs, abided by ethical standards throughout the course of the research. Written permits were secured from the Office of the Municipal Mayor to permit the conduct of the study involving the selected barangays within the municipality of Sibalom, and from the Office of the Barangay Captains of the selected barangays.

During the study, no trees were cut down, nor were any invasive or destructive procedures conducted in order to avoid disruption to the normal ecological balance in the area. Tree leaf samples were collected primarily for the purpose of documentation and species identification.

RESULTS AND DISCUSSION

Species Composition

Table 1 shows the structural characteristics of the riparian forest in Maui-it-Tipuluan River, Salvacion, Sibalom, Antique, 2024. It reveals a diverse array of species across 23 families, totaling 65 species.

The families with the most species include Euphorbiaceae, Leguminosae, and Moraceae. Euphorbiaceae includes species such as Bugos Acalypha amentaceae and Alom/Alim Melanolepis multiglandulosa, with Alom/Alim occurring twice and having an overall frequency of 67% across the site and 3% across species.

Leguminosae include species like Ipil-Ipil Leucaena leucocephala and Kamonsil Pithecellobium dulce, with Ipil-Ipil occurring three times, showing an overall frequency of 100% across the site and 5% across species. Moraceae includes species such as Tipolo Artocarpus treculianus and Tabuyog Ficus nota, with Tabuyog occurring twice and having an overall frequency of 67% across the site and3% across species.

Among the species with the highest values, Rain Tree/Acacia Samanea samman, Kawayan Dendrocalamus, Ipil-Ipil, Banaba Lagerstroemia speciosa, Mahogany Swietenia macrophyla, and Bangkal Nauclea orientalis each occur three times, indicating their significant presence with an overall frequency of 100% across the site and % across species.

The range of these species is predominantly native, with some species being non-native but naturalized, such as Gmelina Gmelina arborea and Mahogany. The IUCN conservation status varies, with most species listed as Least Concern, but some, like Malapaho Mangifera altissima and Tipolo Artocarpus treculianus, are categorized as Data Deficient but Vulnerable as identified by DENR Administrative Order/DAO, respectively.

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Data is shown in Table I.

TABLE I

No.	Family	No. of species per family	Common Name	Scientific Name	Range	Transect 1	Transect 2	Transect 3	No. of occurrence	freq. of occurrence (%) across	freq. of occurrence (%) across	IUCN Conservation Status (IUCN 3.1)
1	Anacardiaceae	3	Anagas	Semecarpus cuneiformis	Native		1		1	0.33	0.02	Least Concern
			An-An	Bucharania arboressens	Native		1		1	0.33	0.02	Least Concern
			Malapaho	Mangifera altissima	Native		1		1	0.33	0.02	Data Deficient (*DAO category: Vulnerable)
2	Bignoniaceae	1	Pingka-Pingkahan	Oroxylum indicum	Native		1		1	0.33	0.02	Least Concern
3	Burseraceae	1	Salong	Canarium asperum	Native	1			1	0.33	0.02	Least Concern
4	Cannabaceae	1	Emelda	Celtis luzonica	Native	1			1	0.33	0.02	Least Concern
5	Chrysobalanaceae	1	Tabon-tabon	Atuna excelsa	Native			1	1	0.33	0.02	Native
6	Combretaceae	2	Talisay	Terminalia catappa	Native		1		1	0.33	0.02	Least Concern
			Lumangog	Termimalia microcarpa	Native		1		1	0.33	0.02	Least Concern
7	Euphorbiaceae	4	Bugos	Acalypha amentaceae	Native	1			1	0.33	0.02	Data Deficient
			Bato-Bato	Neotriwia cumingii	Native		1		1	0.33	0.02	Data Deficient
			Alom/Alim	Melanolepis multiglandulosa	Native		1	1	2	0.67	0.03	Least Concern
			Pabung/Binunga	Macaranga tanarius	Native			1	1	0.33	0.02	Least Concern
8	Fabaceae	3	Rain Tree/Acacia	Samanea samman	Native	1	1	1	3	1.00	0.05	Least Concern
			Antsoan Dilao	Senna spectabilis	Non-native-Natura		1		1	0.33	0.02	Least Concern

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue III March 2025

					lized							
			Kamonsil	Pithecellobium dulce	Non-native-Naturalized		1	1	2	0.67	0.03	Least Concern
10	Lamiaceae	3	Bugawak	Clerodendrum quadriloculare	Non-Endemic		1		1	0.33	0.02	Least Concern (*DAO category: Vulnerable)
			Gmelina	Gmelina arborea	Invasive-Naturalized	1	1	1	3	1.00	0.05	Naturalized and invasive in the Philippines (Joshi 2006)
			Agdaw/ Alagaw	Premna odorata	Native	1	1		2	0.67	0.03	Least Concern
11	Lecythidaceae	1	Murogna	Barringtonia asiatica	Native		1		1	0.33	0.02	Least Concern
12	Leguminosae	4	Ipil-Ipil	Leucaena leucocephala	Invasive-Naturalized (CABI 2017)	1	1	1	3	1.00	0.05	Invasive species (CABI 2017). Naturalized.
			Madre Cacao	Gliricidia sepium	Non-native-Naturalized	1			1	0.33	0.02	Least Concern
			Payhod	Albizia saponaria	Native			1	1	0.33	0.02	Least Concern
			Narra	Pterocarpus indicus	Native	1			1	0.33	0.02	Endangered
13	Lythraceae	1	Banaba	Lagerstroemia speciosa	Native	1	1	1	3	1.00	0.05	Least Concern
14	Malvaceae	1	Tan-ag	Kleinhovia hospita	Native	1	1		2	0.67	0.03	Least Concern
15	Meliaceae	3	Mahogany	Swietenia macrophylla	Non-native-Naturalized	1	1	1	3	1.00	0.05	Naturalized.
			Amugis	Aglaia pachyphylla	Native	1		1	2	0.67	0.03	Least Concern
			Lanipga	Toona calantas	Native	1			1	0.33	0.02	Data Deficient *(DAO category: Vulnerable)
16	Moraceae	6	Tipolo	Artocarpus treculianus	Native	1			1	0.33	0.02	Vulnerable
			Tabuyog	Ficus nota	Native	1	1		2	0.67	0.03	Least Concern

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue III March 2025

			Durarog	Ficus recurva	Native	1			1	0.33	0.02	Native
			Hawili/Labnog	Ficus septica	Native	1	1		2	0.67	0.03	Least Concern
			Niyog-Niyogan	Ficus pseudopalma	Endemic and Native	1			1	0.33	0.02	
			Bayuko	Artocarpus treculianus	Endemic and Native	1			1	0.33	0.02	Vulnerable
17	Myrtaceae	2	Guava	Psidium guajava	Naturalized	1			1	0.33	0.02	Invasive species **(CABI 2017)
			Lumboy	Syzygium cumini	Invasive-Naturalized		1		1	0.33	0.02	Least Concern
18	Palmae	2	Tapikan	Caryota cumingii	Endemic-Native	1			1	0.33	0.02	Data Deficient
			Buri	Corypha utan	Native	1			1	0.33	0.02	Least Concern
19	Pittosporaceae	1	Mamali	Pittosporum pentandrum	Native	1			1	0.33	0.02	Least Concern
20	Poacaea	1	Sarale	Paspalum conjugatum	Non-native-Naturalized		1		1	0.33	0.02	Least Concern
21	Rubiaceae	3	Kahoy Dalaga	Mussaenda phillipica	Endemic and Native	1			1	0.33	0.02	Least Concern
			Bangkal	Nauclea orientalis	Native	1	1	1	3	1.00	0.05	Least Concern
			Balud	Neonuclea formicaria	Endemic and Native	1			1	0.33	0.02	Least Concern
22	Sapotaceae	1	Star Apple	Chrysophyllum cainito	Native		1		1	0.33	0.02	Least Concern
23	Urticaceae	1	Alagasi	Leucosyke capitellata	Native	1			1	0.33	0.02	Least Concern
Total Number of Families						17	17	9				
Total Number of Species						28	25	12	65		100%	
*DAO- DENR Administrative Order												
**CAB International, formerly Commonwealth Agricultural Bureaux												

Community Structure

Dominant Species:

The results show that In Igpanolong, Mahogany Swietenia macrophyla emerges as the most dominant species in the study area, with the highest basal area (12950.86 cm^2m^{-2}) and stand basal area (43.17 m^2 ha^{-1}). It also has the highest tree density (966.67 n ha^{-1}) and sapling density (7400.00 n ha^{-1}), contributing significantly to the forest's structure and function. The high relative dominance (34.56%) and importance value (106.14) of Mahogany highlight its critical role in the ecosystem. Other notable species include Rain Tree/Acacia Samanea samman and Tipolo Artocarpus treculianus, which also show substantial basal areas and importance values, indicating their significant presence and ecological roles (See Appendix A).

Meanwhile, in Salvacion, Bangkal Nauclea junghuhnii stands out with the highest basal area (11067.07 cm^2m^{-2}) and stand basal area (36.89 m^2 ha^{-1}). It also has the highest tree density (1100.00 n ha^{-1}) and seedling density (4633.33 n ha^{-1}), contributing significantly to the relative dominance (46.22%) and importance value (117.68). Mahogany Swietenia macrophyla also shows substantial basal area and importance value, indicating its significant presence in the forest structure (See Appendix B).

In Iglanot, Rain Tree/Acacia Samanea samman is the most dominant species in the study area, with the highest basal area (22789.17 cm^2m^{-2}) and stand basal area (75.96 m^2 ha^{-1}). It also has the highest tree density (566.67 n ha^{-1}) and seedling density (666.67 n ha^{-1}), contributing significantly to the relative dominance (53.37%) and importance value (111.49). Other notable species include Bangkal Nauclea junghuhnii and Gmelina Gmelina arborea, which also show substantial basal areas and importance values, indicating their significant presence and ecological roles (See Appendix C).

Tree and Sapling Density

The total tree density of 1500.00 n ha^{-1} and sapling density of 15300.00 n ha^{-1} in Igpanolong. Mahogany, with its high densities, stands out as a key species for both current forest structure and future growth. The presence of other species like Ipil-Ipil Leucaena leucocephala and Narra Pterocarpus indicus in significant numbers further supports the forest's regenerative capacity.

In Salvacion, the total tree density is 1800.00 n ha^{-1}, with Bangkal contributing the most. Sapling density is highest for Ipil-Ipil Leucaena leucocephala, followed by Mahogany. On the other hand, the total tree density of 1400.00 n ha^{-1} and sapling density of 633.33 n ha^{-1} in Iglanot reflect a healthy regeneration potential within the forest.

Rain Tree/Acacia, with its high densities, stands out as a key species for both current forest structure and future growth. The presence of other species like Kamonsil Pithecelobium dulce and Payhod/Akling Parang Albizia saponaria in significant numbers further supports the forest's regenerative capacity.

Seedling Density

In Igpanolong, the total seedling density is 6366.67 n ha^{-1}, with Mahogany Swietenia macrophyla showing the highest density. This abundance of seedlings indicates a robust potential for natural regeneration, crucial for the continuous renewal of the forest and its resilience to environmental changes and disturbances. In Salvacion, the total seedling density is 9866.67 n ha^{-1}, with Bangkal Nauclea junghuhnii having the highest density, followed by Ipil-Ipil Leucaena leucocephala and Mahogany. This high seedling density underscores the strong regenerative capacity of these species. In Iglanot, the total seedling density is 1666.67 n ha^{-1}, with Rain Tree/Acacia Samanea samman showing the highest density.

Relative Dominance, Frequency, and Density

In Igpanolong, Mahogany Swietenia macrophyla exhibits high relative dominance (34.56%) and relative density (64.44%), reflecting its substantial contribution to the forest's basal area and overall structure. The high relative frequency of species like Mahogany and Rain Tree/Acacia Samanea samman indicates their widespread presence, suggesting they are well-adapted to local conditions.

In Salvacion, Bangkal Nauclea junghuhnii shows the highest relative dominance (46.22%), indicating its significant role in the forest's basal area. The relative frequency is highest for species like Bangkal and Ipil-Ipil Leucaena leucocephala, indicating their widespread presence across the study area.

In Iglanot, Rain Tree/Acacia Samanea samman demonstrates high relative dominance (53.37%) and relative density (40.48%), underscoring its major contribution to the forest's basal area and structure. The high relative frequency of species like Rain Tree/Acacia and Bangkal indicates their adaptability and widespread presence in the area.

Importance Value (IV)

The importance value (IV) combines relative dominance, frequency, and density to provide a comprehensive measure of a species' ecological significance. Mahogany's IV of 106.14, the highest among all species, highlights its dominant role in the forest ecosystem. Other species with high IVs, such as Rain Tree/Acacia and Tipolo, also play crucial roles in maintaining the ecological balance and diversity of the forest.

In Salvacion,, Bangkal has the highest IV (117.68), followed by Mahogany (59.85) and Ipil-Ipil (23.34). Finally, in Iglanot, Rain Tree/Acacia's IV of 111.49, the highest among all species, highlights its dominant role in the forest ecosystem. Other species with high IVs, such as Bangkal and Gmelina, also play crucial roles in maintaining the ecological balance and diversity of the forest.

Species Diversity and Evenness

The table presents the diversity index and species evenness for three sampling stations: Igpanolong, Salvacion, and Iglanot, providing insights into the biodiversity and distribution of species within the riparian forest. The diversity index (H') values for all three stations are very low, with Igpanolong at 1.09, Salvacion at 0.94, and Iglanot at 0.79.

Despite the low diversity, the species evenness (J') values show varying levels of distribution balance among the species present. Igpanolong has a species evenness of 0.75, indicating a moderate level of evenness with some species dominance.

Salvacion has a slightly lower evenness at 0.70, suggesting a less balanced distribution and potential dominance by a few species. In contrast, Iglanot, with the lowest diversity index, has the highest evenness at 0.82, indicating a more balanced distribution of species.

Data is shown in Table II.

TABLE II

DIVERSITY AND EVENNESS INDEX OF RIPARIAN FOREST ALONG MAU-IT-TIPULUAN RIVER.

Sampling Station	Diversity Index	Description	Species Evenness	Description
Igpanolong	1.09	Very Low Diversity	0.75	No Evenness but Approaching
Salvacion	0.94	Very Low Diversity	0.70	No Evenness but Approaching
Iglanot	0.79	Very Low Diversity	0.82	No Evenness but Approaching

DISCUSSION

Species Composition

The riparian forest hosts a diverse array of species across 23 families, totaling 65 species. Families such as Euphorbiaceae, Leguminoseae, and Moraceae are particularly well-represented, indicating their significant role in the forest ecosystem. Euphorbiaceae includes species like Bugos Acalypha amentaceae and Alom/Alim Melanolepis multiglandulosa, with Alom/Alim occurring twice and having an overall frequency of 0.67% across the site and 0.03% across species. Leguminosae features species like Ipil-Ipil Leucaena leucocephala and Kamonsil Pithecellobium dulce, with Ipil-Ipil occurring three times, showing an overall frequency of 1.00% across the site and 0.05% across species. Moraceae includes species such as Tipolo Artocarpus treculianus and Tabuyog Ficus nota, with Tabuyog occurring twice and having an overall frequency of 0.67% across the site and 0.03% across species.

The geographical and ecological context of the Philippines influences tree diversity patterns. The archipelago's unique climatic conditions, elevation gradients, and soil types contribute to the specialization of certain tree species (Culmsee & Leuschner, 2013).

Community Structure/Structural Characteristics

The structural characteristics reveal that certain species, such as Rain Tree/Acacia Acacia confusa, Ipil-Ipil Leucaena leucocephala, Banaba Lagerstroemia speciosa, Mahogany Swietenia macrophyla, and Bangkal Nauclea orientalis, show high occurrence and frequency values, highlighting their dominance and ecological importance. These species contribute significantly to the forest's basal area and overall structure, suggesting they are well-adapted to the local conditions.

The importance value (IV) metrics, which combine relative dominance, frequency, and density, underscore the ecological significance of key species. Mahogany, Bangkal, and Rain Tree/Acacia have the highest IVs in their respective sampling stations, indicating their dominant roles in the forest ecosystem. These species are crucial for maintaining the forest's ecological balance and diversity.

Mahogany is among the most common species found in upland farms, alongside other fast-growing exotics like Acacia mangium and Gmelina arborea [24]. This preference for Mahogany is attributed to its adaptability to various soil types and its ability to thrive in disturbed environments, which is crucial for reforestation efforts aimed at mitigating deforestation and land degradation [24].

On the other hand, Bangkal Nauclea junghuhnii, is a native species that plays a vital role in maintaining the ecological balance within forest ecosystems. Its presence is often associated with healthy forest conditions, and it contributes to the overall biodiversity of the region. The ecological significance of native species like Bangkal is underscored by the need for integrating them into agroforestry systems, which can enhance ecosystem services and promote sustainable land use practices [25]. The conservation of such native species is critical, especially in the face of ongoing deforestation and habitat fragmentation in the Philippines [25].

Acacia species, particularly Acacia mangium and Acacia confusa, are also prominent in the Philippine landscape. These species are recognized for their ability to improve soil fertility through nitrogen fixation, which is beneficial for subsequent crops in agroforestry systems [11]. Acacia's fast growth and resilience make it a popular choice for reforestation projects, especially in degraded lands [11]. However, the dominance of Acacia in certain areas can lead to concerns about biodiversity loss, as these species may outcompete native flora, thereby altering community structures [24], [25].

Biodiversity and Evenness

The table presents the diversity index and species evenness for the three sampling stations, providing insights into the biodiversity and distribution of species within the riparian forest. The diversity index (H’) values for all three stations are very low, with Igpanolong at 1.09, Salvacion at 0.94, and Iglanot at 0.79. These values indicate a limited variety of species in each area, suggesting that factors such as competition, environmental conditions, and human activities may be restricting species richness. Despite the low diversity, the species evenness (J') values show varying levels of distribution balance among the species present. Igpanolong has a species evenness of 0.75, indicating a moderate level of evenness with some species dominance. Salvacion has a slightly lower evenness at 0.70, suggesting a less balanced distribution and potential dominance by a few species. In contrast, Iglanot, with the lowest diversity index, has the highest evenness at 0.82, indicating a more balanced distribution of species.

Conservation Status

The IUCN conservation status of the species varies, with most listed as Least Concern. However, some species, such as Malapaho Mangifera altissima and Tipolo Artocarpus treculianus, are categorized with Data Deficient or Vulnerable, respectively, as identified by the DENR Administrative Order (DAO). This means that more conservation efforts to protect these vulnerable species should be imposed and ensure the sustainability of the riparian forest ecosystem.

Regenerative Potential

The high seedling densities across the sampling stations indicate a robust potential for natural regeneration. In Igpanolong, the total seedling density is 6366.67 n ha^{-1}, with Mahogany showing the highest density. In Salvacion, the total seedling density is 9866.67 n ha^{-1}, with Bangkal having the highest density, followed by Ipil-Ipil and Mahogany. In Iglanot, the total seedling density is 1666.67 n ha^{-1}, with Rain Tree/Acacia showing the highest density. This abundance of seedlings is vital for the continuous renewal of the forest and its resilience to environmental changes and disturbances.

Implications for Disaster Risk Reduction

The findings highlight the critical role of species diversity, structural stability, and regenerative potential in maintaining the ecological balance and resilience of the forest. While species like Mahogany Swietenia macrophyla and Rain Tree/Acacia Samanea samman show high importance values and contribute significantly to the forest's structure, it is important to note that these are non-native species. For effective disaster risk reduction, it is preferable to plant native species that are well-adapted to local conditions and can provide long-term ecological benefits. Native species such as Anagas Semecarpus cuneiformis, Malapaho Mangifera altissima, Salong Canarium asperum, Talisay Terminalia catappa, Alom/Alim Melanolepis multiglandulosa, Narra Pterocarpus indicus, Banaba Lagerstroemia speciosa, Tipolo Artocarpus treculianus, and Bangkal Nauclea orientalis have shown strong regenerative abilities and play crucial roles in soil stabilization and water absorption. These species not only enhance biodiversity but also contribute significantly to the forest's capacity to act as a natural flood buffer, reducing the velocity and volume of floodwaters, trapping sediments, and preventing downstream flooding.

Thus, conservation efforts should prioritize the protection and enhancement of these native species to ensure the long-term resilience and stability of the riparian forest ecosystem, thereby safeguarding local communities from the adverse effects of flooding.

Implications for Reforestation

The results reveal the importance of selecting native species that are well-adapted to local conditions and contribute to the ecological balance and resilience of the forest. In Igpanolong, the focus should be on planting species that contribute to soil stabilization and have strong regenerative abilities.

Recommended species include Anagas Semecarpus cuneiformis, which enhances structural stability, and Malapaho Mangifera altissima, a vulnerable species that plays a role in maintaining ecological balance. Talisay Terminalia catappa is also crucial for preventing soil erosion with its extensive root system, while Narra Pterocarpus indicus, an endangered species, is essential for conservation and soil stabilization.

In Salvacion, the emphasis should be on species that enhance biodiversity and provide robust flood mitigation.

Salong. Canarium asperum is important for soil stabilization and providing habitat for various fauna. Alom/Alim Melanolepis multiglandulosa has shown adaptability and ecological significance, making it a valuable addition. Banaba Lagerstroemia speciosa offers both aesthetic and ecological benefits, including soil stabilization. Tipolo Artocarpus treculianus , a vulnerable species, is important for conservation and contributes to the forest's structural stability.

In Iglanot, the focus should be on species that support natural regeneration and maintain ecological balance. Bangkal Nauclea orientalis has strong regenerative abilities and plays a crucial role in maintaining the forest's ecological balance. Emelda Celtis luzonica contributes to the diversity and stability of the forest, while Agdaw/Alagaw Premna odorata enhances biodiversity and supports the forest's resilience. Buri Corypha utan is important for soil stabilization and water absorption.

The selection of species for reforestation should prioritize native species that are well-adapted to local conditions and contribute significantly to the forest's ecological balance and resilience. By focusing on species such as Anagas Semecarpus cuneiformis, Malapaho Mangifera altissima, Talisay Terminalia catappa, Narra Pterocarpus indicus, Salong Canarium asperum, Alom/Alim Melanolepis multiglandulosa, Banaba Lagerstroemia speciosa, Tipolo Artocarpus treculianus, Bangkal Nauclea orientalis, Emelda Celtis luzonica, Agdaw/Alagaw Premna odorata, and Buri Corypha utan, reforestation efforts can enhance biodiversity, improve soil stabilization, and support natural regeneration.

Studies have shown that non-native species can alter nutrient cycling and soil composition, which adversely affects the growth and survival of native trees [10]. The replacement of nutrient-conserving native species with more aggressive non-native species can shift the ecological balance, making it difficult for native trees to thrive [10]. This phenomenon is particularly pronounced in disturbed habitats where non-native species are more likely to establish themselves due to reduced competition from native flora [23].

CONCLUSION

The study reveals a diverse array of riparian tree species across 23 families, with significant representation from Euphorbiaceae, Leguminosae, and Moraceae. Key species such as Mahogany, Bangkal, and Rain Tree/Acacia show high importance values, indicating their dominant roles in the forest ecosystem. Despite the low diversity indices, the species evenness values suggest varying levels of distribution balance, with some areas showing moderate to high evenness. The high seedling densities across sampling stations indicate a robust potential for natural regeneration, essential for the forest's resilience to environmental changes and disturbances.

The findings underscore the critical role of native species in disaster risk reduction and reforestation efforts. Native species like Anagas Semecarpus cuneiformis, Malapaho Mangifera altissima, and Bangkal Nauclea orientalis are crucial for soil stabilization, water absorption, and maintaining ecological balance. Conservation efforts should prioritize these species to enhance the forest's capacity to act as a natural flood buffer, reducing flood risks and protecting local communities. The study provides a comprehensive framework for selecting appropriate species for reforestation, ensuring long-term ecological benefits and resilience of the riparian forest ecosystem.

RECOMMENDATIONS

Based on the findings of the study, it is recommended that the Local Government Unit (LGU) of Sibalom prioritize the conservation and enhancement of native riparian tree species, particularly those identified with strong regenerative potential and ecological importance, such as Bangkal Nauclea orientalis, Anagas Semecarpus cuneiformis, and Malapaho Mangifera altissima.

Reforestation programs in flood-prone areas should focus on these species to improve soil stabilization, enhance water absorption, and strengthen the forest's capacity as a natural flood buffer.

Additionally, the LGU should implement policies to protect riparian zones from unregulated development and illegal logging, ensuring the preservation of biodiversity and ecosystem services. The Department of Environment and Natural Resources (DENR) is encouraged to use the study's species composition and structural data as a basis for selecting native species in reforestation efforts. Species such as Talisay Terminalia catappa, Narra Pterocarpus indicus, and Salong Canarium asperum should be prioritized for their roles in erosion control and biodiversity enhancement.

The DENR should also strengthen monitoring and enforcement to prevent land conversion and ensure the long-term sustainability of riparian ecosystems.

Furthermore, the local community should be actively involved in riparian conservation initiatives, including tree planting and forest monitoring, to promote stewardship and foster a collective sense of environmental responsibility.

The Disaster Risk Reduction Council should integrate the study's data into flood mitigation strategies, focusing on the restoration of native species as part of disaster preparedness and land-use planning. Schools should incorporate riparian forest conservation and biodiversity topics into their curriculum, encouraging students and teachers to participate in hands-on activities such as tree species identification, ecosystem monitoring, and reforestation projects.

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APPENDIX A

Structural characteristics of Riparian Forest in Maui-it- Tipuluan in Igpanolong

Species	Basal Area (cm^2m^{-2})	Stand Basal Area (m^2 ha^{-1})	Stems per Ha (n ha^{-1})	Tree Density (n ha^{-1})	Sapling Density (n ha^{-1})	Seedling Density (n ha^{-1})	Relative Dominance (%)	Relative Frequency (%)	Relative Density (%)	Importance Value (Iv)	Species Diversity (H')	Species Evenness (J')
Agdaw (Premna odorata)	452.39	1.51	33.33	33.33	66.67	66.67	1.21	2.44	2.22	5.81	0.03	-
Alagasi (Leucosyke capitellata)	0	0	0	0	266.67	0	0	2.44	0	2.38	0.02	-
Amugis (Aglaia pachyphylla)	50.27	0.17	33.33	33.33	33.33	0	0.13	2.44	2.22	4.74	0.03	-
Balud (Neonuclea formicaria)	0	0	0	0	400	0	0	4.88	0	4.76	0.03	-
Banaba (Lagerstroemia speciosa)	0	0	0	0	133.33	0	0	2.44	0	2.38	0.02	-
Bangkal (Nauclea orientalis)	0	0	0	0	233.33	0	0	4.88	0	4.76	0.03	-
Bayuko (Artocarpus treculianus)	0	0	0	0	566.67	0	0	2.44	0	2.38	0.02	-
Buri (Corypha utan)	314.16	1.05	33.33	33.33	366.67	0	0.84	4.88	2.22	7.82	0.04	-
Durarog (Ficus ribes)	254.47	0.85	33.33	33.33	0	0	0.68	2.44	2.22	5.28	0.03	-
Gmelina (Gmelina arborea)	0	0	0	0	66.67	66.67	0	2.44	0	2.38	0.02	-

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue III March 2025

Hawili (Ficus septica)	0	0	0	0	333.33	0	0	4.88	0	4.76	0.03	-
Ipil-Ipil (Leucaena leucocephala)	380.13	1.27	33.33	33.33	866.67	500	1.01	2.44	2.22	5.62	0.03	-
Mahogany (Swietenia macrophyla)	12950.86	43.17	966.67	966.67	7400	4600	34.56	7.32	64.44	106.14	0.16	-
Narra (Pterocarpus indicus)	3848.46	12.83	0	0	566.67	700	10.27	2.44	0	12.65	0.06	-
Rain Tree/Acacia (Acacia confusa)	7238.25	24.13	33.33	33.33	100	0	19.31	2.44	2.22	23.92	0.09	-
Salong (Canarium asperum)	871.01	2.9	66.67	66.67	100	200	2.32	2.44	4.44	9.15	0.05	-
Tipolo (Artocarpus treculianus)	9699.15	32.33	200	200	266.67	0	25.88	4.88	13.33	43.98	0.12	-
Total	**452.39**	**124.92**	**1500.00**	**1500.00**	**15300.00**	**6366.67**	**100.00**	**100.00**	**100.00**	**300.00**	**1.09**	**0.75**

Appendix B											
Structural characteristics of Riparian Forest in Maui-it- Tipuluan in Salvacion											
Species	BA	SBA	Stems per Ha	Tree density	Sapling density	Seedling density	Relative Dom.	Relative Freq.	Relative Den.	Imp. Value	Species Diversity	Species Evenness
	($cm^2 m^{-2}$)	(m^2 ha^{-1})	(n ha^{-1})	(n ha^{-1})	(n ha^{-1})	(n ha^{-1})	(%)	(%)	(%)	(I_v)	H'	J'
Rain Tree/Acacia Acacia confusa	0	0	0	0	166.67	0	0	6.9	0	6.9	0.04	

Agdaw Premna odorata	663.66	2.21	66.67	66.67	66.67	0	2.77	3.45	3.7	9.92	0.05	
Alom/Alim Melanolepis multiglandulosa	0	0	0	0	66.67	0	0	3.45	0	3.45	0.02	
Anagas Semecarpus cuneiformis	0	0	0	0	233.33	0	0	3.45	0	3.45	0.02	
An-An Bucharania arboressens	0	0	0	0	366.67	0	0	10.34	0	10.34	0.05	
Antsoan Dilao Senna Spectabilis	0	0	0	0	66.67	0	0	3.45	0	3.45	0.02	
Bangkal Nauclea orientalis	11067.1	36.89	1100	1100	2366.67	4633.33	46.22	10.34	61.11	117.68	0.16	
Bugawak Cleodendrum quadriluculare	0	0	0	0	66.67	0	0	3.45	0	3.45	0.02	
Hawili /Labnog Ficus septica Burm	0	0	0	0	66.67	0	0	3.45	0	3.45	0.02	
Ipil-Ipil Leucaena leucocephala	895.36	2.98	166.67	166.67	2066.67	2333.33	3.74	10.34	9.26	23.34	0.09	
Kamonsil Pithecolobium dulce	254.47	0.85	100	100	100	0	1.06	3.45	5.56	10.07	0.05	
Lumangog Termimalia microcarpa	0	0	0	0	66.67	0	0	3.45	0	3.45	0.02	
Lumboy Syzgium cumini	0	0	0	0	33.33	0	0	3.45	0	3.45	0.02	
Mahogany Swietenia macrophyla	9513.55	31.71	300	300	1133.33	2900	39.73	3.45	16.67	59.85	0.14	
Malapaho Mangifera altissima	0	0	0	0	66.67	0	0	3.45	0	3.45	0.02	
Murogna Barringtonia asiatica	0	0	0	0	33.33	0	0	3.45	0	3.45	0.02	

Narra Pterocarpus indicus	0	0	0	0	66.67	0	0	3.45	0	3.45	0.02	
Star Apple Chrysophyllum cainito	0	0	0	0	66.67	0	0	3.45	0	3.45	0.02	
Tabuyog Ficus nota	0	0	0	0	233.33	0	0	3.45	0	3.45	0.02	
Talisay Terminalia catappa	1548.81	5.16	66.67	66.67	166.67	0	6.47	3.45	3.7	13.62	0.06	
Tan-ag Kleinhovia hospita	0	0	0	0	233.33	0	0	3.45	0	3.45	0.02	
Total	**23942.9**	**79.81**	**1800**	**1800**	**7766.67**	**9866.67**	**100**	**100**	**100**	**300**	**0.94**	**0.7**

Appendix C

Structural characteristics of Riparian Forest in Maui-it- Tipuluan in Iglanot											
Species	BA	SBA	Stems per Ha	Tree density	Sapling density	Seedling density	Relative Dom.	Relative Freq.	Relative Den.	Imp. Value	Species Diversity	J'
	($cm^2 m^{-2}$)	(m^2 ha^{-1})	(n ha^{-1})	(n ha^{-1})	(n ha^{-1})	(n ha^{-1})	(%)	(%)	(%)	(I_v)	H'	
Alim/Alom Melanolepis multiglandulosa	254.47	0.85	33.33	33.33	33.33	0.00	0.60	5.88	2.38	8.86	0.05	
Banaba Lagerstroemia speciosa	0.00	0.00	0.00	0.00	33.33	0.00	0.00	5.88	0.00	5.88	0.03	
Bangkal Nauclea orientalis	5354.86	17.85	200.00	200.00	33.33	133.33	12.54	17.65	14.29	44.47	0.12	
Gmelina Gmelina arborea	5910.14	19.70	166.67	166.67	0.00	0.00	13.84	11.76	11.90	37.51	0.11	
Ipil-Ipil Leucaena leucocephala	1320.26	4.40	33.33	33.33	100.00	0.00	3.09	5.88	2.38	11.35	0.05	

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue III March 2025

Kamonsil Pithecelobium dulce	2623.24	8.74	200.00	200.00	166.67	800.00	6.14	11.76	14.29	32.19	0.10	
Labnog/Hawili Ficus septica	0.00	0.00	0.00	0.00	33.33	0.00	0.00	5.88	0.00	5.88	0.03	
Payhod/Akling Parang Albizia saponaria	4450.86	14.84	200.00	200.00	0.00	66.67	10.42	17.65	14.29	42.36	0.12	
Rain Tree/Acacia Acacia confusa	22789.17	75.96	566.67	566.67	233.33	666.67	53.37	17.65	40.48	111.49	0.16	
Total	**42702.98**	**142.34**	**1400.00**	**1400.00**	**633.33**	**1666.67**	**100.00**	**100.00**	**100.00**	**300.00**	**0.79**	**0.82**