Vegetation diversity of *Hevea brasiliensis* agroforest system in Tumbang Mantuhe Village, Gunung Mas Regency, Central Kalimantan, Indonesia

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Abstract. A rubber agroforest system is a form of land use that considers ecological and economic aspects that are still maintained by the people of Tumbang Mantuhe Village. This study aims to identify and analyze the diversity of vegetation in the agroforest system in Tumbang Mantuhe Village, Gunung Mas Regency, Central Kalimantan. This research uses purposive sampling and the vegetation analysis method. The results showed that the species of vegetation in the rubber agroforest system amounted to 29 species in 23 families. At the seedling level, it is dominated by *Macaranga* sp. and *Xylopia ferruginea*; the sapling level is dominated by *H. brasiliensis* and *Syzygium tawahense*; the pole level is dominated by *Deplanchea bancana* and *Xylopia ferruginea*; at the tree, the level is dominated by *H. brasiliensis* and *Lithocarpus* sp. At the seedling, sapling, pole, and tree levels, the diversity values were moderate and the species richness values were moderate to high, and the species distribution was even (stable). The *H. brasiliensis* agroforest system with various trees in it is a characteristic of local wisdom that the people of Tumbang Mantuhe Village have applied from generation to generation, which provides a balance between ecology and economy.
1. Introduction

Forests are capable of producing wood and non-timber products. Forest management activities should consider the balance of economic and ecological functions. Forest management efforts that can guarantee economic and ecological aspects are through the agroforest system [1]. De Foresta and Michon (1997) [2] explain that agroforestry is classified into two groups, namely simple agroforestry (intercropping) and complex agroforestry (agroforest). The *H. brasiliensis* agroforest system is a form of agroforestry that has diverse vegetation and is often found on the islands of Sumatra and Kalimantan [3,4]. The formation of *H. brasiliensis* agroforests has similarities with forests formed by natural mechanisms, and the older the age of *H. brasiliensis* agroforests, the structure and composition will be more similar to natural forests or secondary forests [5–7].

In Central Kalimantan *H. brasiliensis* agroforests are generally areas formed by shifting cultivation planted with *H. brasiliensis*-producing trees, fruits, and other plants that grow wild or are intentionally allowed to grow side by side. So it undergoes primary succession into old and forested gardens. One example of the application of the *H. brasiliensis* agroforest system is in the village of Tumbang Mantuhe, Gunung Mas Regency, Central Kalimantan. The Tumbang Mantuhe community has applied the *H. brasiliensis* agroforest system for generations and is still being maintained today.

The *H. brasiliensis* agroforest has the potential as a reservoir for vegetation types from the surrounding forest and can be a wildlife corridor, especially with animals that require large areas [3]. Based on this background, this study reports (a) species composition, (b) species dominance, and (c) species diversity, species richness and species evenness in the *H. brasiliensis* agroforest system in Tumbang Mantuhe village, Gunung Mas district, Central Kalimantan

2. Research methods

2.1. Research time and location

The study was carried out for 3 (three) months from September to November 2020. The location of the study was administratively included in the Tumbang Mantuhe village area, Manuhing Raya District, Gunung Mas Regency. Geographically, Tumbang Mantuhe village is located at 1°20'08.5" S 113°18'43.2" E. The study location is shown in Figure 1.
2.2. Tools and materials
The equipment used in this research are vegetation Tally sheet, camera, phiband, Laser distance meter, tape measure and rope, ribbon, label paper, permanent marker, plastic bag, chalk, mapping application (Quantum GIS 2.14.14), maps and lat write. The materials used are alcohol and tree specimens.

3. Research methods

3.1. Determination of sampling location
Observational sample plots (PCP) were determined using the purposive sampling method. The PCP was chosen based on considerations of land cover representation and accessibility in the field. There are 4 PCPs, and the manufacture of PCPs uses the checkered line method with a combination of alternating and alternating paths, the distance between PCPs is 50 m. The observation plot area of 0.12 ha is sufficient to describe the composition of the vegetation composition [8]. The measuring plots for each growth stage were as follows: seedlings with a plot size of 2 x 2 m, saplings with a plot size of 5 x 5 m, poles with a plot size of 10 x 10 m, trees with a plot size of 20 x 20 m. The complete PCP design is shown in Figure 2.

4. Data analysis

4.1. Type identification
The accuracy of the scientific name was obtained using a comparative method, comparing a sample of trees found in the field with a tree type identification reference.

4.2. Key-value index
The collected vegetation measurement data were then analyzed to determine the dominant type at each growth stage. The dominance of growth rate can be known through the index of important values (INP) [9]. The INP is the sum of the values between relative density (KR), relative dominance (DR), and relative frequency (FR) [10]:

\[ \text{INP} \% = (KR \%) + (DR \%) + (FR \%) \]  \hspace{1cm} (1)
4.3. Type diversity index
The species diversity index was expressed using the Shannon-Wiener formula, calculated using the formula from Kent and Paddy [11] as follows:

\[ H' = -\sum \frac{N_i}{N} \log \frac{N_i}{N} \]  

Description:
\( H' \) = Shannon-Wiener Diversity Index
\( N_i \) = The number of individuals to the \( i \)
\( N \) = The total number of individuals of all types
The classification of type (\( H' \)) diversity values is as follows:
\( H' < 2 \) (low diversity), \( H' \geq 2 \) to \( \leq 3 \) (medium diversity) and \( H' > 3 \) (high diversity) [12]

4.4. Type wealth index
The type of wealth index was determined using the Margalef diversity index [13]. The margalef index is calculated by showing the following equation:

\[ D_{mg} = \frac{S-1}{\ln N} \]  

Description:
\( D_{mg} \) = Margalef Jenis Specific Wealth Index
\( S \) = Number of Types
\( N \) = Total Individual
The criteria for the richness of the Margalef species are as follows:
\( D_{mg} < 2.5 \) (low specificity), \( D_{mg} \geq 2.5 \) to \( 4 \) (medium richness), \( D_{mg} > 4 \) (high specific richness) [13]

4.5. Specific evenness index
The evenness index shows the level of species distribution or species abundance in an area. The species evenness index can be calculated by the formula [14] as follows:

\[ E = \frac{H'}{\ln S} \]  

Description:
\( E \) = Species Abundance
\( H' \) = Species Diversity
\( S \) = Number of Types
The criteria for the evenness of species are as follows:
\( E < 0.3 \) (low evenness), \( E \geq 0.3 \) to \( 0.6 \) (medium evenness) and \( E > 0.6 \) (high evenness) [15].

5. Results and discussion
5.1. Composition type
The species composition shows the large variety of species at the research location. The composition of the types of vegetation in the \( H. brasiliensis \) agroforest system was characterized by 29 species and 20 families. The data from the identification of tree species are presented in Table 1 and the number of families found in the research location is presented in Figure 3.
Table 1. Tree species in the *H. brasiliensis* agroforest system

| Tree species               | Density Per Hectare |
|----------------------------|---------------------|
| 1. Albizia sp.             | 11. Gironniera nervosa | 21. Magnolia sp. |
| 2. Antidesma sp.           | 12. Goniolothalamus sp. | 22. Nephelium sp. |
| 3. Archidendron            | 13. Gordonia sp.     | 23. Pernandra galeata |
| 4. Artocarpus integer      | 14. Hancea griffithiana | 24. Rhus sp. |
| 5. Artocarpus rigidus      | 15. Hevea brasiliensis | 25. Syzygium Antisepicium |
| 6. Campnosperma squamatum  | 16. Ixonanthesicosandra | 26. Syzygium Claviflorum |
| 7. Cartoxylum arborescens  | 17. Lithocarpus sp.   | 27. Syzygium tawahense |
| 8. Dillenia borneensis     | 18. Litsea sp.        | 28. Teijsmanniodendron Sarawakanum |
| 9. Diospyros sp.           | 19. Lophopetalum beccarianum | 29. Xylopia ferruginea |
| 10. Fordia splendidissima  | 20. Macaranga sp.     |

**Figure 3.** The vegetation family of the *H. brasiliensis* agroforest system

The species composition based on the level of tree regeneration in the agroforest system in Tumbang Mantuhe village is presented in a graph, which is shown in Figure 4 as follows.

**Figure 4.** Species composition based on tree regeneration level of *H. brasiliensis* agroforest system
Species composition based on tree regeneration rate is the individual density per hectare at each growth stage. The graph in Figure 4 shows that there are differences in density at each growth rate. The total density at the growth rate of seedlings was 36,250 individuals/ha, saplings 2,500 individuals/ha, poles 450 individuals/ha, and trees 144 individuals/ha. There is a decrease in the amount of density according to the growing maturity level. The density graph of the growth rate forms an inverted “J” curve. Normal type forests will form an inverted J curve and an inverted J will form if seedlings > saplings > poles > trees, so that the regeneration process can take place because there is sufficient regeneration available [16,17]. This confirms that the agroforest system in Tumbang Mantuhe village is still in normal or balanced condition. An inverted “J” curve is commonly found in tropical rain forests, which represents a dynamic forest community [18,19].

5.2. Domination type
The dominance of a species is indicated by a high INP value; the greater the INP value, the composition of the forest is quite good in terms of density and also the frequency of species presence. The INP values at the research sites at the seedling, sapling, pole, and tree levels, are sequentially presented in Table 2 and Table 3.

| Table 2. Results of vegetation analysis at seedling and sapling levels |
|---------------|----------|----------|----------|
| Latine Name   | Number of Individu | KR (%)  | FR (%)  | INP (%)  |
| 1. Seedling   |          |          |          |
| Antidesma sp. | 7        | 12.07    | 11.11    | 23.18    |
| Archidendron  | 3        | 5.17     | 5.56     | 10.73    |
| Artocarpus rigidus | 3   | 5.17     | 5.56     | 10.73    |
| Fordia splendidissima | 1 | 1.72     | 5.56     | 7.28    |
| Hancea griffithiana | 1 | 1.72     | 5.56     | 7.28    |
| Lithocarpus sp. | 7       | 12.07    | 11.11    | 23.18    |
| Litsea sp.    | 2        | 3.45     | 5.56     | 9.00     |
| Macaranga sp. | 9        | 15.52    | 11.11    | 26.63    |
| Pternandra galeata | 1   | 1.72     | 5.56     | 7.28    |
| Syzygium antisepticum | 1 | 1.72     | 5.56     | 7.28    |
| Syzygium claviflorum | 1 | 1.72     | 5.56     | 7.28    |
| Syzygium tawahense | 7   | 12.07    | 11.11    | 23.18    |
| Xylopia ferruginea | 15 | 25.86    | 11.11    | 36.97    |
| 2. Sapling    |          |          |          |
| Antidesma sp. | 1        | 4        | 6.25     | 10.25    |
| Artocarpus integer | 1 | 4        | 6.25     | 10.25    |
| Artocarpus rigidus | 1 | 4        | 6.25     | 10.25    |
| Diospyros sp. | 1        | 4        | 6.25     | 10.25    |
| Fordia splendidissima | 3 | 12       | 6.25     | 18.25    |
| Gironniera nervosa | 2 | 8        | 12.5     | 20.50    |
| Goniothalamus sp. | 1 | 4        | 6.25     | 10.25    |
| Gordonia sp.  | 1        | 4        | 6.25     | 10.25    |
| Hevea brasiliensis | 4  | 16       | 6.25     | 22.25    |
The results of the analysis of vegetation diversity of the *H. brasiliensis* agroforest system at the level of seedlings, saplings, poles, and trees show that each has a specific dominant species. In Table 2 the seedling level vegetation was dominated by *Macaranga* sp. (26.63%) and *Xylopia ferruginea* (36.97%); the sapling vegetation was dominated by *H. brasiliensis* (22.25%) and *Syzygium tawahense* (26.25%); in Table 3 the pole level was dominated by *Deplanchea bancana* (41.05%), and *Xylopia ferruginea* (75.52%) and the tree level vegetation was dominated by *H. brasiliensis* (36.97%) and *Lithocarpus* sp. (41.79%). The results of this analysis showed that the dominance value was almost balanced between *H. brasiliensis* and other species at the pole level and tree level. These results confirm that there is a balance between economic interests and ecological interests in the *H.*
brasiliensis agroforest system in Tumbang Mantuhe village. The rubber agroforest system with diverse trees in it is a characteristic of local wisdom applied by the people of Tumbang Mantuhe Village in descending order, which provides a balanced advantage between ecology and economy. But specifically in the type of H. brasiliensis still need enrichment and control in other types because the results of the analysis revealed that this type is not the main dominant type at all levels of growth, especially at the seedling level. It is feared that the regeneration process of H. brasiliensis may be inhibited if there is a lack of youth. The population structure at all levels of growth will be able to maintain its population in the long run, and the results of INP analysis can be used as a parameter in assessing the ability of a species to adapt to the environment [20]. Maintaining the existence of ecological and economic balance in agroforest management is important.

5.3. Type diversity, type wealth, and type equality
Type diversity index (\( h' \)), type wealth index (\( D_{mg} \)), and type uniformity index (\( E \)) in the vegetation of H. brasiliensis agroforest system are presented in Table 4.

| Indeks   | Seedling | Sapling | Pole  | Tree  |
|----------|----------|---------|-------|-------|
| \( H' \) | 2.39     | 2.57    | 2.16  | 2.44  |
| \( D_{mg} \) | 2.96 | 4.35    | 3.46  | 3.74  |
| \( E \) | 1.07     | 0.97    | 0.94  | 0.98  |

In Table 4 it is seen that the index of vegetation type diversity of agroforest system H brasiliensis at all growth levels (seedlings, saplings, poles, and trees) showed moderate diversity values. The type wealth index is quite good with the value of medium type wealth to high, seedlings (medium type wealth), saplings (high type wealth), poles (medium type wealth), and trees (medium type wealth). The value of type uniformity at all levels of growth indicates a high uniformity (stable type spread) in the direction with the value of uniformity ranging between 0.98-1.07. Most farmers have traditionally viewed these microclimate conditions in agroforestry systems as a factor in the increased incidence of fungal diseases when compared to full-sun monocultures [21,22].

So, in general, it can be said that with the management of the existing or already running H. brasiliensis agroforest system in the village of Tumbang Mantuhe can continue to exist and can carry out further regeneration processes.

6. Conclusion
Based on the results of vegetation diversity research on H. brasiliensis agroforest system in Tumbang Mantuhe village, it can be concluded:

- The composition of the vegetation composition of the H. brasiliensis agroforest system is characterized by 29 species and 20 families, as well as the density at the growth rate forming an inverted “J” curve
- There are different types of dominance at the level of seedlings, saplings, poles, and trees. The almost balanced dominance value between H. brasiliensis and other species at the pole level and tree level reinforces that there is a balance between economic and ecological interests.
- Type diversity at all growth levels showed moderate diversity values (1<\( H' \)<3). The value of type wealth is quite good, with the value of type wealth being medium to high. The value of an evenly spaced type or a stable type spread.
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