Economic Potential of Species Diversity in Agroforestry System Buffer Zones

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Abstract. Rantau Rasau is one of the buffer villages in the Berbak and Sembilang National Parks where located between the Batanghari River and Berbak National Park Area. This village has potential enhancement community economy based on vegetation diversity. However, its baseline data is still limited. The objectives of this study were to 1) analyze stand structure, vegetation composition and diversity in an agroforestry system, 2) investigate the economic potential of vegetation diversity in the agroforestry system of Rantau Rasau Village, a buffer zone of Berbak National Park, Jambi. The method used was purposive sampling and vegetation analysis. The agroforestry type in Rantau Rasau Village is a simple agroforestry system. The value of diversity index at pole and tree levels belonged to the low category (H <2). Species richness (R) at the pole level was moderate, while at the tree level was low. Important value index (IVI) showed that the dominant species were coconut (Cocos nucifera), areca nut (Areca catechu), rubber (Hevea brasiliensis), and coffee (Coffea robusta). The dominant crops were bananas (Musa sp.) and cassava. Agroforestry in this village supports the achievement of SDGs point 15.4 and 15.9 by increasing the communities’ income by USD 8,471.11/year.

1. Introduction

Indonesia is located in a tropical area that has high biodiversity compared to the subtropics (moderate climate) and the poles (polar climate). According to Kusuma and Hikmat[1] biodiversity is a diversity that includes species diversity, genetic diversity, and habitat diversity where these species grow. Indonesia is estimated to have a flora of about 25% of flowering plant species worldwide, with the seventh-largest country having a total of 20,000 species. Biodiversity in Indonesia can be seen from various kinds of ecosystems in Indonesia, such as coastal ecosystems, mangrove forests, grasslands, tropical rain forests, freshwater, seawater, savanna, and others. Each of these ecosystems has characteristics of biodiversity.

Rantau Rasau Village is one of the buffer villages of the Berbak National Park which is located between the Batanghari River and the Berbak National Park Area. This village has the problem of low vegetation diversity but has the potential to improve the community’s economy. The economy of the community in Rantau Rasau Village has improved with the existence of an agroforestry cropping pattern.

Agroforestry is a system that combines forest components with components of agriculture, fisheries, and animal husbandry which will produce a form of nature conservation that can provide economic value for the perpetrators and can also be used for nature conservation [2]. Applications of
agroforestry systems in Indonesia include yard gardens, talun, intercropping, and fallow. Based on the statement of Ebrahim and Mohamed [3], the application of a system to increase vegetation diversity in an agroforestry area is a system of planting various species agroforestry can well because the system plants on land the same one. Land optimization is needed to increase productivity both on woody plants and intercrops such as agricultural products in a sustainable manner to support the community's economy.

Application of Agroforestry in Rantau Rasau Village, Tanjung Jabung Timur Regency, Jambi has a simple type of agroforestry system. A simple agroforestry system is an agricultural system in which trees can be planted intercropping with one or more other types of seasonal crops. Baseline data relating to vegetation diversity and the potential for community economic development in Rantau Rasau Village are still very limited. Based on this background, the purpose of this study is to analyze the stand structure and composition of vegetation, and the diversity of vegetation in the agroforestry system in Rantau Rasau Village, Berbak National Park, Jambi, to analyze the strengthening of the community's economy based on vegetation diversity. On agroforestry systems in support implementation Sustainable Development Goals (SDGs).

2. Method

2.1. Time and location
This study was conducted in Buffer Zone Rantau Rasau Village, Tanjung Jabung Timur Regency, Jambi Province on 3-6 August 2019. Rantau Rasau Village is located between the Batanghari River and the Berbak National Park Area (Figure 1). Rantau Rasau Village is astronomically located at the coordinates of 10° 48’0” East Longitude and 1° 6’0” South Latitude.

![Figure 1](https://via.placeholder.com/150)

**Figure 1.** Location in Rantau Rasau Village, Jambi (Source: Google Maps 2021)

2.2. Materials
Materials and equipment used during the study, namely writing instruments, tally sheets, measuring tape, meter tape, hagameter, and camera. The object of the study used was vegetation in an agroforestry system on the land of the community of Rantau Rasau Village, Berbak National Park, Jambi.

2.3. Data collection
Primary data collection in this study was carried out directly from field on sample plots on selected agroforestry lands purposive sampling. The plot size used in this study was 20 x 20 m for the growth rate of poles, trees, and crops. Measurements were made in the form of height and diameter for the growth rate of poles and trees with a total of 36 plots. The structure and composition of plant species were known by calculating the density of woody plants, frequency of woody plants, dominance, and Important Value Index (IVI). According to Zulkarnain et al. [4] the structure and composition of the
stand are visually (vertical and horizontal) depicted using the app Corel Draw. Interviews were conducted with agroforestry landowners in Rantau Rasau Village, Jambi. The results of the interviews were then used to calculate the community's annual income.

2.4. Data analysis

Important Value Index (IVI) is the sum of the relative density (KR), relative frequency (RF), and relative dominance (DR), for the growth rate of poles and trees. The formula for calculating IVI is presented in Table 1.

| No | Parameter                  | Formula                                                                 |
|----|----------------------------|-------------------------------------------------------------------------|
| 1  | Individual Density (K)     | \( K = \frac{\text{Number of individuals}}{\text{sample plot area}} \) (1) |
| 2  | Relative Density (KR)      | \( \text{KR} = \frac{K}{\text{all kinds of } K} \times 100\% \) (2)      |
| 3  | Frequency (F)              | \( F = \frac{\text{Number of the species plot area of the whole plot}}{F} \) (3) |
| 4  | Relative Frequency (FR)    | \( \text{FR} = \frac{F}{\text{all kinds of } F} \times 100\% \) (4)      |
| 5  | Dominance (D)              | \( D = \frac{\text{LBDS of a kind sample plot area}}{D} \times 100\% \) (5) |
| 6  | Relative Dominance (DR)    | \( \text{DR} = \frac{\text{all kinds of } D}{D} \times 100\% \) (6)      |
| 7  | Important Value Index (IVI)| \( \text{IVI} = \text{KR} + \text{FR} + \text{DR} \) (7)               |

The species richness index was calculated using the Margallef formula [5] as follows:

\[ R = \frac{(S-1)}{\ln(N)} \]  

Where,

- \( R \) = Specific Richness Index
- \( S \) = Number of species found
- \( N \) = Total number of individuals

Analysis of the Species Diversity Index (\( H' \)) was calculated using the Shannon species diversity formula as follows:

\[ H' = \sum P_i \ln(P_i) \]  

Where,

- \( H' \) = Shannon Diversity Index
- \( P_i = \frac{n_i}{N} \)
- \( n_i \) = The value of the density of the i-th type
- \( N \) = Total density

Species Evenness Index (E) shows the level of individual evenness per species. The value of E is calculated using the formula:

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

Where,
E = Specific Evenness Index
H = Diversity Index
S = Number of all Species

Dominance index is a parameter that states the level of centralized dominance (mastery) of species in a community [6]. Species Dominance Index is used to determine the dominance of a species in a community. This index is calculated using the formula, namely:

$$C = \sum_{i=1}^{n} \left( \frac{n_i}{N} \right)^2$$  \hspace{1cm} (11)

Where,
C = Species Dominance Index
n_i = The i-year density
N = Total density

3. Result and discussion

3.1 Stand Structure and Vegetation Composition of Agroforestry in Rantau Rasau Village

The vegetation structure of an area, species composition, and distribution pattern can be identified by conducting a vegetation analysis. According to Maridi et al. [7], vegetation analysis is a technique that studies the composition of the type and structure of the vegetation needed to determine the distribution of the number of species, planting patterns, and plant growth in each plot. The vegetation structure studied is in the form of a community of all plants from a habitat, the result of which is the type of composition and community structure, which is influenced by the relationship between each individual of each species of organism.

The horizontal structure of the vegetation by diameter class forms an inverted J curve, which is a negative exponential (Figure 2). This structure relation was alike to Hartoyo et al. [8], which shows Berau’s agroforestry structure was an undamaged forest. It states that the larger the diameter of the plant, the lower the individual density. Although there are deviations in one diameter class, namely the 26-30 cm class, the overall curve formed is an inverted J. Based on the statement of Saputra et al.[9], the horizontal structure of vegetation in a forest that has an inverted J curve is a normal condition of the forest, because the number of individuals at each level of seedlings, saplings was 45, poles were 417, and trees was 163, the higher the level, the less, so the regeneration process can continue. Besides Hartoyo et al. [10], agroforestry in the rehabilitation of Meru Betiri National Park doesn't form an inverted J curve. Meru Betiri National Park's agroforestry was not in a balanced condition.
The Importance Value Index of a plant species in its community is a statement that shows the role of that species in its community because the presence of a plant species in an area shows its adaptability to the local environment. The results of the analysis of the structure of the vegetation in this experiment have a large IVI value, which is included in the composition of the plant community in the area [11].

Table 2. The top ten highest vegetation index of important values (IVI) in the agroforestry system in Rantau Rasau Village, Jambi.

| Species Name     | Scientific Name         | IVI (%) | Pole       | Tree       |
|------------------|-------------------------|---------|------------|------------|
| Coconut          | Cocos nucifera          | 4.345   | 162.723    |            |
| Jengkol          | Pithecellobium lobatum  | 35.908  | 51.136     |            |
| Rubber           | Hevea brasiliensis      | 18.669  | 44.338     |            |
| Rambai           | Baccaurea motleyana     | 0.000   | 10.144     |            |
| Betel Nut        | Areca catechu           | 186.559 | 6.434      |            |
| Watter Apple     | Eugenia aquea           | 0.000   | 5.815      |            |
| Mango            | Mangifera indica        | 0.000   | 4.656      |            |
| Petai            | Parkia speciosa         | 0.000   | 3.853      |            |
| Mango Bacang     | Mangifera odorata       | 0.000   | 2.871      |            |
| Durian           | Durio zibethinus        | 2.686   | 2.843      |            |
| Jambubol         | Syzygium malaccensis    | 8.482   | 0.000      |            |
| Cacao            | Theobroma cacao         | 7.455   | 0.000      |            |
| Jackfruit        | Artocarpus heterophyllus| 5.728   | 0.000      |            |
| Matoa            | Pometia pinnata         | 3.663   | 0.000      |            |
| Starfruit        | Averrhoa bilimbi        | 2.572   | 0.000      |            |

Based on the observations listed in Table 2, the highest IVI value at the pole level is the areca nut, while at the tree level is the coconut with a value of 186.6% and 162.72%, respectively. This shows that areca nut and coconut have high adaptability on agroforestry system land in Rantau Rasau Village, Jambi. Certain species that can grow to reach the pole level can adapt to an ecosystem [12]. In addition, the community has a preference for these two species because they can increase income. Based on observations, 23 species were found at the pole level, while at the tree level 12 species were found.

Figure 3. Visualization of individual low-density structures (i), and visualization of high-density structures (ii).
Figure 3 shows the pattern of species diversity and structural complexity in the stand profile. The lowest individual density was in plot 26, while the highest individual density was in plot 23. The dominant woody plants were *Cocos nucifera* and *Areca catechu*. Differences in individual density may occur due to differences in the components of nutrients, water, and land management in each plot. Land management that is usually carried out on types of fruit trees is usually in the form of fertilizing with goat manure, NPK, and urea, areca nut plants with gambier fertilizer, and coconut plants with salt fertilizer.

### 3.2 Vegetation Diversity of Agroforestry System in Rantau Rasau Village

Based on Table 3, the highest value of vegetation diversity was obtained at the tree level with a value of 1.354. However, the value of species diversity at all growth levels is included in the low category. This is reinforced by the statement of Magurran [5] where the value of $H' < 2$ is then included in the low category.

| Vegetation Level | R    | $H'$ | E   | C   |
|------------------|------|------|-----|-----|
| Pole             | 3.649| 1.140| 0.363| 0.567|
| Tree             | 2.160| 1.354| 0.545| 0.385|

The species richness index ($R$) is used to determine the amount of plant species richness in a community. A community is said to have high species richness if the value of $R > 5.0$, moderate category if the value of $R = 3.5-5.0$ and low if the value of $R < 3.5$ [13]. Based on the calculation results, the pole level has a species richness value ($R$) of 3.649 which is included in the medium category, while the tree level has a value below 3.5 and is included in the low category.

The evenness index value ($E$) ranges from zero to one. According to Magurran [5] the evenness index value close to one indicates that a plant community is more evenly distributed. The results of the calculation of the evenness index show that all growth rates tend to be close to zero, which means the level of equity is low. The highest dominance value is 0.567 is at pole level. Mardiyati et al. [14] state that species that dominate an area can be expressed as species that have wide adaptability and tolerance to environmental conditions. The existence of a dominant species in one location, while not at another location or not at another growth rate. This can be caused by a decrease in the number of individuals of a species or the loss of species in a plant community.

Types of plants that are suitable for planting such as balau merah (*Shorea Balarangan*), jabon putih (*Anthocephalus cadamba*), sungkai (*Peronema canescens*), and for crops can be grown medicines such as turmeric, galangal and so on. According to Firdaus et al. [15], increasing the diversity of vegetation on agroforestry land can be done by enriching other types of plants that are already known to the public and the planting technology is known, the compatibility between the types of plants and the land planted so that land productivity is maximized, and the results of crop production that can be utilized by the community.

### 3.3 The Economic Potential of Vegetation Diversity in Agroforestry System

The potential for agroforestry development to optimize yields from sustainable land use. Guarantee, improvement of people's living needs, and increasing human support capacity, especially in rural areas as an action to improve community welfare [16]. Agroforestry in Rantau Rasau Village has a relatively low diversity, but the results of the commodities planted already have a market. The dominant species that are easily found in Rantau Rasau Village are coconut (*Cocos nucifera*) and areca nut (*Areca catechu*). The selling price is USD 0.035/piece up to USD 0.14/fruit for both coconut and areca nut. The selling price is higher when coconut (*Cocos nucifera*) and areca nut (*Areca catechu*) have been peeled and dried in the sun, which is USD 0.35/kg to USD 0.64/kg. In addition to
being popular because they sell well in the market, people also grow crops using an agroforestry system because of suitable soil conditions. These plants include jengkol (*Pithecellobium lobatum*), chocolate (*Theobroma cacao*), rubber (*Hevea brasiliensis*), durian (*Durio zibethinus*), durian (*Durio zibethinus*), starfruit (*Averrhoa bilimbi*), rambai (*Baccaurea motleyana*), petai (*Parkia speciosa*), mango (*Mangifera indica*), duku (*Lansium domesticum*), ambacang (*Mangifera odorata*), water apple (*Eugenia aquea*), and guava (*Syzygium malaccense*). Plants are said to be suitable because they grow well and produce quite a lot of fruit.

The use of agroforestry systems is continuously being developed so that farmers plant eatable crops in the form of trees and the lower part of the canopy is used for cultivation activities such as crops. There are benefits derived from agroforestry, namely increased food production, increased farmer income, employment opportunities, and the quality of community nutrition for the welfare of farmers around the forest [17]. This proves that even though these types of plants are only suitable for soil conditions, there is also a fairly high market demand. Prices of eatable crops from agroforestry products such as jengkol (*Pithecellobium lobatum*) have a selling price of USD 7.06 to USD 49.41/sack. Chocolate (*Theobroma cacao*) with a selling price of USD 1.06 to USD 1.76/kg. Rubber (*Hevea brasiliensis*) for USD 0.46 to USD 0.49/kg. Agroforestry products that are not sold due to too little production per land, such as durian (*Durio zibethinus*), starfruit (*Averrhoa bilimbi*), tassel (*Baccaurea motleyana*), petai (*Parkia speciosa*), mango (*Mangifera indica*), duku (*Lansium domesticum*), ambacang (*Mangifera odorata*), water apple (*Eugenia aquea*), and guava (*Syzygium malaccense*). The production results are only used for personal consumption by the people of Rasau Rantau Village.

Table 4. Community income per year

| No | Species | Amount (Individual/Ha) | Price/harvest (USD) | Income/year (USD) |
|----|---------|------------------------|---------------------|-------------------|
| 1  | Coconut | 333                    | 4936.54             | 4936.54           |
|    |         |                        |                     |                   |
|    | Areca nut | 1000                 | 10588.88            | 10588.88          |
|    |         |                        |                     |                   |
|    | Cassava | 10000                 | 6353.33             | 23997.53          |
|    | Banana  | 625                   | 2118.78             |                   |

Table 4 presents the results of income observations society per year obtained by direct interviews with agroforestry landowners in Rantau Rasau Village, Jambi. Species of coconut and areca nut in monoculture can be combined in agroforestry along with cassava and banana. Monoculture and agroforestry patterns earn income in one coconut harvest for at USD 4936.54. Results annual income from coconut plantations is USD 4936.54. The same applies to monoculture and agroforestry cropping patterns for areca nut, with a price of USD 10588.88, which yields the same annual income. If these plants are combined in an agroforestry cropping pattern with the addition of intercrops in the form of cassava and bananas, the income of the community will increase per year. Production results obtained from agroforestry cropping patterns in the form of crops produce higher community income than monoculture cropping patterns. The additional income from agroforestry cropping patterns is USD 84711.11, so the total income with agroforestry cropping patterns is USD 23997.53.

Planting agroforestry systems can produce medicinal plants, spices, aromatic plants, and feed crops. These types of plants include bananas (*Moses sp.*) which has a selling price of USD 0.21 to USD 0.35/comb. Other crops such as cassava (*Manihot esculenta*), sweet potato (*Ipomea batatas*),
chilli (*Capsicum annum*), sugarcane (*Saccharum* sp.), taro (*Colocasia esculenta*), kale (*Ipomoea aquatica*), galangal (*Alpinia galanga*), balanced (*Solanum torvum*), pawpaw (*Carica papaya*), turmeric (*Curcuma longa*), pineapple (*Ananas comosus*), lemongrass (*Cymbopogon citratus*), bows (*Ocimum tenuiflorum*), eggplant (*Solanum melongena*), leek (*Allium fistulosum*), pandan (*Pandanus amaryllifolius*), cucumber (*Cucumis sativus*), katuk (*Sauropus androgynus*), winged bean (*Psophocarpus tetragonolobus*), and peas (*Pisum sativum*) which can be consumed personally with their respective functions.

3.4 The Achievement of SDGs through The Agroforestry System in Rantau Rasau Village, Jambi

The agroforestry system in Rantau Rasau Village, Jambi has low species diversity at all growth levels, but the highest species diversity was obtained at the tree level with a value of 1.354. This demonstrates the potential to produce marketable forest products, thereby increasing capacity and benefits that are important for sustainable development. The existence of sustainable development achievements can achieve SDGs point 15 regarding Land Ecosystems (land use) with specification 15.4, namely by 2030, ensure the preservation of mountain ecosystems, including their biodiversity, to increase their capacity to provide benefits that are very important for sustainable development.

Land optimization using agroforestry systems can support sustainable development goal number 15, namely terrestrial ecosystems with a 15.9 focus on 2020, integrating ecosystem and biodiversity values into regional and national planning, development processes and poverty alleviation strategies. Agroforestry practices in Rantau Rasau Village can be categorized as having supported the SDGs. Agroforestry practices have combined ecosystem values in the form of being able to improve the economy with the presence of biodiversity from planting on agroforestry land. Regional and national planning with development on agroforestry land. Poverty alleviation strategies can be carried out in the community, so that they have greater income in one land owned because the community gets income from crops for the short term and woody plants for the long term.

4. Conclusion

The stand structure and vegetation composition in this study resulted in an inverted J curve indicating that the stand structure in Rantau Rasau Village, Jambi had normal forest conditions and the vegetation composition was dominated by areca nut species at the pole level and coconut species at the tree level. Diversity of vegetation on land in Rantau Rasau Village, Jambi has species diversity at all growth levels which are included in the low category. This can be overcome by increasing the diversity of vegetation on agroforestry land, which can be done by enriching other types of plants that are known to the public and whose planting technology is known, the compatibility between the types of plants and the land planted so that land productivity is maximized, and the results of plant products that can be utilized by the community.

Agroforestry in Rantau Rasau Village has low diversity but the results are in demand in the market. The dominant species in Rantau Rasau Village are coconut (*Cocos nucifera*) and areca nut (*Areca catechu*) because this species is suitable for soil conditions in agroforestry systems. The benefits obtained from agroforestry are in the form of increased food production, increased farmer income, job opportunities, and the quality of community nutrition for the welfare of farmers around the forest. This supports the achievement of SDGs point 15 regarding Land Ecosystems (land use) with specifications 15.4, ensuring the preservation of mountain ecosystems, including their biodiversity, to increase their capacity to provide critical benefits for sustainable development and 15.9, integrating ecosystem and biodiversity values into regional and national planning, processes development and poverty alleviation strategies.

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