Plant diversity components of agroforestry in Tanjung Botung, Village, Barumun District, Padang Lawas Regency, North Sumatra

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Abstract. Agroforestry is a land-use pattern that combines crops in one land with spatial and temporal arrangements. This study aims (1) to identify the species components of agroforestry, (2) to analyze the species diversity in agroforestry, and (3) to calculate the benefits of species in agroforestry for the community around Tanjung Botung Village. Based on the results in this research, it is known that there are 33 species of plants found in agroforestry land which consists of 19 families. To determine the type that dominates the growth rate, it is seen from the value of the Important Value Index. The highest IVI level was in the shrubs level namely Elaeis guineensis (56.67), in the seedling level namely Hevea brasiliensis (83.57), in the sapling level namely Durio zibethinus (38.37), in the pole level namely Hevea brasiliensis (68.04) and in tree level namely Hevea brasiliensis (99.69). To find out the level of species diversity was calculated using the Shannon-Wiener Index (H'). From the results of the study, it was concluded that the value of species diversity ranged from 1.63 to 2.35, meaning that the value of species diversity (H') for all growth levels was categorized as moderate.

1. Introduction
Agroforestry is a land-use system and technology in which long-lived trees and short-lived crops are cultivated on the same land in time and space settings [1,2]. The component of agroforestry is in the form of food plants that are needed by the community daily. According to [3] states that food plants are everything that grows, lives, has stems, roots, leaves, and can be eaten or consumed by humans. Foodstuffs that come from plants in the forest are in the form of fruits, leaves, and seeds.

The application of agroforestry patterns has been carried out since ancient times in various regions in Indonesia. The agroforestry pattern contains various types of plants (tree-based) that are grown and treated with a forest-like cropping pattern and ecosystem. This system is covered by various components such as trees, shrubs, annual plants and grasses in large quantities [4,5]. Because the types of plants vary so the products produced will vary as well. In addition to the dual benefits, it also has a high ecological function because it consists of several canopy stars.

One of the challenges of land management in the community in North Sumatera is the conversion of land to monoculture plantations such as oil palm plantations. Tanjung Botung is one of the villages that still has agroforestry land which is still being developed by the community. The existence of Agroforestry in Tanjung Botung Village is expected to continue to be maintained by the community.
Agroforestry can provide food crops, fruits, sources of firewood and others. This study aims (1) to identify the species components of agroforestry, (2) to analysis the species diversity in agroforestry, and (3) to calculate the benefits of species in agroforestry for the community around Tanjung Botung Village.

2. Method

2.1 Study location and method
This research was conducted from January to March 2021 in Tanjung Botung Village, Barumun District, North Padang Lawas Regency, North Sumatera Province. The research method was carried out by analysis of vegetation on 20 plots of agroforestry land. The plots were laid out intentionally on community lands that applied agroforestry patterns. Vegetation analysis was carried out at each growth level, namely understorey and seedlings with a subplot size of 2 x 2 m, saplings with a size of 5 x 5 m, poles 10 x 10 m and trees with a plot size of 20 x 20 m.

2.2 Analysis data
Important Value Index (IVI)
Important value index is a quantitative parameter that can be used to express the level of dominance (level of control) of species in a plant community. Important value index (IVI) is calculated by the formula [6]:

a. Density of a species (D) 1)

\[ D = \frac{\sum \text{Individual of a species}}{\text{Sample plot area}} \]

b. Relative Density (RD) 2)

\[ \text{RD} = \frac{\text{Density a species}}{\text{Density all a species}} \times 100\% \]

c. Frequency of a species (F) 3)

\[ F = \frac{\sum \text{Sub - plot where a species is found}}{\sum \text{All sub - plot}} \]

d. Relative Frequency (RF) 4)

\[ \text{RF} = \frac{\text{Frequency a species}}{\text{Frequency of all species}} \times 100\% \]

e. Dominance 5)

\[ D = \frac{\text{Area of the base of a species}}{\text{Sample plot area}} \]
f. Relative Basal Area (RBA)  

\[
RBA = \frac{\text{Dominance a species}}{\text{Dominance all species}} \times 100\%
\]

For pole and tree level:  
\[
IVI = RD + RF + RBA
\]

For seedlings, saplings and understorey:  
\[
IVI = KR + FR
\]

Where:
- \(RD\) = Relative Density
- \(RF\) = Relative Frequency
- \(DR\) = Relative Dominance

Shannon-Wiener index \((H')\)  
The level of species diversity Shannon-Wiener index \((H')\) was classified into high \((H' > 3)\), medium \((1 \leq H' \leq 3)\), and low \((H' < 1)\). Species diversity can be calculated using the Shannon-Wiener diversity index with the following formula [7].

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

Where:
- \(H'\) = Shannon-Wiener diversity index
- \(n_i\) = Number of individuals of one species
- \(N\) = Total number of individuals of all species

3. Results and Discussion

3.1 Composition of species found on agroforestry land  
Based on the research results, it is known that there are 33 species found in agroforestry land which consists of 19 families, namely 4 species of Fabaceae (21.05%), 4 species of Myrtaceae (21.05%), 3 species of Anacardiaceae (15.78%), 2 species of Arecales (6%), 2 species Malvaceae (10.52%), 2 species of Lauraceae (10.52%), 2 species of Sapindaceae (10.52%), 2 species of Clusiaceae (10.52%), 2 species of Moraceae (10.52%). While the family asparageaceae, solanaceae, caricaeae, musaceae, zingiberaceae, rutaceae, euphorbiaceae, rubiaceae, malvaceae, bombacaceae, meliaceae, sapotaceae, oxalidaceae has a species (5.26%). The number species composition at the understorey level was 7 species, the seedling level was 9 species, the sapling level was 15 species, the pole level was 14 species, and the tree level was 13 species. The species composition found in the agroforestry land of Tanjung Botung Village can be seen in Table 1.

Compared to the results [8] in Jurit Village Agroforestry, there were 15 species of understorey, 11 species of seedling level, 19 species of sapling level, 22 species of pole level and 22 species of tree level. The difference in the number of species is caused by differences in cropping patterns. Based on [9] study in Nanga village Pemubuh District Sekadau Hulu Sekadau Regency at agroforestry there were 16 types of trees, 17 types of poles, 18 types of poles, and 16 types of seedlings. The most dominant family in Nanga Pemubuh Village at all growth stages consisted of 3 families, namely Arecales, Dipterocarpaceae, and Moraceae.
| No | Local name | Scientific name | Family       | Utilization       | Understory | Seed | Sapling | Pole | Tree |
|----|------------|----------------|--------------|-------------------|------------|------|---------|------|------|
| 1  | Hanjuang   | Cordyline fruticosa | Asparagaceae | Hedgerows         |            |      |         |      |      |
| 2  | Kelapa     | Elaeis guineensis | Arecaceae    | Food              |            |      |         |      |      |
| 3  | Terong     | Solanum torvum   | Solanaceae   | Food              |            |      |         |      |      |
| 4  | Putri Malu | Mimosa pudica    | Fabaceae     | Medicinal plant   |            |      |         |      |      |
| 5  | Tehu       | Saccharum officinarum | Poaceae   | Food              |            |      |         |      |      |
| 6  | Pepaya     | Carica papaya    | Caricaceae   | Food              |            |      |         |      |      |
| 7  | Aren       | Arenga pinnata   | Arecaceae    | Food              |            |      |         |      |      |
| 8  | Jeruk nipsis | Citrus aurantiifolia | Rutaceae | Spices            |            |      |         |      |      |
| 9  | Karet      | Hevea brasiliensis | Moraceae    | rubber            |            |      |         |      |      |
| 10 | Kopi       | Coffea sp        | Rubiaceae    | Food              |            |      |         |      |      |
| 11 | Jengkol    | Archidendron pauciflorum | Fabaceae | Food              |            |      |         |      |      |
| 12 | Jambu bol  | Syzygium malaccense | Myrtaceae | Food              |            |      |         |      |      |
| 13 | Coklat     | Theobroma cacao  | Malvaceae    | Food              |            |      |         |      |      |
| 14 | Kayu manis | Cinnamomum verum | Lauraceae    | Spices            |            |      |         |      |      |
| 15 | Cengkeh    | Syzygium aromaticum | Myrtaceae | Spices            |            |      |         |      |      |
| 16 | Durian     | Durio zibethinus | Malvaceae    | Food              |            |      |         |      |      |
| 17 | Langsat    | Lansium domesticum | Meliaceae | Food              |            |      |         |      |      |
| 18 | Rambutan   | Nephelium lappaceum | Sapindaceae | Food              |            |      |         |      |      |
| 19 | Jambu biji | Psidium guajava  | Myrtaceae    | Food              |            |      |         |      |      |
| 20 | Sawo manila | Manilkara zapota | Sapotaceae   | Food              |            |      |         |      |      |
| 21 | Belimbing | Averrhoa bilimbi | Oxalidaceae  | Food              |            |      |         |      |      |
| 22 | Kelor      | Mangira ollefera | Moringaceae  | Food              |            |      |         |      |      |
| 23 | Manggis    | Garcinia mongostana | Clusiaceae | Food              |            |      |         |      |      |
| 24 | Alpukat    | Persia Americana | Lauraceae    | Food              |            |      |         |      |      |
| 25 | Kelengkeng | Dimocarps longan | Sapindaceae  | Food              |            |      |         |      |      |
| 26 | Daun salam | Syzygium polyanthum | Myrtaceae | Spices            |            |      |         |      |      |
| 27 | Nangka     | Artocarpus heterophyllus | Moraceae | Food              |            |      |         |      |      |
| 28 | Asam gelugur | Garcinia atroviridis | Clusiaceae | Spices            |            |      |         |      |      |
| 29 | Gedongdon  | Spondias dulcis  | Anacardiaceae | Food              |            |      |         |      |      |
| 30 | Lamtoro    | Leucaena leucocephala | Fabaceae | Food              |            |      |         |      |      |
| 31 | Mangga     | Mangifera Indica | Anacardiaceae | Food              |            |      |         |      |      |
| 32 | Kweni      | Mangifera odorata | Anacardiaceae | Food              |            |      |         |      |      |
| 33 | Asam Jawa  | Tamarindus indica | Fabaceae     | Spices            |            |      |         |      |      |

**Note:** + = present, – = not present

| Total | 7 | 9 | 15 | 14 | 13 |
3.2 Important Value Index of Understorey
The understorey is all vegetation that is not a tree species and cannot grow to a tree level. The presence of understorey in forest plantations, apart from being a source of biodiversity, also plays a role in protecting the soil and soil organisms, helping to create a microclimate on the forest floor, protecting the soil from erosion, and maintaining soil fertility [6]. The presence of a plant species in an area indicates the ability adaptation to habitat and wide tolerance to environmental conditions [10,11]. The higher the IVI value of a species shows the higher level of control over the community. The dominant species is the species that has the highest IVI value in a forest vegetation [12]. A species can be said to play a role if the IVI value for the seedling and sapling level is 10% and for the pole and tree level it has an IVI value 15%. The IVI value of each understorey species in detail can be seen in Table 2.

Table 2. Values of Relative Density, Relative Frequency and Important Value Index for understorey levels

| No | Scientific name         | RD    | RF    | IVI   |
|----|-------------------------|-------|-------|-------|
| 1  | Cordyline fruticose     | 6.89  | 5.12  | 12.02 |
| 2  | Elaeis guineensis       | 31.03 | 25.64 | 56.67 |
| 3  | Solanum torvum         | 8.62  | 7.69  | 16.31 |
| 4  | Mimosa pudica          | 20.69 | 25.63 | 31.81 |
| 5  | Saccharum officinarum   | 22.41 | 20.51 | 42.92 |
| 6  | Arenga pinnata         | 6.89  | 10.25 | 17.15 |

Note:
RD= Relative Density, RF= Relative Frequency, IVI value above 10%

The highest IVI at the understorey level was Elaeis guineensis (56.67), followed by Saccharum officinarum (42.92), and Mimosa pudica (31.81). Based on the IVI value, the highest of IVI values was found in oil palm plants, which was 56.67, meaning that the type of oil palm was the dominant species at the understorey level. Elaeis guineensis is a plantation commodity that has recently been in great demand because it has a promising economic value.

3.3 Important Value Index of Seedling
The results showed that the highest IVI at the seedling level was Hevea brasiliensis (83.57), followed by Coffea sp (29.14), Theobroma cacao (25.75) and then Durio zibethinus (21.28). Hevea brasiliensis was the dominant species in the growth rate of seedlings. While the lowest IVI were Archidendron pauciflorum, Cinnamomum verum, and Syzygium aromaticum. Values of Relative Density, Relative Frequency and Important Value Index for the seedling level can be seen in Table 3.

Table 3. Value of Relative Density, Relative Frequency and Index of Important Values for Seedling Level

| No | Scientific name           | RD    | RF    | IVI   |
|----|---------------------------|-------|-------|-------|
| 1  | Citrus aurantiifolia      | 6.78  | 11.11 | 17.89 |
| 2  | Hevea brasiliensis        | 47.46 | 36.11 | 83.57 |
| 3  | Coffea sp                 | 15.25 | 13.89 | 29.14 |
| 4  | Theobroma cacao           | 11.86 | 13.89 | 25.75 |
| 5  | Durio zibethinus          | 10.17 | 11.11 | 21.28 |

Note:
RD= Relative Density, RF= Relative Frequency, IVI value above 10%
3.4 Important Value Index of Sapling

The highest growth rate of saplings IVI was *Durio zibethinus* (38.37), then *Coffea* sp (32.94) and *Theobroma cacao* (28.27). At the sapling growth rate, *Durio zibethinus* had the highest number compared to other species, meaning that *Durio zibethinus* was the dominant species. *Durio zibethinus* is a type of fruit plant that is deliberately planted to produce fruit.

### Table 4. Value of Relative Density, Relative Frequency and Index of Importance Values for Sapling Levels

| No | Scientific name       | RD  | RF  | IVI   |
|----|-----------------------|-----|-----|-------|
| 1  | *Coffea* sp           | 14.52 | 18.42 | 32.94 |
| 2  | *Citrus aurantiifolia*| 8.06  | 7.89  | 15.96 |
| 3  | *Durio zibethinus*    | 22.58 | 15.79 | 38.37 |
| 4  | *Nephelium lappaceum* | 6.45  | 7.89  | 14.35 |
| 5  | *Theobroma cacao*     | 17.74 | 10.53 | 28.27 |
| 6  | *Garcinia mangostana*  | 4.84  | 5.26  | 10.10 |

Note: RD= Relative Density, RF= Relative Frequency, IVI value above 10%

3.5 Important Value Index of Pole

The highest growth rate of pole IVI was *Hevea brasiliensis* (68.04), *Theobroma cacao* (37.00) then *Coffea* sp (30.56). Based on the IVI value, each species has a value more than 10. The highest IVI value is *Hevea brasiliensis*, this indicates that this species dominates the growth of agroforestry at the pole level. *Hevea brasiliensis* is a type of plant that is deliberately cultivated to produce sap.

### Table 5. Value of Relative Density, Relative Frequency and Important Value Index for pole level

| No | Scientific name       | RD  | RF  | RBA  | IVI   |
|----|-----------------------|-----|-----|------|-------|
| 1  | *Dimocarpus longan*   | 1.31 | 2.50 | 6.33 | 10.14 |
| 2  | *Hevea brasiliensis*  | 32.89 | 27.50 | 7.65 | 68.04 |
| 3  | *Durio zibethinus*    | 11.84 | 10.00 | 6.21 | 28.06 |
| 4  | *Syzygium polyanthum* | 2.63  | 5.00  | 6.56 | 14.19 |
| 5  | *Theobroma cacao*     | 17.10 | 12.50 | 7.40 | 37.00 |
| 6  | *Coffea* sp           | 11.84 | 12.50 | 6.21 | 30.56 |
| 7  | *Archidendron pauciflorum* | 3.94 | 5.00 | 8.82 | 17.76 |
| 8  | *Artocarpus heterophyllus* | 1.31 | 2.50 | 8.42 | 12.23 |
| 9  | *Persea Americana*    | 1.31  | 2.50  | 6.44 | 10.26 |
| 10 | *Garcinia atroviridis*| 1.31  | 2.50  | 7.77 | 11.59 |
| 11 | *Spondias dulcis*     | 2.63  | 5.00  | 8.68 | 16.31 |
| 12 | *Leucaena leucocephala* | 5.26 | 5.00 | 4.16 | 14.42 |
| 13 | *Mangifera Indica*    | 2.63  | 5.00  | 7.90 | 15.53 |
| 14 | *Nephelium lappaceum* | 3.94  | 2.50  | 7.40 | 13.84 |

Note: RD= Relative Density, RF= Relative Frequency, RBA= Relatif Basal Area, IVI

3.6 Tree

The highest IVI value at the tree level was *Hevea brasiliensis* (99.69), followed by *Durio zibethinus* (39.59), and *Nephelium lappaceum* (20.93). The lowest IVI score was *Persea americana* (10.42).
study by [13,14] also revealed that *H. brasiliensis* can dominate community lands around riverbanks. *H. brasiliensis* is a type of wood that is deliberately planted to produce sap.

### Table 6. Values of Relative Density, Relative Frequency and Significance Index for tree level

| No | Scientific name            | KR  | FR   | RBA  | INP   |
|----|----------------------------|-----|------|------|-------|
| 1  | *Nephelium lappaceum*      | 7.14| 7.14 | 6.64 | 20.93 |
| 2  | *Hevea brasiliensis*       | 50.00| 42.85| 6.84 | 99.69 |
| 3  | *Mangifera Indica*         | 3.57| 3.57 | 7.73 | 14.87 |
| 4  | *Artocarpus heterophyllus* | 1.78| 3.57 | 8.46 | 13.82 |
| 5  | *Durio zibethinus*         | 16.07| 14.28| 9.23 | 39.59 |
| 6  | *Archidendron pauciflorum* | 1.78| 3.57 | 9.80 | 15.16 |
| 7  | *Persea americana*         | 1.78| 3.57 | 4.88 | 10.24 |
| 8  | *Mangifera odorata*        | 3.57| 3.57 | 10.99| 18.13 |
| 9  | *Garcinia atroviridis*     | 1.78| 3.57 | 9.46 | 14.81 |
| 10 | *Psidium guajava*          | 5.35| 3.57 | 5.73 | 14.66 |
| 11 | *Tamarindus indica*        | 1.78| 3.57 | 5.73 | 11.09 |
| 12 | *Garcinia mangostana*      | 3.57| 3.57 | 7.63 | 14.77 |
| 13 | *Dimocarpus longan*        | 1.78| 3.57 | 6.84 | 12.19 |
|    | Total                      | 100 | 100  | 100  | 300   |

**Note:**
Relative Density (RD)
Relatif Frequency (RF)
Relatif Basal Area (RBA)

### 3.7 Shannon-Wiener Index (H')

To see the level of plant diversity is calculated using the Shannon-Wiener Index (H'). The H' value at the understorey level is 1.72, at the seedling level is 1.63, at the sapling level is 2.35, at the pole level is 2.09 and tree level of 1.77. From the results of the study, it was concluded that the value of species diversity ranged from 1.63 to 2.35, meaning that the value of species diversity (H') for all growth levels was categorized as moderate.

### 4. Conclusion

There are 33 species found in agroforestry land which consists of 19 families, namely 4 species of Fabaceae (21.05%), 4 species of Myrtaceae (21.05%), 3 species of Anacardiaceae (15.78%), 2 species of Arecaceae (%), 2 species Malvaceae (10.52%), 2 species of Lauraceae (10.52%), 2 species of Sapindaceae (10.52%), 2 species of Clusiaceae (10.52%), 2 species of Moraceae (10.52%). While the family asparageaceae, solanaceae, caricaeae, musaceae, zingiberaceae, rutaceae, euphorbiaceae, rubiaceae, malvaceae, bombacaceae, meliaceae, sapotaceae, oxalidaceae has a species (5.26%). The highest IVI was at the understorey level, namely *Elaies guinensis* at 56.67%, at the seedling level, *Hevea brasiliensis* at 83.56%, at the sapling level, *Durio zibethinus*, at 38.37%, at the pole level, at *Hevea brasiliensis* at 68.04. % and at the highest IVI tree level, *Hevea brasiliensis* was 99.69%.

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