The phytosociological of agroforestry Tembawang at secondary forest Sekadau Hulu in West Kalimantan Indonesia

Rafdinal¹ and R Pitopang²

¹ Department of Biology, Faculty of Mathematics & Natural Sciences, Tanjungpura University, Pontianak.
² Department of Biology, Faculty of Mathematics & Natural Sciences, Tandulako University, Palu

Email: rafdinal.mipa@gmail.com

Abstract. A phytosociological study on the flora and vegetation community of Tembawang was carried out in of Traditional Agroforestry secondary Forest of Sekadau Hulu West Kalimantan, Indonesia. The main objectives of this study were to identify composition and structure of Tembawang in secondary forest Sekadau Hulu. A total of 30 plots (20×20 m in size) were constructed according to the line transect method. The vegetation sampling and data analysis were done according to the Mueller-Dombois and Ellenberg approach. The results showed that there were 43 species belonging to 32 genera and 13 families in the form of trees. The most common species in the study area were Havea brasilensis (Will.ex A.Juss) dan Durio zibethinus Murr. The results also showed that most of the species belong to the Dipterocarpaceae and Moraceae. This indicates that the Traditional Agroforestry Tembawang forest more potential a carbon storage in West Kalimantan Indonesia.

1. Introduction
Indonesia is one of the countries that has the largest tropical forest in the world. Recorded as many as 10.2 million people are in and around forest areas [1]. However, with the increasing number of people around the forest a threat to forest sustainability. Increasing the number of people will be directly proportional to the increased needs of resources such as food, protection, land use and so forth.

Tembawang Agroforestry is one of the traditional forest management systems in tropical forests. The forest management system has been carried out by Dayak communities in West Kalimantan for generations [2]. Tembawang area has unique ecosystem with high biodiversity and conservation value. For Dayak people the forest of tembawang is known as forest area which they plant various kinds of wood, fruit, sap, and spices as medicinal plants [3],[4]. Tembawang Agroforestry, in addition to being in forest areas, gardens, yards, is also found in former longhouses owned by indigenous Dayaks living in the interior of Borneo [4].

Forest conversion to agricultural areas often also leads to land degradation of agroforestry areas of tembawang. This degeneration occurs due to misallocation of designation, clearing of forest and its management. This also occurs in various areas of land or land managed by traditional communities in the tropics, so that forest ecological research in tropical agroforestry especially in Indonesia is very important in the management of the area in the future. Several Phytosociological studies of plants in

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primary forest areas and forest areas managed by traditional communities have been widely used among others [2], [3], [5], [6]. However, the study shows the composition and structure of tree stands vary from one place to another depending on habitat conditions. The anthropogenic effects of surrounding communities can also lead to changes in vegetation composition in forest areas.

The main purpose of this study was to identify the composition and structure of Tembawang Agroforestry in Sekadau Hulu, West Kalimantan. This research was one of the efforts to conserve tropical tree species by knowing the composition and ecological relationship between the species in the community. This condition can be achieved by phytosociological studies. Furthermore, the knowledge gained from these phytosociological studies will contribute to the development of future Tembawang Agroforestry as well as further research.

2. Methods

2.1 Research sites

Sekadau Hulu Sub-district is one of 7 (seven) Subdistricts in Sekadau Regency which has an area of ± 869.7 km² with generally highland topography with relatively low lowland. Geographically Sekadau Hulu District is located at 0.8.25 South Latitude and 0.21.30 South Latitude and between line 110.8.45 East Longitude and 111.15.20 East Longitude. Because of its location adjacent to the equator, Sekadau Hulu Subdistrict is a tropical region that has only 2 (two) seasons i.e. dry season and rainy season. The average rainfall in the Sekadau Hulu sub-district ranges from 1,684 to 12,000 mm. The topography in Sekadau Regency is a natural condition in the form of land and hills with altitude is in the range 0 - 1,000 m asl (figure 1).

![Figure 1. Location of Study in Sekadau Forest West Kalimantan Indonesia](image)

Soil type, most of Sekadau regency is land of PMK (Podsolit Merah Kuning) that is equal to 390,301 Ha (71.69%), and the rest consists of Podsol (26.88%) and alluvial (1.43%). Types of Soil Content in Sekadau Regency are mostly Plistocene-Pliocene (47.77%), Intrusive and Plutonic Basa Menengah (31.52%) and the rest consists of Quartet, Trias, Permata Tribon Up, Permo Carbon, Sekis Hablur, Effusive Medium, Intrusive and Plutonic Acid, and Intrusive and Plutonic Bases. Viewed from the distance to the District District Sekadau, which has the furthest distance is Belitang Hulu (Balai Sepuak) with 112.20 km distance. While the shortest distance is Sekadau Hulu (Rawak) with a distance of 20.35 km. There are 3 (three) main river that passes through Sekadau regency, Kapuas River, Sekadau River and Ayak River.
2.2. Field Surveys and Data Collection
Field surveys and data collection were done based on the techniques described in detail by Mueller-Dombois and Ellenberg [7]. A total of 30 plots with 20×20 m in size were constructed according to the line transect method. The size of the plot was estimated by means of a ‘minimal area’ which was 0.8 Ha. The plots were located at various altitudes, expositions, inclinations and reliefs. An effort was made to achieve high ecological and physiognomic homogeneity within each the plot. Every plot was georeferenced with a Garmin GPS. Scientific names of each vascular plant species in each plot were identified. Basal area or density data of all vascular plant species for each plot were verified. All vascular plant species in each plot with a trunk diameter at breast height (DBH) ≥10 cm were marked and numbered and their diameter were recorded. Lastly, these samples were classified in a phytosociological table according to their floristic composition. In addition to vegetation sampling, soil samples were also taken for analysis of soil chemical properties. Soil chemistry measured includes soil pH by comparison method of pH H₂O and KCL, %C-organic by Walkley and Black method with spectrophotometer, total N with Kjedahal method, P is available by Bray method 2, K, Ca, Mg, and C / N. Analysis of soil chemical properties was analyzed in Soil Laboratory of Soil Department, Faculty of Agriculture, University of Tanjungpura Pontianak and Chemical Laboratory Faculty of Mathematics and Natural Sciences University of Tanjungpura Pontianak.

2.3. Data Analysis
Data analysis, the density and basal area values were done according to the Magurran approach [8], with the goal of identifying the floristic composition and structure vegetation agroforestry tembawang. Lastly, the associations of the species were described based on all the 30 plots, the relationship of vegetation composition to environmental conditions was analyzed using a Principle Component Analysis (PCA) by SPSS version 16

3. Results and Discussion
3.1. Community Structure and Floristic Composition
Based on the identification of species, genera and families plants, there were 43 species of trees classified in 32 genera and 13 families. The families that have the most species are Dipterocarpaceae, and Moraceae. The distribution of species quantities in the sub-plots follows the tree species curve as shown in figure 2.

![Figure 2. Curva species area (species with diameter ≥ 10 cm in 30 sub-plots (20 m x 20 m) at the Tembawang Agroforestry in Sekadau Hulu](image-url)
The total density of the stands at the observation Tembawang agroforestry Sekadau Hulu is much lower than the stand density in mountainous slopes of Mount Salak Bogor [5], in Pakuli forest area of Central Sulawesi [6] and almost the same as in Tembawang Sanggau agroforestry area, West kalimantan [3]. Based on the density of species, there are six dominant stands in the Tembawang agroforestry Sekadau Hulu, namely Durio zibethinus, Hevea brasiliensis, Nephelium lappaceum, Artocarpus sp, Shorea stenoptera, Level heterogeneity of tree species, reflected in the spread of frequency of species, recorded quite high. Recorded 54.9% with frequency between 0-10%, and only 23.8% of species reached frequency> 30%, but there was also one type of Hevea brasiliensis (Will.exA.Juss) which reached the frequency of 83.33. %. This indicates that the species is spread fairly evenly in the study area.

The results showed that from 43 species of trees with diameter ≥ 10 cm, there were 8 dominant tree species in Agroforestry tembawang forest with INP> 5%. Forest stands are dominated by Hevea brasiliensis (Will.exA.Juss) and Durio zibethinus Murr. The density and basal area of the dominant species are listed in Table 1. Based on the highest type of INP, it can be said that Tembawang Agroforestry in Sekadau Hulu is the most common type of fruit, rubber and timber species and is common in secondary forests, but there are also two primary species Shorea leprosula and Shorea stenoptera. Family Dipterocarpaceae, Moraceae and Euphorbiaceae are 3 families that have a high enough INP which is the accumulation of the 3 parameters, based on number of species, the density and the basal area. Thus the three families as the most common family in the study area. From the Euphorbiaceae family, the contribution of Hevea brasiliensis (Will.exA.Juss) contributes greatly to the largest density, this is possible due to local plantings as well as the regeneration of such species is large enough as a consequence of the adaptability to various environmental conditions.

| No. | Species                      | Tembawang density | Tembawang basal area |
|-----|------------------------------|-------------------|----------------------|
| 1   | Artocarpus heterophyllus     | 13.75             | 203.75               |
| 2   | Artocarpus elasticus         | 10                | 40.13                |
| 3   | Durio zibethinus             | 26.25             | 308.56               |
| 4   | Hevea brasiliensis           | 57.5              | 170.59               |
| 5   | Nephelium lappaceum          | 11.25             | 28.13                |
| 6   | Shorea leprosula             | 12.5              | 323.55               |
| 7   | Anacardium occidentale       | 10                | 8.16                 |
| 8   | Shorea stenoptera            | 13.33             | 39.93                |

The existence of dominant families appears not to be followed by dominance at the level of its member type, which is likely to result from the difference in the number of species of each family. Of the 43 recorded the highest total densities found in Hevea brasiliensis (Will.exA.Juss) were 57.5 trees / ha with a basal area of 170.59 m² / ha while the next largest basal area was Durio zibethinus Murr. And Artocarpus heterophyllus that is 308.56 m² / ha and 203.75 m² / ha with density respectively 26.25 trees / ha and 13.75 tree / ha.

The structure of the forest stand can be seen from the distribution of plant diameter and structure of the forest can also be defined as the distribution of trees per unit area in various diameter classes [9], [10], [11]. The overall tree standing structure in the research plot is presented in figure 3. The vertical tree distribution does not indicate stratification. so there are many stands seen from various sizes from small to large enough. The tree with the highest diameter is foundin Durio zibethinus Murr, Artocarpus heterophyllus, Hevea brasiliensis (Will.exA.Juss), Shorea leprosula and Shorea stenoptera. With a height can reach 35m. The results of the distribution of all trees for 10-20 cm, 20-
30 cm, 30-40 cm, 40-50 cm, and ≥ 50 cm diameter at the study sites are shown in figure 3. The number of stems per hectare in the agroforestry of tembawang from figure 3 can be said that the forest structure at the study site shows the number of trees decreasing from the small-diameter class to the large-diameter class, so that the shape of the curve is generally characterized by the number of proportions that resemble an inverted "J". In contrast figure 3 shows that the volume per hectare of large diameter stands (≥ 50 cm) is higher than the volume per hectare in the stands with a diameter below it. If the lower diameter limit is below 10 cm, then there is a more drastic change in the species composition and tree structure in the Sekadau tembawang forest area.

Figure 3. Distribution of tree density and basal area based on size diameter

3.2. Relationship of soil condition between structure of vegetation at Agroforestry Tembawang

Soil condition is an aspect affecting vegetation in a forest in Tembawang forest area. Based on the data recapitulation of soil conditions in the forest area of tembawang is illustrated in table 2. Characteristics of some soil chemical characteristics of tembawang forest include soil pH, organic C, N total, P, K, Ca, and Mg. The characteristic ordinal analysis of soil chemical components in Tembawang forest area was analyzed using PCA analysis. The characteristics of the chemical components of the forest floor of the tembawang forest are illustrated in two major axes as shown in table 2. Based on the main axis 1 the main physical-chemical characteristics of the Tembawang forest area is determined by soil Ph, % C, N, P, Ca, K, and Mg. The amount of information generated on the main axis 1 is indicated by the magnitude of the variant produced the main axis 1 by 62.58%. A complete description of the grouping of soil chemical physics characteristics in Tembawang based on each major axis can be seen in table 2

Table 2. Summary of statistical analysis of the soil chemistry of tembawang agroforestry

| Soil Parameter | (Average±sd) | criteria |
|----------------|-------------|----------|
| pH H2O         | 4.58±0.42   | Very acid-acid |
| C (%)          | 3.23±2.32   | High     |
| N-total (%)    | 0.37±0.24   | Medium   |
| P (ppm)        | 31.75±15.53 | Medium   |
| K (me/100 g)   | 0.23±0.06   | Very low |
| C/N            | 10.96±7.70  | Low      |
| Ca (me/100 g)  | 8.17±4.43   | Low-Medium |
| Mg (me/100 g)  | 3.70±1.05   | Medium-High |

Note : sd. : standar deviation, *. Soil Research Office (2005)
The composition of stands in a forest is also strongly determined by the presence of forest land. The results of non-parametric statistical analysis test using Spearman correlation (rho) between density and basal area of tree with physical chemical properties of forest soil are shown in Table 3. The result shows that the chemical physics of forest soil is correlated with the density and basal area of the tree. Strong and weak correlation between the density and basal area of the tree to the physical characteristics of the chemical soil forest is reflected in the size of the correlation value produced. Based on Table 3, it shows that soil pH, soil Ca, K and Mg are highly correlated with tree density (P <0.05) and basal area of Tembawang forest. This shows that there is a close relationship between tree density and basal area with Ph land, Ca, K and Mg content are available in forest soil, which is indicated by rho > 0.50 and P <0.05. While for other variables the form of correlation that occurs is not real (rho <0.50 and P > 0.05). The relationship pattern between soil Ph, Ca, K and Mg content available in Tembawang forest land showed a negative pattern of relationship to tree density and basal area. This shows the soil Ph, calcium, potassium and Mg elements are very important soil chemical factors in determining the structure of stands in the Tembawang Sekadua forest area.

**Table 3. Correlation between soil chemical characteristics (0-30 cm) to Tembawang forest tree composition based on principle component analysis (PCA)**

| Variabel            | Axis | density (rho) | basal area (rho) |
|---------------------|------|---------------|------------------|
| pH H₂O              | 1    | 0.4213        | -1.00**          |
|                     | 2    | -0.0106       | -1.00**          |
| % Carbon            | 1    | -0.2151       | 0.500            |
|                     | 2    | 0.4685        | 0.500            |
| N (%)               | 1    | -0.2229       | 0.500            |
|                     | 2    | 0.4624        | 0.500            |
| Ca (me/100 g)       | 1    | 0.4175        | -1.00**          |
|                     | 2    | -0.0742       | -1.00**          |
| K (me/100 g)        | 1    | 0.4211        | -1.00**          |
|                     | 2    | 0.0272        | -1.00**          |
| Mg (me/100 g)       | 1    | 0.4209        | -1.00**          |
|                     | 2    | 0.0272        | -1.00**          |
| P (ppm)             | 1    | 0.2450        | -0.500           |
|                     | 2    | 0.4433        | -0.500           |
| Density             | 1    | -0.3701       | 62.576           |
|                     | 2    | -0.2605       | 37.424           |
| basal area (%)      |      | 0.0277        | 0.5437           |
| Variasi (%)         |      | 62.576        | 37.424           |

***Correlation is significant at the 0.01 level (2-tailed).** Correlation is significant at the 0.05 level (2-tailed). Rho = Correlation Spearman

The results of the relationship between the density (number of population) of trees with soil chemical characteristics of the results of this study are not different as reported in Kubota et al., for Ulu Gadut forest area of West Sumatra. Kubota et al. [12] reported that there is a close relationship between species number, population density of trees (population number of trees) and species diversity with soil chemical physics characteristics. Kubota et al. [12] found some elements of forest soil in Ulu Gadut such as Ca, Mg, Na, Al, Si, Mo and S soil were negatively correlated to the total population of trees and elements of K, Mn, Fe and P were positively correlated of the total population of trees and generally high species diversity found in soils with low fertility. The same condition is also reported by Pauli et al. [13] on emergency stands in the Gunung Palung area of West Kalimantan, particularly the effect of P and K elements. The different responses between density and basal area to soil chemical physics factors are also related to the existence of the maximum and minimal limits of nutritional needs used for growth. Hardjowigeno [14] suggests that calcium, potassium and magnesium are macro elements that play a significant role in plants.
4. Conclusion
Based on the high percentage of tree, the Tembawang forest in Sekadau Forest is actually a secondary forest. Restoration of Tembawang Forest will become more feasible with all the basic information on the forest community obtained in this study. The composition and distribution of species in this study were influenced by environmental factors such as natural forest gap, soil mineral viability, and the antropogenic aspects. This study is only a preliminary research, thus, further research should be conducted on those mentioned factors especially the antropogenic aspects.

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