International Journal of Design & Nature and Ecodynamics
Vol. 19, No. 3, June, 2024, pp. 937-946
Journal homepage: http://iieta.org/journals/ijdne

# Impact of Agroforestry Practices on Vegetation Diversity and Structure in Pesawaran, Indonesia

Machya Kartika Tsani[1], Surnayanti[1*], Refi Arioen[2], Sugeng Prayitno Harianto[1], Trio Santoso[1]
Erlina Rufaidah[3], Mohamad Arif Prasetyo[1]

[1] Department Forestry, Faculty of Agriculture, Universitas Lampung, Bandar Lampung 35145, Indonesia
[2] Study Program of Management, Universitas Sang Bumi Ruwa Jurai, Lampung 35118, Indonesia
[3] Department of Agribusiness, Faculty of Agriculture, Universitas Lampung, Bandar Lampung 35145, Indonesia

Corresponding Author Email: surnayanti@fp.unila.ac.id



https://doi.org/10.18280/ijdne.190323

**Received:** 8 April 2024
**Revised:** 30 May 2024
**Accepted:** 5 June 2024
**Available online:** 25 June 2024

***Keywords:***
*agroforestry, analysis of vegetation, plant composition, Register 20 Pesawaran*

**ABSTRACT**

Agroforestry is the practice of combining agricultural and forest crops. In Indonesia's forest areas, agroforestry systems are widely used. Agroforestry in Indonesia makes many contributions to food and the environment. Agroforestry is often carried out in forest areas, to get around this usually uses HKm (social forestry). Among them are those who carry out the Register 20 Pesawaran Regencies in Lampung Province, permit to use HKm, but the composition of many plant types almost resembles forests, so research has not been carried out to analyze various types of plants and determine plant stratum in agroforestry. This research aims to identify types and stratum on agroforestry land. The type of data collected includes primary data, namely plant vegetation analysis (IVI, SDR and H) and determination of plant stratum. Based on the IVI plant vegetation analysis, the tallest plant at the tree stage is the durian, at the pole level is the cocoa, at the sapling level is the cardomon, and at the seedling level is the bayur and jengkol. Of all plants, cocoa plants have the largest SDR. The species diversity index (H) is moderate. The plant stratum is divided into four stratums (B, C, D, E).

## 1. INTRODUCTION

Plant species, including those utilized for agriculture, livestock, fishing, and forestry, and featuring multiple strata of canopy. Agroforestry has been widely adopted across the globe for an extended period of time, consistently aiming to enhance the economic well-being of local communities while simultaneously conserving agricultural land for environmental sustainability [1-3]. Agroforestry is also regarded as a means of enhancing biodiversity on a national and international scale while contributing to the development of a sustainable economy [4]. In contrast, agroforestry has been referred to as practical agroecology [5], and its management was based on an approach grounded in ecological principles. Therefore, by demonstrating diligence in this regard, the preservation of the environment will be upheld. Agroforestry success has become contingent upon a number of elements, including the selection of suitable plant varieties, the upkeep of the plants, the availability of markets and institutions, and plant maintenance [6]. The agroforestry system has been widely implemented in forest areas in Indonesia. Agroforestry plays a significant role in Indonesia as well, boosting income, promoting environmental stability, and ensuring food security. Agroforestry in Indonesia contributes to food security on a number of Indonesian islands [7].

The community uses an agroforestry technique to manage a large number of protected woods. Because the community is restricted by a forest land use permit in social forestry (HKm), which permits the community to manage forest land to increase community welfare by not chopping down trees, the agroforestry system is typically found in forested areas.

Hkm is a social forestry scheme that implements an agroforestry system. According to the Republic of Indonesia's Minister of Environment and Forestry's Regulation NO.P.83/MENLHK/SETJEN/KUM.1/10/2016, HKm is a state with authority for the welfare of its citizens. HKm is a form of legality in the use of state forests for the community. In order to lessen tension amongst the communities surrounding the forest, HKm aims to conserve the forest while growing the community's social economy. For many years, protected forest Indonesia has been using HKm various changes to achieve the desired goals [8, 9]. In Indonesia, HKm first started providing HKm permits to the community in 1995. Although until now not all protected forests in Indonesia have permits to manage HKm land. The protected forest record of the 20 Pesawaran Forest Management Units (KPH) in the province of Lampung is one example.

In addition to managing the 20 protected forests on the Register, the Pesawaran Forest Management Unit (PFM) of Lampung Province has long combined plantation crops, forestry, and agriculture to create a sustainable agroforestry pattern. Like durian, nutmeg, chocolate, and cardamom, it has long been a superior product for the community, but it didn't get a HKm permit until 2021The property at the 20 KPH

Pesawaran registration has a vegetation structure that has already developed into several structures that is a bottom structure that is home to cardamom trees, an upper structure that is occupied by candlenut durian plants, and a middle structure that is occupied by nutmeg and areca nut plants. This arrangement is almost exactly like a natural forest. It takes decades for a vegetation structure like this to grow. Numerous studies have been conducted about the species composition of land used for agroforestry. Recently, great scientific interest has been devoted to examining plant species composition in agroforestry lands [10-14]. However, no research has been carried out on the list of 20 Pesawaran KPHs, and previous research has only focused on analyzing plant types without integrating plant type structure, even though the examination of plant stand structure is equivalent. Thus, the purpose of this study is to identify the plant stratum and examine the vegetation of register 20 in Pesawaran Regency, Lampung Province.

## 2. MATERIALS AND METHODS

The study was carried out on the forest management unit (FMU) Register 20, Pesawaran Regency, Lampung Province. The study was conducted in June to September 2023. Research location (Figure 1) was chosen based on its substantial community-driven management through an agroforestry system.

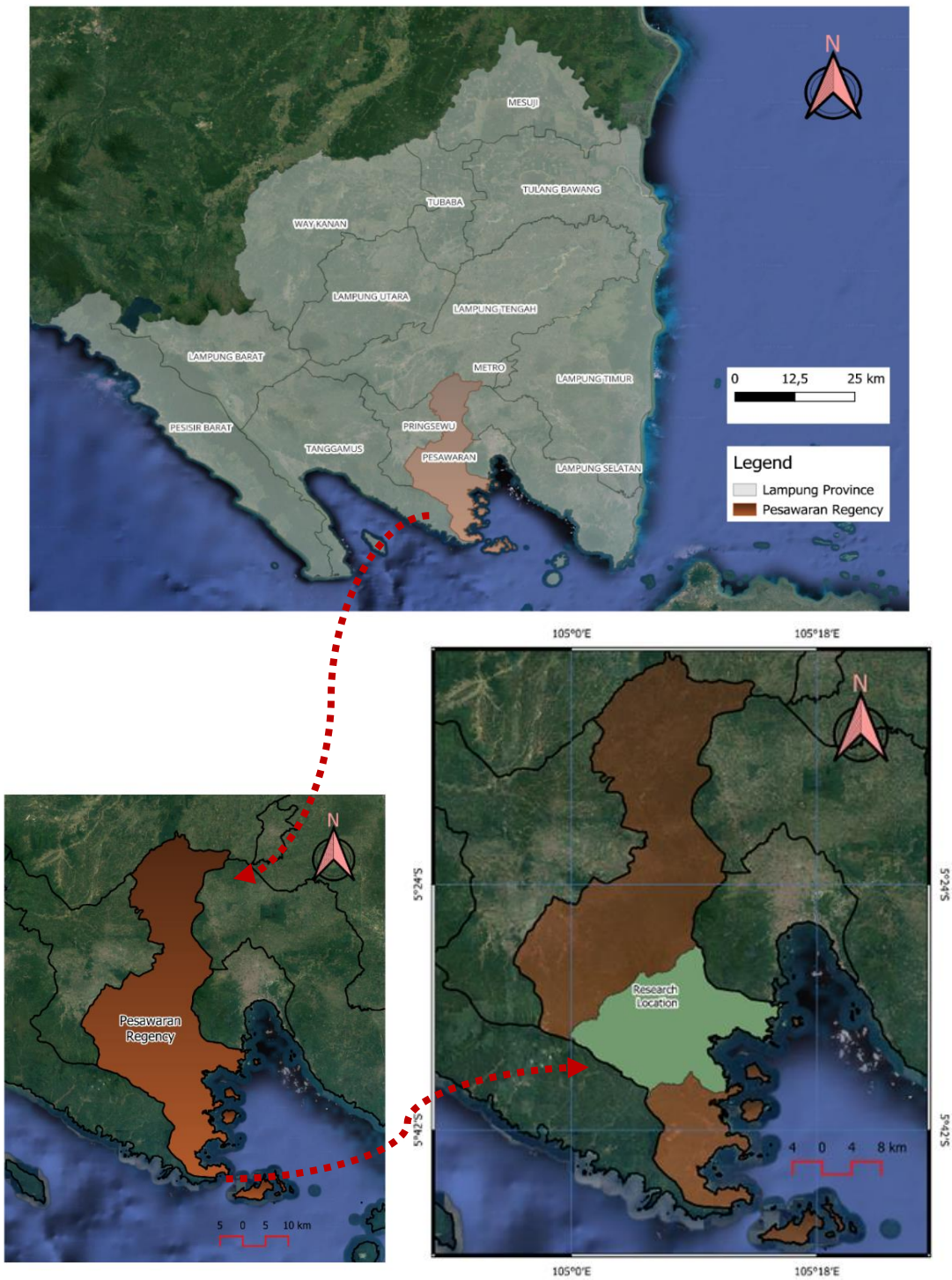


**Figure 1.** Research location on agroforestry land in Register 20 KPH Pesawaran, Lampung Province

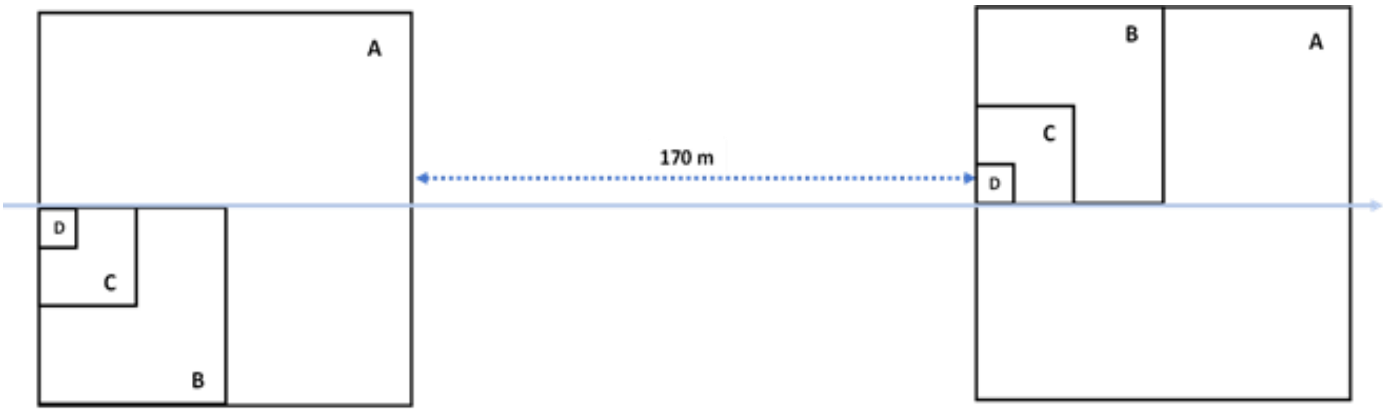


**Figure 2.** Plot design for vegetation observation

The information gathered includes primary data on plant species composition, plant height, plant number, and plant diameter. Register 20 KPH Pesawaran, divided administratively into four Neighbourhood. The type of plant is consistent overall. For this investigation, thirty measurement sites were used in four different contexts. Eight plots each are located in Neighbourhood 1 and 2, and seven plots each are located in Neighbourhood 3. Additionally, Neighbourhood 4 has seven measurement plots. Every plot taken is separated by 170 meters. The square plot comes in different sizes and has dimensions of 20 m × 20 m. with the following details: 20 m × 20 m for observations at tree level with diameters up to ≥ 20 cm, 10 m × 10 m for level of polishing diameter observations (10-19 cm), 5 m × 5 m for tiller level observations < 10 cm in diameter, and 2 m × 2 m for seedling height observations ≤ 1.5 m are the available dimensions. to gauge the various plants' levels. Figure 2 [15] provides an example of a geometric plot created with the grid line technique.

1. Vegetation analysis of plant types is carried out in the following stages:
   a. The importance value index (IVI) of each species at the three successional stages was calculated to examine which species is ecologically significant in the forest ecosystem, and this index was used to relate how important they are in providing ecosystem goods [16, 17]. Steps involved to get IVI value:

$$\text{Density (D)} = \frac{\text{Total number of individuals}}{\text{Size of plots}}$$

$$\text{Relative Density (RD)} = \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \times 100$$

$$\text{Frequency (F)} = \frac{\text{Number of quadrats in which species occured}}{\text{Total size of plots}}$$

$$\text{Relative Frequency (RF)} = \frac{\text{Number of occurrence of the species}}{\text{Number of occurence of all species}} \times 100$$

$$\text{Dominance (Dm)} = \frac{\text{Total basal area of the species}}{\text{Total size of plots}}$$

$$\text{Relative Dominance (RDm)} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all species}} \times 100$$

IVI of tree and pole growth level = RD + RF + RDm

IVI of sapling and seedling growth level = RD + RF

where,

Dominant, if IVI> (lowest IVI + 2I)
Medium, if INP = (lowest IVI + I) – (lowest IVI + 2I)
Low, (Not dominant), if IVI < lowest IVI +1

   b. Summed Dominance Ratio (SDR). Formulas are employed to express the mastery level, or dominance level:
      - Summed Dominance Ratio (SDR) $=\frac{\text{IVI}}{3}$ (for pole and tree level)
      - Summed Dominance Ratio (SDR) $=\frac{\text{IVI}}{2}$ (for seedling and sapling level)
   c. Species Diversity Index. The species diversity index was calculated using the Shannon-Wiener index (H) [18, 19].

$$H' = -\Sigma \frac{n_i}{N} \ln\left(\frac{n_i}{N}\right)$$

where, H was the Shannon-Weiner index, $n_i$ was the number of species' individuals, and N was all species' total individuals. The range of values from the calculation of the Shannon-Wiener index can be interpreted as follows: H' ≤ 1 = Low diversity, 1 < H' ≤ 3 = Moderate diversity, and H'≥ 3 = high diversity.

2. Determination of canopy stratification. Determining header stratification using cricket is as follows:
   a) Stratum A: trees that have a total height above 30 meters
   b) Stratum B: trees 20 - 30 meters high.
   c) Stratum C: if the tree is 4 - 20 meters high
   d) Statum D: plants that are 1 - 4 meters high.
   e) Stratum E: namely the lowest canopy which is less than 1 meter high.

## 3. RESULTS AND DISCUSSION

### 3.1 Analysis of agroforestry plant composition in Register 20 Pesawaran Regency

According to the findings shown in (Table 1), a total of 28 plant species were identified on the agroforestry site of Register 20 KPH Pesawaran, Lampung Province. The classification of plants encompasses four distinct groups: woody plants, MPTS plant types, agricultural plant types, and other types. The woody plants in this category are Bayur (Pterospermum javanicum), Dadap (Erythrina variegata), Sengon (Albizia chinensis), Waru (Hibiscus tiliaceus) dan Cempaka (Magnolia champaca). The MPTS plants include Randu (Ceiba pentandra), Jengkol (Archidendron pauciflorum), Nutmeg (Myristica fragrans), Durian (Durio zibethinus), Candlenut (Aleurites moluccana), Rambutan (Nephelium lappaceum), Petai (Parkia speciosa), Jackfruit (Artocarpus heterophyllus), Duku (Lansium domesticum var. duku), Clove (Syzygium aromaticum), Areca nuts (Areca catechu), Langsat (Lansium domesticum), Mango (Mangifera indica). The agricultural crops include, Cocoa (Theobroma cacao), Coffee robusta (Coffea canephora), Cardamom (Elettaria cardamomum), dan Chilli (Capsicum annuum). Additional examples include paku-pakuan (Pteridophyta spp), sengganen (Melastoma sp), Landri (Bridelia monoica), walur (Amorphophallus variabilis) dan, senduduk (Melastoma hirta). Agroforestry land exhibits several typologies, as supported by empirical findings [3, 20]. Based on researches:

According to Lehmann et al. [21], the analysis conducted using the IFNS system reveals that the utilisation of different combinations of plants and trees leads to differences in production levels, resulting in varying degrees of productivity. The use of an agroforestry system for planting has a beneficial effect on the preservation of biodiversity and serves as a socio-economic resource for the community [22].

Plants with distinct strata exhibit varying growth forms, and each stratum within a community may consist of diverse morphological categories of individuals [23]. The determination of the canopy strata was contingent upon the specific field conditions observed. Consequently, the borders of each observation area will vary according to the specific growing conditions. Nevertheless, the analysis distinguishes between saplings, seedlings, poles, trees, and other categories by considering their pace of growth [24]. At Register 20 KPH Pesawaran, Lampung Province, the forest area exhibits varying levels of density, frequency, dominance, and IVI across different plant species and growth stages. Specifically, durian plants have the highest values in these parameters during the mature phase, cocoa plants during the pole phase, cardamom plants also during the pole phase, and bayur plants during the seedling stage.

The density of plant species has a direct influence on the soil quality. According to Leonika et al. [25], the density of vegetation in a certain land cover exerts influence on the soil quality and the surrounding ecosystem. Increased vegetation density positively affects soil porosity. Agroforestry systems, which entail growing various plant species on a single piece of land, have a substantial impact on the livelihoods of people living in wooded areas [26].

The primary plant species found in Register 20 KPH Pesawaran, consist of durian, cocoa, nutmeg, and bayur. However, while taking into account the whole, the MPTS kind of plant remains the most widely grown by the community. The MPTS plant is a multifunctional plant that utilizes not only its wood, but also its fruit, leaves, and other stem components. Based on researches by Dobo et al. [27] and Lehmann et al. [21] provided evidence that the MPTS plant species exhibited dominance in forest zones. Forest-dwelling communities highly preferred MPTS plants. Register 20 KPH Pesawaran cultivates MPTS plants that fulfill the community's needs for fruit, flowers, seeds, and other resources, while also producing extra income when they are sold.

**Table 1.** Results of analysis of plant types at Register 20 KPH Pesawaran, Lampung Province

| Growth Level | No. | Local Name | Scientific Name | Family | K | KR | F | FR | D | DR | IVI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trees** | 1 | Randu | *Ceiba pentandra* | Malvaceae | 15 | 12.766 | 0.6 | 12.766 | 1.49 | 9.596 | 35.128 |
| | 2 | Jengkol | *Archidendron pauciflorum* | Fabaceae | 30 | 25.532 | 1.2 | 25.532 | 4.06 | 26.09 | 77.154 |
| | 3 | Nutmeg | *Myristica fragrans* | Myristicaceae | 5 | 4.255 | 0.2 | 4.255 | 0.15 | 0.995 | 9.506 |
| | 4 | Durian | *Durio zibethinus* | Malvaceae | 45 | 38.298 | 1.8 | 38.298 | 6.83 | 43.92 | 120.514 |
| | 5 | Candlenut | *Aleurites moluccana* | Euphorbiaceae | 7,5 | 6.383 | 0.3 | 6.383 | 1.38 | 8.872 | 21.638 |
| | 6 | Rambutan | *Nephelium lappaceum* | Sapindaceae | 2,5 | 2.128 | 0.1 | 2.128 | 0.64 | 4.101 | 8.356 |
| | 7 | Petai | *Parkia speciosa* | Fabaceae | 5 | 4.255 | 0.2 | 4.255 | 0.51 | 3.305 | 11.815 |
| | 8 | Jackfruit | *Artocarpus heterophyllus* | Moraceae | 2,5 | 2.128 | 0.1 | 2.128 | 0.23 | 1.465 | 5.720 |
| | 9 | Duku | *Lansium domesticum var. duku* | Meliaceae | 2,5 | 2.128 | 0.1 | 2.128 | 0.14 | 0.925 | 5.180 |
| | 10 | Bayur | *Pterospermum javanicum* | Sterculiaceae | 2,5 | 2.128 | 0.1 | 2.128 | 0.11 | 0.733 | 4.989 |
| **Poles** | 1 | Clove | *Syzygium aromaticum* | Myrtaceae | 50 | 7.143 | 0.5 | 7.143 | 0.44 | 0.044 | 18.197 |
| | 2 | Nutmeg | *Myristica fragrans* | Myristicaceae | 40 | 5.714 | 0.4 | 5.714 | 0.87 | 0.087 | 19.159 |
| | 3 | Areca nuts | *Areca catechu* | Arecaceae | 30 | 4.286 | 0.3 | 4.286 | 0.56 | 0.056 | 13.514 |
| | 4 | Cocoa | *Theobroma cacao* | Malvaceae | 400 | 57.143 | 4 | 57.143 | 6.16 | 0.616 | 168.890 |
| | 5 | Langsat | *Lansium domesticum* | Meliaceae | 20 | 2.857 | 0.2 | 2.857 | 0.43 | 0.043 | 9.552 |

| Growth Level | No. | Local Name | Scientific Name | Family | K | KR | F | FR | D | DR | IVI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 | Jengkol | *Archidendron pauciflorum* | Fabaceae | 110 | 15.714 | 1.1 | 15.714 | 2.12 | 0.212 | 50.246 |
| | 7 | Duku | *Lansium domesticum var. duku* | Meliaceae | 10 | 1.429 | 0.1 | 1.429 | 0.09 | 0.009 | 3.699 |
| | 8 | Durian | *Durio zibethinus* | Malvaceae | 30 | 4.286 | 0.3 | 4.286 | 0.52 | 0.052 | 13.190 |
| | 9 | Randu | *Ceiba pentandra* | Malvaceae | 10 | 1.429 | 0.1 | 1.429 | 0.08 | 0.008 | 3.553 |
| | 1 | Walur | *Amorphophallus variabilis* | Araceae | 40 | 2.941 | 0.1 | 2.941 | 0.03 | 1.739 | 7.622 |
| | 2 | Durian | *Durio zibethinus* | Malvaceae | 80 | 5.882 | 0.2 | 5.882 | 0.21 | 11.61 | 23.372 |
| | 3 | Sengganen | *Melastoma sp* | Melastomataceae | 40 | 2.941 | 0.1 | 2.941 | 0.03 | 1.739 | 7.622 |
| | 4 | Jengkol | *Archidendron pauciflorum* | Fabaceae | 160 | 11.765 | 0.4 | 11.765 | 0.34 | 18.812 | 42.341 |
| | 5 | Nutmeg | *Myristica fragrans* | Myristicaceae | 40 | 2.941 | 0.1 | 2.941 | 0.07 | 3.799 | 9.681 |
| **Saplings** | 6 | Clove | *Syzygium aromaticum* | Myrtaceae | 200 | 14.706 | 0.5 | 14.706 | 0.43 | 23.36 | 52.767 |
| | 7 | Cocoa | *Theobroma cacao* | Malvaceae | 120 | 8.824 | 0.3 | 8.824 | 0.24 | 12.98 | 30.624 |
| | 8 | Coffee | *Coffea canephora* | Rubiaceae | 80 | 5.882 | 0.2 | 5.882 | 0.03 | 1.679 | 13.443 |
| | 9 | Cardamom | *Elettaria cardamomum* | Zingiberaceae | 440 | 32.353 | 1.1 | 32.353 | 0.08 | 4.380 | 69.086 |
| | 10 | Dadap | *Erythrina variegata* | Fabaceae | 40 | 2.941 | 0.1 | 2.941 | 0.01 | 0.337 | 6.219 |
| | 11 | Jackfruit | *Artocarpus heterophyllus* | Moraceae | 40 | 2.941 | 0.1 | 2.941 | 0.03 | 1.653 | 7.535 |
| | 12 | Petai | *Parkia speciosa* | Fabaceae | 80 | 5.882 | 0.2 | 5.882 | 0.33 | 17.92 | 29.687 |
| | 1 | Clove | *Syzygium aromaticum* | Myrtaceae | 250 | 3.226 | 0.1 | 3.226 | | | 6.452 |
| | 2 | Landri | *Bridelia monoica* | Euphorbiaceae | 250 | 3.226 | 0.1 | 3.226 | | | 6.452 |
| | 3 | Mango | *Mangifera indica* | Anacardiaceae | 750 | 9.677 | 0.3 | 9.677 | | | 19.355 |
| | 4 | Bayur | *Pterospermum javanicum* | Sterculiaceae | 1250 | 16.129 | 0.5 | 16.129 | | | 32.258 |
| | 5 | Paku-pakuan | *Pteridophyta spp* | Pteridaceae | 500 | 6.452 | 0.2 | 6.452 | | | 12.903 |
| | 6 | Senduduk | *Melastoma hirta* | Melastomataceae | 500 | 6.452 | 0.2 | 6.452 | | | 12.903 |
| | 7 | Durian | *Durio zibethinus* | Malvaceae | 1000 | 12.903 | 0.4 | 12.903 | | | 25.806 |
| **Seedlings** | 8 | Coffee | *Coffea canephora* | Rubiaceae | 500 | 6.452 | 0.2 | 6.452 | | | 12.903 |
| | 9 | Randu | *Ceiba pentandra* | Malvaceae | 250 | 3.226 | 0.1 | 3.226 | | | 6.452 |
| | 10 | Jengkol | *Archidendron pauciflorum* | Fabaceae | 1250 | 16.129 | 0.5 | 16.129 | | | 32.258 |
| | 11 | Chilli | *Capsicum annuum* | Solanaceae | 250 | 3.226 | 0.1 | 3.226 | | | 6.452 |
| | 12 | Cempaka | *Magnolia champaca* | Magnoliaceae | 250 | 3.226 | 0.1 | 3.226 | | | 6.452 |
| | 13 | Sengon | *Albizia chinensis* | Fabaceae | 250 | 3.226 | 0.1 | 3.226 | | | 6.452 |
| | 14 | Waru | *Hibiscus tiliaceus* | Malvaceae | 250 | 3.226 | 0.1 | 3.226 | | | 6.452 |
| | 15 | Areca nuts | *Areca catechu* | Arecaceae | 250 | 3.226 | 0.1 | 3.226 | | | 6.452 |

IVI the highest plant at the tree level is the durian plant, while at the poles level it is the cacao plant, and at the saplings level it is the cardomon plant, and at the seedlings level it is the bayur and jengkol plants. Based on (Table 1), the highest level of plant diversity in the tree, polish and sapling phases is the type of plant cultivated by registered farmers in 20 Pesawaran Districts. This is because the choice of plant types on agroforestry land is the type preferred by the local community [15]. Meanwhile, the highest types of plants at the seedling level are bayur and jengkol plants. Bayur plants are a type of woody plant, the number of woody plant types at the seedling level of agroforestry land is in register 20 because of the government's obligation to plant woody plants on agroforestry land in forest areas.

The analysis result value has been calculated using the summed dominance ratio (SDR) technique [28] following the identification of the dominant plant species in each measuring plot. The SDR (Species Dominance Ratio) are a mathematical method that considers the relative density, relative frequency, and relative dominance of a species to determine the most important plant types in a specific measurement plot [29]. In order to precisely assess the most prevalent plant species within a given area, it has become crucial to possess knowledge of the SDR (Species Dominance Ratio) value. The investigation produced the SDR values, which are presented in Table 2.

The Register 20 KPH Pesawaran tree phase exhibited the highest Standardized Difference Ratio (SDR) value of 40.17% among durian plant varieties, as indicated by the data in Table 2. This occurs because wealthy Register 20 KPH Pesawaran farmers often cultivate durian. The durian plant was an example of an MPTS (Multi-Purpose Tree Species) plant that contributes to the local economy through fruit production. Among the plants seen during the pole plant phase, cocoa plants exhibited the highest SDR value, measuring at 56.30%. Due to the prior cultivation of cacao plants by the community, the agroforestry planting strategy implemented by Register 20 KPH Pesawaran, farmers have resulted in the prevalence of cocoa plants. The SDR value of 23.03% was the highest among cardamom plants during the seedling phase. Register 20 KPH Pesawaran farmers often cultivate cardamom due to

its low light requirements, which makes it a suitable option for agroforestry areas [30, 31].

The level of authority over the living and nonliving elements of the land increases in proportion to the SDR value [32]. According to Suwinda et al. [28], dominance in a specific area is established by the plants that have the highest level of control over the ecosystem. Boiko and Dementieva [33] observed that it can take many years for dominating plants to establish themselves in forest regions. Nevertheless, the involvement of landowners will expedite the formation of pores and dominant plants on agroforestry land [29]. The Shannon-Weiner diversity index (H') was employed to assess the species diversity value, alongside the SDR value. One of the research findings is the H' value, which can be shown in Table 3.

**Table 2.** SDR dominance value

| Growth Level | No. | Local Names | Scientific Name | Family | SDR |
|---|---|---|---|---|---|
| Trees | 1 | Randu | *Ceiba pentandra* | Malvaceae | 11.71 |
| | 2 | Jengkol | *Archidendron pauciflorum* | Fabaceae | 25.72 |
| | 3 | Nutmeg | *Myristica fragrans* | Myristicaceae | 3.17 |
| | 4 | Durian | *Durio zibethinus* | Malvaceae | 40.17 |
| | 5 | Candlenut | *Aleurites moluccana* | Euphorbiaceae | 7.21 |
| | 6 | Rambutan | *Nephelium lappaceum* | Sapindaceae | 2.79 |
| | 7 | Petai | *Parkia speciosa* | Fabaceae | 3.94 |
| | 8 | Jackfruit | *Artocarpus heterophyllus* | Moraceae | 1.91 |
| | 9 | Duku | *Lansium domesticum* | Meliaceae | 1.73 |
| | 10 | Bayur | *Pterospermum javanicum* | Sterculiaceae | 1.66 |
| Poles | 1 | Clove | *Syzygium aromaticum* | Myrtaceae | 6.07 |
| | 2 | Nutmeg | *Myristica fragrans* | Myristicaceae | 6.39 |
| | 3 | Areca nuts | *Areca catechu* | Arecaceae | 4.50 |
| | 4 | Cocoa | *Theobroma cacao* | Malvaceae | 56.30 |
| | 5 | Langsat | *Lansium domesticum* | Meliaceae | 3.18 |
| | 6 | Jengkol | *Archidendron pauciflorum* | Fabaceae | 16.75 |
| | 7 | Duku | *Lansium domesticum var. duku* | Meliaceae | 0.76 |
| | 8 | Durian | *Durio zibethinus* | Malvaceae | 4.40 |
| | 9 | Randu | *Ceiba pentandra* | Malvaceae | 1.18 |
| Saplings | 1 | Walur | *Amorphophallus variabilis* | Araceae | 2.54 |
| | 2 | Durian | *Durio zibethinus* | Malvaceae | 7.79 |
| | 3 | Sengganen | *Melastoma sp* | Melastomataceae | 2.54 |
| | 4 | Jengkol | *Archidendron pauciflorum* | Fabaceae | 14.11 |
| | 5 | Nutmeg | *Myristica fragrans* | Myristicaceae | 3.23 |
| | 6 | Clove | *Syzygium aromaticum* | Myrtaceae | 17.59 |
| | 7 | Cocoa | *Theobroma cacao* | Malvaceae | 10.21 |
| | 8 | Coffee | *Coffea canephora* | Rubiaceae | 4.48 |
| | 9 | Cardamom | *Elettaria cardamomum* | Zingiberaceae | 23.03 |
| | 10 | Dadap | *Erythrina variegata* | Fabaceae | 2.07 |
| | 11 | Jackfruit | *Artocarpus heterophyllus* | Moraceae | 2.51 |
| | 12 | Petai | *Parkia speciosa* | Fabaceae | 9.90 |

**Table 3.** Diversity Index (H') per level growth

| Growth Level | No. | Local Name | Scientific Name | Family | H' |
|---|---|---|---|---|---|
| Trees | 1 | Randu | *Ceiba pentandra* | Malvaceae | 0.869 |
| | 2 | Jengkol | *Archidendron pauciflorum* | Fabaceae | |
| | 3 | Nutmeg | *Myristica fragrans* | Myristicaceae | |
| | 4 | Durian | *Durio zibethinus* | Malvaceae | |
| | 5 | Candlenut | *Aleurites moluccana* | Euphorbiaceae | |
| | 6 | Rambutan | *Nephelium lappaceum* | Sapindaceae | |
| | 7 | Petai | *Parkia speciosa* | Fabaceae | |
| | 8 | Jackfruit | *Artocarpus heterophyllus* | Moraceae | |
| | 9 | Duku | *Lansium domesticum var. duku* | Meliaceae | |
| | 10 | Bayur | *Pterospermum javanicum* | Sterculiaceae | |
| **Poles** | 1 | Clove | *Syzygium aromaticum* | Myrtaceae | 0.635 |
| | 2 | Nutmeg | *Myristica fragrans* | Myristicaceae | |
| | 3 | Areca nuts | *Areca catechu* | Arecaceae | |
| | 4 | Cocoa | *Theobroma cacao* | Malvaceae | |
| | 5 | Langsat | *Lansium domesticum* | Meliaceae | |
| | 6 | Jengkol | *Archidendron pauciflorum* | Fabaceae | |
| | 7 | Duku | *Lansium domesticum* | Meliaceae | |
| | 8 | Durian | *Durio zibethinus* | Malvaceae | |
| | 9 | Randu | *Ceiba pentandra* | Malvaceae | |
| **Saplings** | 1 | Walur | *Amorphophallus variabilis* | Araceae | 0.951 |
| | 2 | Durian | *Durio zibethinus* | Malvaceae | |
| | 3 | Sengganen | *Melastoma sp* | Melastomataceae | |
| | 4 | Jengkol | *Archidendron pauciflorum* | Fabaceae | |

| | | | | | |
|---|---|---|---|---|---|
| | 5 | Nutmeg | *Myristica fragrans* | Myristicaceae | |
| | 6 | Clove | *Syzygium aromaticum* | Myrtaceae | |
| | 7 | Cocoa | *Theobroma cacao* | Malvaceae | |
| | 8 | Coffee | *Coffea canephora* | Rubiaceae | |
| | 9 | Cardamom | *Elettaria cardamomum* | Zingiberaceae | |
| | 10 | Dadap | *Erythrina variegata* | Fabaceae | |
| | 11 | Jackfruit | *Artocarpus heterophyllus* | Moraceae | |
| | 12 | Petai | *Parkia speciosa* | Fabaceae | |
| | 1 | Clove | *Syzygium aromaticum* | Myrtaceae | |
| | 2 | Landri | *Bridelia monoica* | Euphorbiaceae | |
| | 3 | Mango | *Mangifera indica* | Anacardiaceae | |
| | 4 | Bayur | *Pterospermum javanicum* | Sterculiaceae | |
| | 5 | Paku-pakuan | *Pteridophyta spp* | Pteridaceae | |
| | 6 | Senduduk | *Melastoma hirta* | Melastomataceae | |
| | 7 | Durian | *Durio zibethinus* | Malvaceae | |
| Seedlings | 8 | Coffee | *Coffea canephora* | Rubiaceae | 1.084 |
| | 9 | Randu | *Ceiba pentandra* | Malvaceae | |
| | 10 | Jengkol | *Archidendron pauciflorum* | Fabaceae | |
| | 11 | Chilli | *Capsicum annuum* | Solanaceae | |
| | 12 | Cempaka | *Magnolia champaca* | Magnoliaceae | |
| | 13 | Sengon | *Albizia chinensis* | Fabaceae | |
| | 14 | Waru | *Hibiscus tiliaceus* | Malvaceae | |
| | 15 | Areca nuts | *Areca catechu* | Arecaceae | |

The subsequent metric, known as the Diversity Index (H), measures the extent of diversity within Register 20 KPH Pesawaran. The Diversity Index can be defined as: A value of $1 \leq H \leq 3$ indicates a significant level of diversity, while a value of $H < 1$ indicates a low level of diversity. Register 20 KPH Pesawaran H diversity index indicates that seedlings exhibit the largest concentration of hydrogen (H) content during their growth period. This allows farmers to perpetually establish agroforestry plants—a hybridization of agricultural and forestry vegetation—on agroforestry land as a means of regenerating non-productive plants. Aside from that, the soil will grow more fertile the more seedlings there are, which is also consistent with D'Hervilly et al. [34] showing that different kinds of herbaceous plants can improve soil fertility. During the progression from sapling to pole and then to the mature phase, there are few disparities. Furthermore, research conducted by studies [35-37] has shown that agroforestry systems have a minimal or negative impact on forest variety. The vertical extent at which a species thrives can significantly influence its geographic range.

### 3.2 Stratum on agroforestry land Register 20 Pesawaran Regency

The height of a plant directly influences its overall dimensions. The goal of the plant height assessment, which is done at every stage, is to identify the layers of vegetation on the Register 20 KPH Pesawaran the agroforestry land. The research findings pertaining to measurements are shown in Table 4.

**Table 4.** Stratum on agroforestry land

| Growth Level | No. | Local Name | Scientific Name | Family | Tree Height |
|---|---|---|---|---|---|
| Trees | 1 | Randu | *Ceiba pentandra* | Malvaceae | 7-23 m |
| | 2 | Jengkol | *Archidendron pauciflorum* | Fabaceae | 10-18 m |
| | 3 | Nutmeg | *Myristica fragrans* | Myristicaceae | 10-18 m |
| | 4 | Durian | *Durio zibethinus* | Malvaceae | 14-30 m |
| | 5 | Candlenut | *Aleurites moluccana* | Euphorbiaceae | 10-25 m |
| | 6 | Rambutan | *Nephelium lappaceum* | Sapindaceae | 13 m |
| | 7 | Petai | *Parkia speciosa* | Fabaceae | 14-25 m |
| | 8 | Jackfruit | *Artocarpus heterophyllus* | Moraceae | 10 m |
| | 9 | Duku | *Lansium domesticum var. duku* | Meliaceae | 12 m |
| | 10 | Bayur | *Pterospermum javanicum* | Sterculiaceae | 24 m |
| Poles | 1 | Clove | *Syzygium aromaticum* | Myrtaceae | 10-12 m |
| | 2 | Nutmeg | *Myristica fragrans* | Myristicaceae | 7-14 m |
| | 3 | Areca nuts | *Areca catechu* | Arecaceae | 14-16 m |
| | 4 | Cocoa | *Theobroma cacao* | Malvaceae | 3-10 m |
| | 5 | Langsat | *Lansium domesticum* | Meliaceae | 14-18 m |
| | 6 | Jengkol | *Archidendron pauciflorum* | Fabaceae | 5-16 m |
| | 7 | Duku | *Lansium domesticum var. duku* | Meliaceae | 7 m |
| | 8 | Durian | *Durio zibethinus* | Malvaceae | 12-18 m |
| | 9 | Randu | *Ceiba pentandra* | Malvaceae | 6 m |
| Saplings | 1 | Bakauan | | | 2 m |
| | 2 | Durian | *Durio zibethinus* | Malvaceae | 2-6 m |
| | 3 | Sengganen | | | 1.5 m |
| | 4 | Jengkol | *Archidendron pauciflorum* | Fabaceae | 1.5-6 m |
| | 5 | Nutmeg | *Myristica fragrans* | Myristicaceae | 1.5 m |
| | 6 | Clove | *Syzygium aromaticum* | Myrtaceae | 4-6 m |
| | 7 | Cocoa | *Theobroma cacao* | Malvaceae | 2-4 m |

| | | | | | |
|---|---|---|---|---|---|
| | 8 | Coffee | *Coffea canephora* | Rubiaceae | 3 m |
| | 9 | Cardamom | *Elettaria cardamomum* | Zingiberaceae | 1-2 m |
| | 10 | Dadap bogor | *Erythrina variegata* | Fabaceae | 2 m |
| | 11 | Jackfruit | *Artocarpus heterophyllus* | Moraceae | 3-7 m |
| | 12 | Petai | *Parkia speciosa* | Fabaceae | 2-7 m |
| Seedlings | 1 | Clove | *Syzygium aromaticum* | Myrtaceae | 1 m |
| | 2 | Landri | | | 0.8 m |
| | 3 | Mango | *Mangifera indica* | Anacardiaceae | 0.3 m |
| | 4 | Bayur | *Pterospermum javanicum* | Sterculiaceae | 01-0.3 m |
| | 5 | Paku-pakuan | *Pteridophyta spp* | Pteridaceae | 0.6-0.7 m |
| | 6 | Senduduk | *Melastoma hirta* | Melastomataceae | 0.1-0-2 m |
| | 7 | Durian | *Durio zibethinus* | Malvaceae | 0.3-0.9 m |
| | 8 | Coffee | *Coffea canephora* | Rubiaceae | 0.6-0.7 m |
| | 9 | Randu | *Ceiba pentandra* | Malvaceae | 0.1 1m |
| | 10 | Jengkol | *Archidendron pauciflorum* | Fabaceae | 0.2-0.7 m |
| | 11 | Chilli | *Capsicum annuum* | Solanaceae | 0.9 m |
| | 12 | Cempokak | *Magnolia champaca* | Magnoliaceae | 0.3 m |
| | 13 | Sengon | *Albizia chinensis* | Fabaceae | 0.9 m |
| | 14 | Waru | *Hibiscus tiliaceus* | Malvaceae | 0.4 m |
| | 15 | Areca nuts | *Areca catechu* | Arecaceae | 0.8 m |

The stratum of the Register 20 KPH Pesawaran agroforestry area was assessed, and measurements of the height of each plant species in each phase yielded the following results. The tree phase reveals that the durian tree stands as the tallest, reaching a height ranging from approximately 14 to 30 metres. These findings indicate that the topmost layer of soil on this site consists primarily of durian. In addition, the pole phase indicates that the langsat and durian varieties are the tallest plants. During the sapling phase, the plants present are jackfruit and petai. In the seedling phase, the plants that can be found include cloves and kapok. The configuration of the stratum and the botanical composition of the utilised plants can impact the variety of species present inside it [38]. In addition to measuring the height of the tree, the diameter of the plant is also assessed in order to calculate the pace of growth for each individual plant.

The findings of horizontal measurements, obtained by measuring the diameter of the plant at each stage of growth, are as follows. Candlenut trees reach a maximum diameter of 75.4 cm in their adult phase. The plant species with the largest pole diameter is observed in the sengt and jengkol plants, measuring 18.4 cm. During the sapling phase, jengkol plants have the largest diameter, measuring 9.3 cm.

The Register 20 KPH Pesawaran agroforestry area has been divided into four stratums, namely stratum B, C, D, and E, based horizontal measurements of the plants. If a plant has a height above 30 m, it has been categorised as stratum A, if it is tall. According to study [39], plants that are between 20-30 m tall are categorised as stratum B. Plants with a height of 4-20 m are categorised as stratum C, while those with a height of 1-4 m have been deemed part of stratum D. Finally, plants that were below 1 m in height are included in stratum E. Stratum B has been filled with MPTS plants. Stratums C and D contain agricultural crops such as nutmeg, cloves, cocoa, and coffee, whereas stratum E has been filled with cardamom and understory plants [40]. Register 20 KPH Pesawaran consists of four out of the five available stratums. Register 20 KPH Pesawaran xhibits a plant profile that closely matches that of a natural forest. This has been consistent with the assertion made by Murniati et al. [41].

The Agroforestry technique implemented by Register 20 KPH Pesawaran involves a mixed/random pattern of plant components. The haphazard arrangement of plants and the lack of planned positioning of woody plants on the land result in the formation of this random pattern. Agricultural plants were interplanted in a mixed arrangement with woody plants to utilise the woody plants as shade providers for low canopy plants. The agricultural crops that have been merged include cocoa, coffee, cloves, and nutmeg. Meanwhile, the woody plants that have been included in this combination are durian, avocado, melinjo, kapok, mango, and candlenut. This leads to significant fluctuations in crop productivity due to the diverse range of plant species cultivated on the site [42].

## 4. CONCLUSIONS

During the adult phase, the highest values of density, frequency, dominance, and IVI were noted in durian plants. On the other hand, cardamom, jengkol, and bayur plants showed these traits during the seedling phase, whereas cocoa trees did so at the pole phase. With an SDR (Species Distribution Range) of 56.30% in the pole phase, the cocoa plant has the largest. While it is low during the adult phase, poles, and sapling phases, the species diversity index (H) is moderate during the seedling phase. Four separate stratum, B, C, D, and E, have formed as a result of the unique horizontal vegetation structure found in the Register 20 KPH Pesawaran agroforestry area.

## REFERENCES


[1] Santoso, T., Tsani, M.K. (2021). Precision agroforestry planning and productivity estimation using DEMNAS imagery data around Tahura Wan Abdul Rachman. In the 3rd International Conference on Tropical Silviculture, Bogor.

[2] Santoso, T., Paridduar, R., Bintoro, A. (2023). Plant diversity under traditional agroforestry system of repong damar in Pesisir Barat District, Lampung Province, Indonesia. Biodiversitas Journal of Biological Diversity, 24(8). https://doi.org/10.13057/biodiv/d240849

[3] Tsani, M.K., Surnayanti., Santoso, T. (2023). Development of community forests as locations for honey bee cultivation based on potential feed sources: Case study of Mataram Village community forests, Indonesia. Forestry Ideas, 29(1): 62-73.

[4] Pantera, A., Mosquera-Losada, M.R., Herzog, F., Den Herder, M. (2021). Agroforestry and the environment.

Agroforestry Systems, 95(5): 767-774. https://doi.org/10.1007/s10457-021-00640-8
[5] Fahad, S., Chavan, S.B., Chichaghare, A.R., et al. (2022). Agroforestry systems for soil health improvement and maintenance. Sustainability, 14(22): 14877. https://doi.org/10.3390/su142214877
[6] Terrasse, F., Brancheriau, L., Marchal, R., Boutahar, N., Lotte, S., Guibal, D., Pignolet, L., Candelier, K. (2021). Density, extractives and decay resistance variabilities within branch wood from four agroforestry hardwood species. iForest - Biogeosciences and Forestry. https://doi.org/10.3832/ifor3693-014
[7] Duffy, C., Toth, G.G., Hagan, R.P., McKeown, P.C., Rahman, S.A., Widyaningsih, Y., Sunderland, T.C.H., Spillane, C. (2021). Agroforestry contributions to smallholder farmer food security in Indonesia. Agroforestry Systems, 95(6): 1109-1124. https://doi.org/10.1007/s10457-021-00632-8
[8] Kaskoyo, H., Mohammed, A.J., Inoue, M. (2014). Present state of community forestry (Hutan Kemasyarakatan/HKm) program in a protection forest and its challenges: Case study in Lampung Province, Indonesia. Journal of Forest Science, 30(1). https://doi.org/10.7747/JFS.2014.30.1.15
[9] Safe'i, R., Wulandari, C., Kaskoyo, H. (2019). Analisis kesehatan hutan dalam pengelolaan hutan rakyat pola tanam agroforestri di wilayah Kabupaten Lampung Timur. In Talenta Conference Series: Agricultural and Natural Resources (ANR), Medan, 2(1): 97-103.
[10] Surnayanti, S., Tsani, M.K., Santoso, T., Safe'i, R., Jalal, A. (2022). Density of plant types and maintenance in Maju Jaya HKm agroforestry system, Hujung village, west Lampung. Jurnal Hutan Pulau-Pulau Kecil, 6(2): 149-158. https://doi.org/10.30598/jhppk.v6i2.7346
[11] Torralba, M., Fagerholm, N., Burgess, P.J., Moreno, G., Plieninger, T. (2016). Do European agroforestry systems enhance biodiversity and ecosystem services? A meta-analysis. Agriculture, Ecosystems & Environment, 230: 150-161. https://doi.org/10.1016/j.agee.2016.06.002
[12] Udawatta, R.P., Rankoth, L.M., Jose, S. (2019). Agroforestry and biodiversity. Sustainability, 11(10): 2879. https://doi.org/10.3390/su11102879
[13] Prasetyo, A.D., Riniarti, M. (2019). Jenis jenis tanaman di lahan garapan petani kpph wana makmur dalam tahura wan abdul rachman. EnviroScienteae, 15(2): 154-165.
[14] Umami, W., Kasim, M., Rozen, N. (2018). Effect inundation period to summed dominant ratio (SDR) and biomass rice weeds of method SRI (System of Rice Intensification) in Indonesia. International Journal of Environment, Agriculture and Biotechnology, 3(6): 266215. https://doi.org/10.22161/ijeab/3.6.2
[15] Bajigo, A., Tadesse, M. (2015). Woody species diversity of traditional agroforestry practices in Gununo watershed in Wolayitta zone, Ethiopia. Forest Research, 4(4): 2168-9776. https://doi.org/10.4172/2168-9776.1000155
[16] Reshad, M., Mohammed, M., Beyene, A. (2020). Distribution and importance value index of woody species under different successional stages at Jello-Muktar dry Afromontane Forest, South-eastern Ethiopia. American Journal of Agriculture and Forestry, 8(1): 1-8. https://doi.org/10.11648/j.ajaf.20200801.11
[17] Kuchler, A.W., Mueller-Dombois, D., Ellenberg, H. (1976). Aims and methods of vegetation ecology. Geographical Review, 66(1): 114-116. https://doi.org/10.2307/213332
[18] Magurran, A.E. (1988). Ecological Diversity and Its Measurement. Princeton University Press.
[19] Magurran, A.E. (2004). Measuring Biological Diversity. Blackwell Science, Oxford.
[20] Asmarahman, C., Surnayanti., Indriyanto., Tsani, M.K., Santoso, T. (2023). Productivity and constraint in multipurpose tree species cultivation: A case study from Cilimus Village, Wan Abdul Rachman Forest Park, Indonesia. International Journal of Design & Nature and Ecodynamics, 18(6): 1453-1458. https://doi.org/10.18280/ijdne.180619
[21] Lehmann, L.M., Smith, J., Westaway, S., Pisanelli, A., Russo, G., Borek, R., Sandor, M., Gliga, A., Smith, L., Ghaley, B.B. (2020). Productivity and economic evaluation of agroforestry systems for sustainable production of food and non-food products. Sustainability, 12(13): 5429. https://doi.org/10.3390/su12135429
[22] Santos, P.Z.F., Crouzeilles, R., Sansevero, J.B.B. (2019). Can agroforestry systems enhance biodiversity and ecosystem service provision in agricultural landscapes? A meta-analysis for the Brazilian Atlantic Forest. Forest Ecology and Management, 433: 140-145. https://doi.org/10.1016/j.foreco.2018.10.064
[23] Kittitornkool, J., Kaewwongsri, P., Tongkam, P., Bumrungsri, S., Sawangchote, P. (2019). Livelihoods of small-scale rubber farmers: A comparative study of rubber agroforestry systems and monocropping rubber plots in Southern Thailand. Kasetsart Journal of Social Sciences, 40(2): 420-426.
[24] Crous-Duran, J., Graves, A.R., Paulo, J.A., Mirck, J., Oliveira, T.S., Kay, S., de Jalón, S.G., Palma, J.H. (2019). Modelling tree density effects on provisioning ecosystem services in Europe. Agroforestry Systems, 93: 1985-2007. https://doi.org/10.1007/s10457-018-0297-4
[25] Leonika, A., Nugroho, Y., Rudy, G.S. (2021). Effect of the density againts physical properties of soil on various landcover in KHDTK Mandiangin ULM. Jurnal Sylva Scienteae, 4(4): 608-616. https://doi.org/10.20527/jss.v4i4.3935
[26] Roupsard, O., Audebert, A., Ndour, A.P., et al. (2020). How far does the tree affect the crop in agroforestry? New spatial analysis methods in a Faidherbia parkland. Agriculture, Ecosystems & Environment, 296: 106928. https://doi.org/10.1016/j.agee.2020.106928
[27] Dobo, B., Asefa, F., Asfaw, Z. (2018). Effect of tree-enset-coffee based agro-forestry practices on arbuscular mycorrhizal fungi (AMF) species diversity and spore density. Agroforestry Systems, 92: 525-540. https://doi.org/10.1007/s10457-016-0042-9
[28] Suwinda, R., Warnita, W., Chaniago, I., Irfan, Z. (2019). Effect inhibitor packlobutrazol of against type and Summed Dominance Ratio (SDR) weeds in potato (Solanum tuberosum L.) plant. International Journal of Environment, Agriculture and Biotechnology, 4(5): 1579-1583. https://doi.org/10.22161/ijeab.45.45
[29] Chen, Y.C., Wu, C.F., Lin, S.H. (2014). Mechanisms of forest restoration in landslide treatment areas. Sustainability, 6(10): 6766-6780. https://doi.org/10.3390/su6106766
[30] Singh, M., Das, S.K., Avasthe, R.K. (2018). Effect of multipurpose trees on production of large cardamom and soil fertility in agroforestry systems in Sikkim, Himalaya. Indian Journal of Agroforestry, 20(2): 25-29.

[31] Lepcha, N.T., Devi, N.B. (2020). Carbon cycling and balance in a traditional cardamom based agroforestry system of Sikkim Himalayas. Tropical Ecology, 61: 527-537. https://doi.org/10.1007/s42965-020-00110-9
[32] Samedani, B., Juraimi, A.S., Anwar, M.P., Rafii, M.Y., Sheikh Awadz, S.H., Anuar, A.R. (2013). Competitive interaction of Axonopus compressus and Asystasia gangetica under contrasting sunlight intensity. The Scientific World Journal, 2013(1): 308646. https://doi.org/10.1155/2013/308646
[33] Boiko, T.O., Dementieva, O.I. (2018). The tree vegetation of the Kherson State Agrarian University Arboretum. Ukrainian Journal of Ecology, 8(2): 120-127. https://doi.org/10.15421/2018_318
[34] D'Hervilly, C., Marsden, C., Capowiez, Y., Béral, C., Delapré-Cosset, L., Bertrand, I. (2021). Trees and herbaceous vegetation strips both contribute to changes in soil fertility and soil organism communities in an agroforestry system. Plant and Soil, 463: 537-553. https://doi.org/10.1007/s11104-021-04932-x
[35] Neya, T., Neya, O., Abunyewa, A.A. (2018). Agroforestry parkland profiles in three climatic zones of Burkina Faso. International Journal of Biological and Chemical Sciences, 12(5): 2119-2131. https://doi.org/10.4314/ijbcs.v12i5.14
[36] Erwin, E., Bintoro, A., Rusita, R. (2017). Vegetation diversity in utilization block, integrated conservation education forest, wan Abdul Rachman Great Forest Park, Lampung Province. Jurnal Sylva Lestari, 5(3): 1-11. https://doi.org/10.23960/jsl351-11
[37] Beech, E., Rivers, M., Oldfield, S., Smith, P.P. (2017). GlobalTreeSearch: The first complete global database of tree species and country distributions. Journal of Sustainable Forestry, 36(5): 454-489. https://doi.org/10.1080/10549811.2017.1310049
[38] Sofiah, S., Metusala, D., Trimanto, T., Nurfadilah, S. (2018). Flora diversity, composition and ecology in Besiq Bermai tropical forest of Damai District, East Kalimantan. Biotropia, 25(2): 85-94. https://doi.org/10.11598/btb.2018.25.2.724
[39] Indriyanto, ekologi hutan, cetakan ke. Bumi Akasara, Jakarta. https://inlislite.uin-suska.ac.id/opac/detail-opac?id=16510, accessed on Jun. 5, 2024.
[40] Rakocevic, M., dos Santos Scholz, M.B., Pazianotto, R. A.A., Matsunaga, F.T., Ramalho, J.C. (2023). Variation in yield, berry distribution and chemical attributes of coffea arabica beans among the canopy strata of four genotypes cultivated under contrasted water regimes. Horticulturae, 9(2): 215. https://doi.org/10.3390/horticulturae9020215
[41] Murniati, Suharti, S., Minarningsih, Nuroniah, H.S., Rahayu, S., Dewi, S. (2022). What makes agroforestry a potential restoration measure in a degraded conservation forest?. Forests, 13(2): 267. https://doi.org/10.3390/f13020267
[42] Niether, W., Jacobi, J., Blaser, W.J., Andres, C., Armengot, L. (2020). Cocoa agroforestry systems versus monocultures: A multi-dimensional meta-analysis. Environmental Research Letters, 15(10): 104085. https://doi.org/10.1088/1748-9326/abb0