BIOTROPIA ISSN: 0215-6334 | e-ISSN: 1907-770X
The Southeast Asian Journal of Tropical Biology
Vol. 31 No. 3, 2024: 380 - 390
DOI: 10.11598/btb.2024.31.3.2281

Research Article

TREE SPECIES DIVERSITY AND MANAGEMENT IN AGROFORESTRY *POHPOHAN (Pilea melastomoides)*: THE CASE IN THE TRADITIONAL ZONE OF GUNUNG HALIMUN SALAK NATIONAL PARK, INDONESIA

Adisti Permatasari Putri Hartoyo[1,2,*], Sheikha Ananda Mosa[1], Bayu Winata[1], Lufthi Rusniarsyah[1], Peniwidiyanti[3], Izzbilhaq[1]

[1]Department of Silviculture, Faculty of Forestry and Environment, IPB University, Bogor 16680, Indonesia

[2]Environmental Research Centre, IPB University, Bogor 16680, Indonesia

[3]Research Center for Ecology and Ethnobiology, National Research and Innovation Agency (BRIN), Bogor 16911, Indonesia

ARTICLE HIGLIGHTS

- *Pohpohan* (*Pilea melastomoides*) is the main commodity cultivated by using traditional agroforestry in the traditional zone of Gunung Halimun Salak National Park as a fresh vegetable.
- There is a limited database of plant species diversity in the traditional zones, which is dynamic and needs further research.
- This study found 54 tree species from 37 families with the dominant family being Rubiaceae.
- Most farmers cultivated *Pohpohan* by conducting plant spacing, maintenance, and harvesting. Their income is USD 154 – 256/month.

Article Information

Received 17 June 2024
Revised 1 October 2024
Accepted 11 October 2024

Reviewers
Khin Maung Sint, Arifah Rahayu Rusdi Evizal

***Corresponding author, e-mail:**
adistipermatasari@apps.ipb.ac.id

ABSTRACT

Gunung Halimun Salak National Park (GHSNP) is Java Island's largest tropical mountain rainforest. GHSNP is still facilitating community grounds around GHSNP with the existence of a traditional zone. *Pohpohan* (*Pilea melastomoides*) is the primary commodity in the traditional zone cultivated by the local people around GHSNP. *Pohpohan* is planted using traditional agroforestry planting patterns. The traditional zone has a limited diversity of plant species and a limited management database, so further study is necessary. This study was carried out in the agroforestry system in Tamansari Village, Bogor Regency, which is in the traditional zone of GHSNP. Data collection for tree diversity was conducted by establishing 25 plots. This study also interviewed 30 local farmers belonging to the Mandiri farmer group. There were 54 tree species from 37 families found in this study. Rubiaceae, Malvaceae, Fabaceae, and Phyllanthaceae families were the most common families existed in the study site. *Pinus merkusii, Agathis dammara*, and *Maesopsis eminii* had the highest important value index (IVI). The understory and seedlings were categorized as low in H' due to the dominant presence of *Pohpohan* planting. Most respondents were farmers aged 35-55 (70%) with a farming area of 1,000 m2. They cultivated *Pohpohan* by conducting plant spacing, plant maintenance (e.g., soil cultivation, weeding, fertilization), and harvesting. Fertilization for *Pohpohan* was conducted 9 times a year. The farmers produced 30,000-50,000 bunches per harvest time. Their monthly income was about USD 154-256 per month.

Keywords: farmer group, IVI, *Pohpohan*, traditional agroforestry, vegetation diversity

INTRODUCTION

Gunung Halimun Salak National Park (GHSNP) is an area of natural conservation. It is the largest tropical mountain rainforest on Java Island. Administratively, GHSNP is located in three regencies, namely Bogor Regency, Lebak Regency, and Sukabumi Regency. The designation of the GHSNP area as a conservation area began with the Decree of the Minister of Forestry of the Republic of Indonesia Number 282/Kpts-II/1992 issued on 28 February 1992 declaring an area of 40,000 ha as the Gunung Halimun National Park (GHNP). Subsequently, the Minister of Forestry of the Republic Indonesia issued a Decree Number 175/Kpts-II/2003 dated 10 June 2003 to expand the GHSNP area to 113,357 ha as a response to the growing occurrences of forest disturbances. This expansion included the forests of Mount Salak, Mount Endut, and the surrounding areas, which had previously been classified as limited-production forests and protected forests managed by State-Owned Forest Enterprise (*Perum*

Perhutani). Since then, the GHNP area has been transformed into a unified GHSNP conservation area (Ekayani *et al.* 2014).

Gunung Halimun Salak National Park is classified into several zones to facilitate spatial arrangement within the national park. These zones are generally classified based on the community's ecological, social, economic, and cultural conditions. According to the 2007-2026 GHSNP Management Plan, the GHSNP area is divided into eight zones: traditional zone, cultural zone, special zone, rehabilitation zone, utilization zone, jungle zone, core zone, and enclave. However, zoning in the GHSNP forest area was slightly altered based on the Decree of the Minister of Environment and Forestry of the Republic of Indonesia Number 327/Menlhk/Setjen/PLA.2/4/2016 dated 26 April 2016, which changed the function of 17,373 ha in the GHSNP forest area and returning another use area (enclave) covering 7,847 ha. As a result, the GHSNP is divided only into seven zones, covering an area of 87,699 ha (BTNGHS 2021).

The expansion of the GHNP into the GHSNP area, which includes land used for community economic activities, has created a conflict between ecological (conservation) and economic interests. This issue is addressed by allowing a small portion of the GHSNP area for community use, which permits local farmers to continue their economic activities. The Gunung Halimun Salak National Park Office (GHSNPO) still facilitates several community grounds around GHSNP, designating these areas as the traditional zone. Local communities use the traditional zone to supply their daily necessities by using non-timber forest resources, such as tapping pine sap, tapping copal sap, and farming *Pohpohan* leaves.

Pohpohan (*Pilea melastomoides*) is the main commodity cultivated by using traditional agroforestry planting patterns in the traditional zone as fresh vegetable, mainly by the Sundanese people in Indonesia. *Pohpohan* cultivation is particularly significant in Tamansari Village, Bogor Regency. Agroforestry is a form of multi-story land use that includes a mixture of trees and annual plants. Agroforestry land must have at least woody plant species (Olivi *et al.* 2015). In the traditional zone of GHSNP, *Pohpohan* is shaded by pine (*Pinus merkusii*), agathis (*Agathis dammara*), and African wood (*Maesopsis eminii*), which are planted by Perum Perhutani. Local communities have been practising the *Pohpohan* agroforestry system in this area for decades, considering ecological, social, and economic factors. Therefore, to accomplish sustainable management, studying agroforestry systems is crucial. Additionally, there is a limited database of plant species diversity in the traditional zones, particularly in the *Pohpohan* agroforestry system, which is dynamic and needs further research. The purpose of this study is to analyze the diversity of tree species and management in the *Pohpohan* agroforestry of Gunung Halimun Salak National Park, built upon Traditional Ecological Knowledge (TEK).

MATERIALS AND METHODS

Study Area

This study was carried out in the traditional zone of Gunung Halimun Salak National Park (GHSNP), West Java Province, Indonesia. The specific study site is the *Pohpohan* (*Pilea melastomoides*) agroforestry system in Tamansari Village, Bogor Regency, West Java Province, Indonesia (Fig.1). GHSNP is administratively divided into three districts: Bogor Regency, Lebak Regency, and Sukabumi Regency. Geographically, the national park is located between 106°21' - 106°38' E and 6°37' - 6°51' S.

GHSNP is vital in maintaining biodiversity, regulating water management, supporting education and research, and functions as germplasm sources, cultivation development, and tourism. Salak Mountain has a height ranging from 400 to 2,210 masl. The climate type of GHSNP is classified as type B according to Schmidt and Ferguson, characterized by wet conditions with rainfall of 4,000-6,000 mm/year and a dry season that lasts less than three months, typically from May to September. The average monthly temperature in GHSNP ranges from 19.7 °C to 31.8 °C and the average air humidity is 88% (Adalina *et al.* 2014).

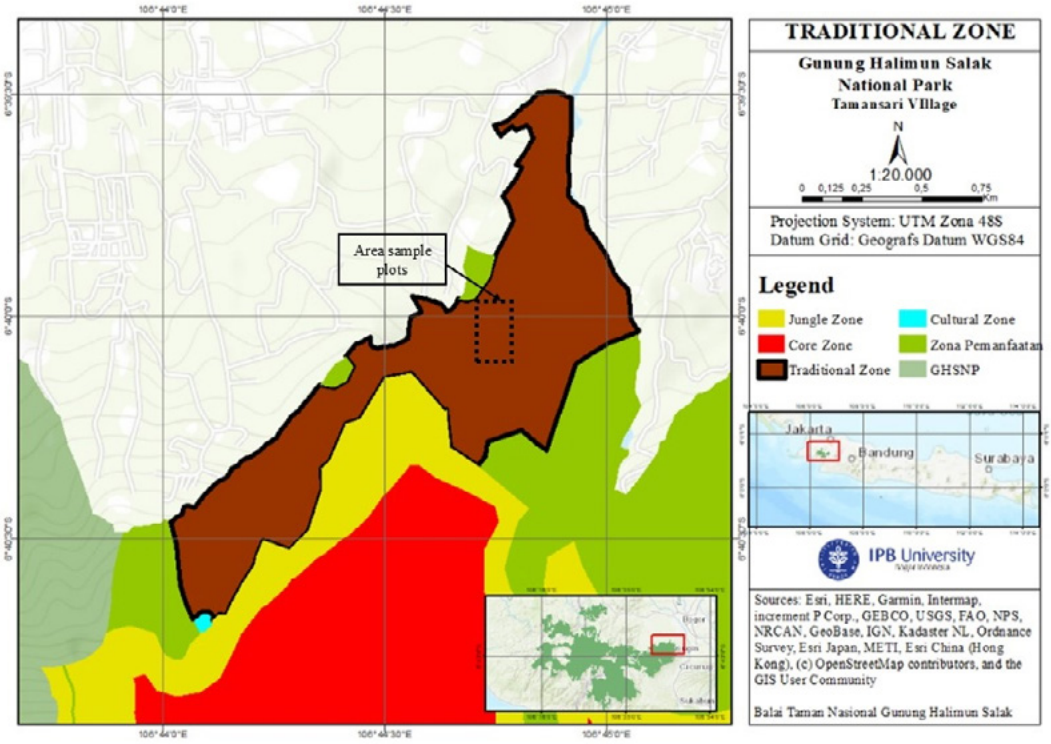

Figure 1 Study area in the traditional zone of GHSNP

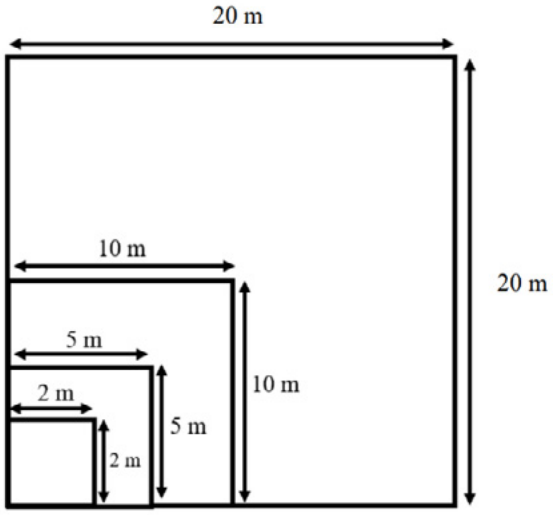

Figure 2 Design of observation plots

Procedures

Plot Establishment

Data on tree diversity was collected by establishing 25 plots within GHSNP. The plot selection was carried out using the purposive sampling method, with criteria including representing an agroforestry system containing at least one species of woody plant, managed by the local community for generations, and having at least one main commodity species contributing to the income of the local community. Each of the 25 plots measured 20 m × 20 m. The square plots were divided into several square subplots. For detailed observation, 20 m × 20 m plots for tree level, 10 m × 10 m for pole level, 5 m × 5 m for sapling level, and 2 m x 2 m for understory and seedling level (Fig. 2).

Tree Species Diversity Measurement

This study collected data on understory vegetation and all tree growth levels, including seedlings, saplings, poles, and trees. For understory vegetation and seedlings (lower-tier shrubs and

small trees with a height of < 1.5 m), the data collected included the names of species and the number of individuals for each species. For saplings (trees with a height of at least 1.5 m and a diameter of under 10 cm), poles (trees with a diameter of 10-20 cm), and mature trees (trees with a diameter of ≥ 20 cm), the measured parameters included the individual's DBH (diameter at breast height), total height, and branch-free height.

Interviewing the Local Farmers Related to the Management of Agroforestry Based on Traditional Ecological Knowledge

Traditional Ecological Knowledge (TEK) data were gathered through in-depth interviews using an interview guide with all members of the Mandiri Farmers Group (*Kelompok Tani Mandiri*) in Tamansari Village. This community has a conservation partnership cooperation agreement with Gunung Halimun Salak National Park. TEK reflects the close relationship between society and the environment, particularly in planting. TEK encompasses ideological superstructures (religion/beliefs and religious values), material infrastructure (ideas, concepts, and equipment used), and social structures that shape culture and evolve (UNESCO 2009). TEK documentation was conducted through participatory observation (Kawulich 2005) of community activities to verify interview results.

Thirty respondents of local *Pohpohan* farmers from *Kelompok Tani Mandiri* were interviewed using questionnaires. These questionnaires included questions about the farmers' identities, conditions of agroforestry sites, challenges faced by the local farmers, and their needs in managing agroforestry sites. The community interviews focused on activities related to managing the conservation partnership area, from cultivation and harvesting to post-harvest handling.

Data Analysis

Importance Value Index

The collected vegetation data were subjected to a quantitative analysis, with each species' Importance Value Index (IVI) calculated. The IVI was used to describe and compare the species in the plots (Cottam & Curtis 1956). The plot's most "important" species were those with the highest IVI. This index aids in assessing each species' relative relevance within the community structure. The relationship between the total relative density (RD), relative frequency (RF), and relative dominance (RDo) represents the IVI for each species, which has values ranging from 0 to 300 (Ismail 2017).

The calculation of IVI for seedlings, understory, and saplings differs from that for poles and trees. The total of RD, RF, and RDo is the IVI for poles and trees. In contrast, the IVI for the understory vegetation, seedlings, and saplings is the total of the RD and RF, resulting in IVI values ranging from 0 to 200. According to Sari *et al.* (2022), the following formula can be used to calculate the density (D), frequency (F), and dominance (Do) of the IVI.

Density (D)	=	$\frac{\text{Total number of individuals of a species found}}{\text{Total area examined}}$	(1)
Relative Density (RD)	=	$\frac{\text{Number of individuals of the species}}{\text{Total number of individuals of all species}} \times 100\%$	(2)
Frequency (F)	=	$\frac{\text{Number of a plot where species found}}{\text{Total size plots}}$	(3)
Relative Frequency (RF)	=	$\frac{\text{Frequency of species}}{\text{Sum of frequency values for all species}} \times 100\%$	(4)
Dominance (Do)	=	$\frac{\text{Total basal area of the species}}{\text{Total size plots}}$	(5)
Relative Dominance (RDo)	=	$\frac{\text{Total basal area of the species}}{\text{Total basal area of the species}} \times 100\%$	(6)
Important Value Index (IVI)	=	RD + RF (for seedlings and saplings)	(7)
Importance Value Index (IVI)	=	RD + RF + RDo (for poles and trees)	(8)

Index of Species Diversity (H')

An ecosystem's species diversity, stability, and maturity can be measured by the tree species diversity index which is also known as the Shannon-Wiener Index. According to Putri and Indriyanto (2021), a high H' value indicates that a community is stable against disturbance, comprising many species with similar abundances. Margalef (1972) stated that the Shannon-Wiener index ranges from 1.5 to 3.5, with ecosystems having an H' value below 1.5 considered low diversity. This species diversity index can be determined using the formula below (Margalef 1972):

$$H' = - \sum_{i=I}^{n} \left(\left(\frac{ni}{N} \right) \ln \left(\frac{ni}{N} \right) \right) \quad (9)$$

where:
H'= species diversity index (Shannon-Wiener index)
ni = the significance value of the i-th species
N = the importance of all species

Index of Species Dominance (C)

The Simpson species dominance index (C) estimates the dominance levels of certain species within a community. A high level of diversity in a community corresponds to a low dominance value. The Simpson dominance index ranges from 0 to 1. A dominance value close to 1 indicates that one or a few species dominate the community, while a value close to 0 suggests that multiple species share dominance. According to Simpson (1949), species dominance can be determined using the formula below:

$$C = \sum_{k=0}^{n} \left(\frac{ni}{N} \right)^2 \quad (10)$$

where:
C = species dominance index
ni = the i-th species density
N = the total of density

Index of Species Richness (R)

The Margalef Species Richness Index indicates the species richness in a study area. Jorgensen *et al.* (2005) set the lower limit value for the species richness index at 2.05. A species richness index of more than 2.05 indicates a high species richness in an ecosystem. The formula for calculating the R-value is as follows:

$$R = \frac{(S-1)}{\ln(N)} \quad (11)$$

where:
R = species evenness index
S = number of species found
N = total number of individuals found

Index of Species Evenness (E)

The Species Evenness Index shows the relationship between species abundance and species diversity in a community (Wahyuningsih *et al.* 2019). The species evenness index value ranges from 0 to 1. A value close to 0 indicates low species evenness, while a value close to 1 indicates high species evenness. The formula for the species evenness index is as follows:

$$E = \frac{H'}{\ln(S)} \quad (12)$$

where:
E = species evenness index
H' = species diversity index
S = number of species found

RESULTS AND DISCUSSION

Species Composition

In the 25 plots of 20 m x 20 m, there were 54 species from 37 families recorded. The most frequent families found were Rubiaceae (4 species) and Malvaceae, Fabaceae, and Phyllanthaceae (each with 3 species) (Table 1).

Table 1 The number of species found in the traditional zone of GHSNP

Categories	Number of species
Understory and seedling	34
Sapling	9
Pole	5
Tree	13
The sum of all categories	31

Understory and seedlings are two different things. Understory refers to vegetation found beneath forest stands, excluding tree saplings. Seedlings are part of tree regeneration, which is included in the tree growth level. The existence of understory plants on the forest floor can improve soil and water conservation. Their extensive root systems form dense clumps that prevent erosion, protect the soil from rainwater and surface runoff,

and increase organic matter (Indriyani *et al.* 2017). Additionally, understory vegetation plays a crucial role in forest ecosystems by influencing the microclimate. However, understory plants can also compete with and inhibit the growth of tree regeneration (Hilwan *et al.* 2013). In this study, data of understory and seedlings were combined because they were found in the same plots. The understory and seedlings had the most species compared to other categories (Table 1).

Importance Value Index (IVI) analysis was used to identify the species dominating the observation plot. According to Smith (1977), the dominant species can utilize their environment more efficiently than other species in the same place. The IVI in the traditional zone of GHSNP is presented in Table 2.

Importance Value Index (IVI) is an indicator to determine the role of species in a community. Higher IVI indicates a more significant role of the species within the community, and vice versa (Rawana *et al.* 2022). The dominant species in forest vegetation are those with the highest IVI values (Ismail 2017). A species is considered significant if the IVI value is ≥ 10% for seedlings and saplings, and ≥ 15% for poles and trees. This study showed that *Pohpohan* (*Pilea melastomoides*) had the highest IVI in the understory and seedling categories (Table 2). Based on this definition, *Pohpohan* was the dominant species in the observation plot, which was influenced by a combination of anthropogenic and ecological factors. Local farmers cultivated *Pohpohan* due to its use as a vegetable or medicinal plant. This intervention significantly increased *Pohpohan* presence and dominance then raised its IVI. Additionally, *Pohpohan* often grows well in partially shaded areas, such as forest understories. It competes effectively when light intensity is moderate.

Forest management with the community (PHBM) mechanism, which was based on the Decree of the *Perum Perhutani* Supervisory Board No. 136/KPTS/DIR/2001 issued on 29 March 2001 regarding Forest Resource Management in collaboration with the local community, promoted the sharing principle to ensure that common interests in sustaining the functions and benefits of forest resources are achieved in an optimal and proportionate approach. In GHSNP, PHBM is used by implementing a social forestry model, specifically agroforestry, with pine (*Pinus merkusii*) as the primary tree species and *Pohpohan* (*Pilea melastomoides*) as the primary agricultural crop for the Tamansari Village community. Despite changes in land management, the residents of Tamansari Village still can sustainably cultivate and utilize trees. According to the terms of Cooperation Agreements (PKS) 255.T.14/TU/KUM.3/2/2021 and PKS.1/KTMandiri/2/2021 with GHSNP, the community formed a Conservation Partnership in 2021, which granted the community access to a 79.29 ha area for cultivating *Pohpohan* within the pine stands (Adhiningsih *et al.* 2022).

Plants that shaded the *Pohpohan* area were dominated by the species on the tree growth level in Table 2. Based on that, pine, agathis, and African wood had the highest IVI values and thus, the three species were considered dominating the land. Pine resin and copal were used as Non-Timber Forest Products (NTFPs) by local communities that depended on their livelihoods as sap tappers. The Gunung Halimun Salak National Park Office (BTNGHS) still facilitates several community groups around TNGHS, such as pine sap tappers, copal sap tappers, and *Pohpohan* leaf (*Pilea melastomoides*) farmers. Apart from that, African wood (*Maesopsis eminii*) and agathis (*Agathis dammara*) were often found in the GHSNP area, which *Perum Perhutani* previously planted with the aim of reforestation. These three species are suitable as shade plants for *Pohpohan*. This follows the previous study by Hartoyo *et al.* (2022) that shade trees had an important role in *Pohpohan* growth. *Pohpohan* can live at no more than 60% shading because overshading trees will affect the growth of *Pohpohan*. Pine, agathis, and African wood have medium canopy coverage, so these three species are suitable for *Pohpohan* growth, and these three species can continue to be maintained.

Table 2 Five Highest IVI

Categories	Scientific name	IVI (%)
Understory and seedling	*Pilea melastomoides*	90.13
	Pallinia ciliate	14.14
	Pandanus amaryllifolius	9.45
	Kakasoan	8.98
	Stenochlaena palustris	7.33
Sapling	*Baccaurea racemosa*	46.75
	Swietenia macrophylla	32.47
	Solanum torvum	23.38
	Agathis dammara	16.23
	Spathodea campanulate	16.23
Pole	*Baccaurea motleyana*	80.65
	Maesopsis eminii	73.47
	Artocarpus heterophyllus	54.77
	Baccaurea racemose	52.08
Tree	*Pinus merkusii*	83.96
	Agathis dammara	62.92
	Maesopsis eminii	48.45
	Altingia excelsa	36.92
	Schima wallichii	28.42

Tree Species Diversity

Biodiversity is an indicator and a mechanism for changes in ecological systems and species dynamics. Rahayu *et al.* (2017) stated that biodiversity encompasses species richness and complex ecosystems, influencing community structure, stability, and ecosystem development. Therefore, it is important to understand the relation between tree species diversity and general biodiversity. In this study, information about biodiversity is needed to assess the compatibility and interactions between plants in the study area, particularly in agroforestry land. Species diversity can be evaluated using the vegetation index values, which consist of species diversity index (H'), species dominance index (C), species richness index (R), and species evenness index (E). The vegetation index values for the GHSNP traditional zone are presented in Table 3.

Table 3 Vegetation index

Categories	H'	E	R	C
Understory and seedling	1.44 (l)	0.41	4.64 (h)	0.49
Sapling	2.04 (m)	0.93	3.03 (h)	0.15
Pole	1.55 (m)	0.96	2.05 (h)	0.22
Tree	1.89 (m)	0.74	2.58 (h)	0.20

Notes: (l) = low; (m) = moderate; (h) = high.

Shannon-Wiener species diversity index (H') measures the complexity of species interactions within a community. Soerianegara (1996) explained that there is no absolute standard for determining high or low species diversity index values, as these categories vary by location and ecosystem. However, Shannon-Wiener index values rarely exceed 4. It typically ranges from 1.5 to 3.5. In Indonesia, diversity index values below 1.5 are considered low for various forest types. H' value calculated in this study for saplings, poles, and trees fell into the medium category, while understory plants were categorized as having low diversity (Table 2). This lower diversity is attributed to the predominance of a single commodity cultivated, namely *Pohpohan* (*Pilea melastomoides*).

Species evenness index (E) ranges from 0 to 1. An E value close to 0 indicates low species evenness, while a value near 1 suggests relatively even species abundance (Magurran 2004). The highest E values were observed in the sapling and pole categories (Table 2). Hilwan and Irfani (2018) explained that the conditions of the research plot support the proliferation and domination of multiple species, as shown by a high E value. This indicates that the distribution of individuals and species at the sapling and pole level is nearly even, and the species present have the stability to maintain their populations (Ibadurrohmah 2016).

Jorgensen *et al.* (2005) set a species richness index lower limit of 2.05, considering an ecosystem's species richness to be high if it exceeds this value. In this study, all categories of trees were

in the high species richness category (Table 2). The R value corresponded to the relatively small number of species found at the tree growth level. This finding aligns with Karim (2017), who stated that a high species richness index (R) is influenced by the number of species and individuals in the study area.

The Simpson Species Dominance Index (C) ranges from 0 to 1. A dominance value close to 0 indicates that multiple species dominate equally and that no single species dominates. The understory and seedling category showed the highest C value (Table 3). This high dominance is related to the low Shannon-Wiener species diversity index (H') due to the predominance of *Pohpohan* (*Pilea melastomoides*) in the observation plot.

Management in Agroforestry *Pohpohan* (*Pilea melastomoides*) based on Traditional Ecological Knowledge

Local communities are key stakeholders with significant potential in the collaborative management of the Gunung Halimun Salak National Park. According to a village survey conducted by the GHSNPO and Japan International Cooperation Agency (2007), there were 348 villages in and around the GHSNP area, with a population of approximately 99,000. Many of these communities rely on forest resources for their daily necessities, such as firewood, animal feed, water, medicinal plants, bamboo, and agricultural land. Darusman (2000) argued that people who benefit from a forest are more likely to take action to preserve it. Several studies showed that communities around GHSNP can manage forests effectively (Rahmawati *et al.* 2008; Hendarti 2008; Adalina 2014). The more critical a party's influence, the greater the need for their involvement in natural resource management (Reed *et al.* 2009).

General Information

General information from these respondents is necessary to understand the age distribution within the community and identify the predominant types of work performed by the community. The interview results providing this general information are illustrated in Figure 3.

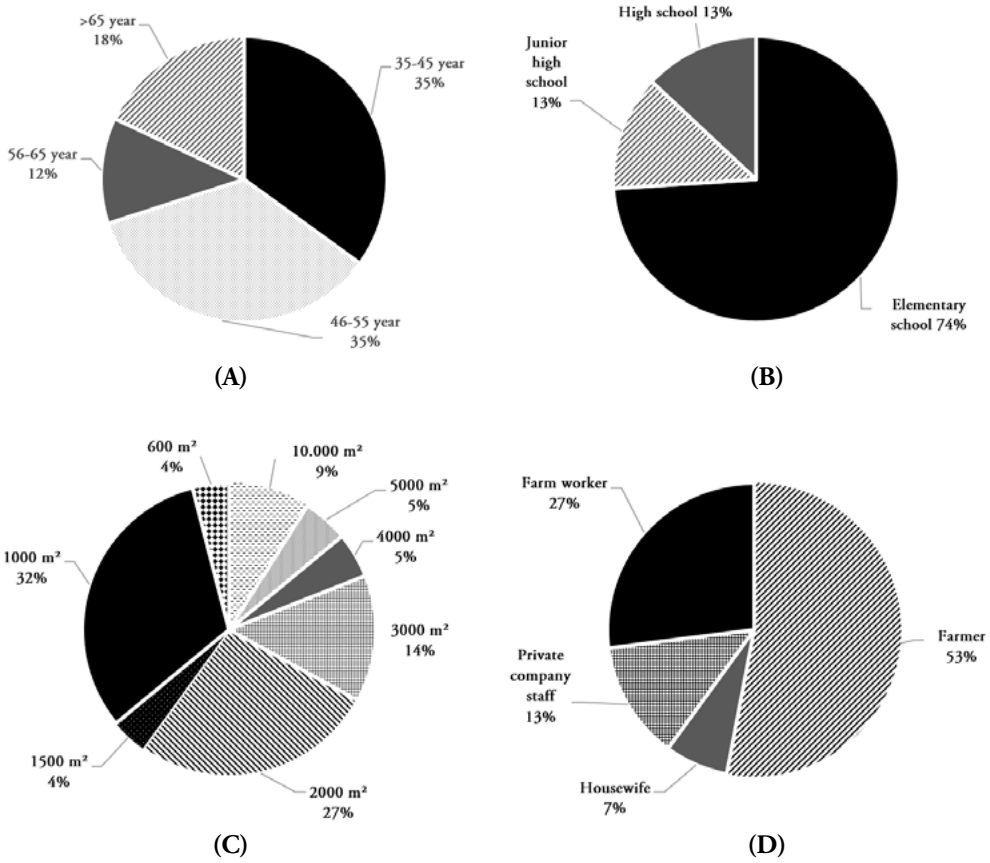

Figure 3 General information on interview results

Notes: (a) Age of respondent; (b) Educational background; (c) Large farm area; (d) Main job.

The interview results showed that of the 30 members of *Pohpohan* local farmers involved in *Kelompok Tani Mandiri* in Tamansari Village, the majority (35%) were between the ages of 35-45 years old and 46-55 years old. Interestingly, 18% of the group members, who were over 65 years old, were still actively engaged in *Pohpohan* farming activities. Most members had only completed elementary school. Only 13% of them graduated from high school.

The interviews revealed that 32% of the members had a *Pohpohan* farming area of 1,000 m2, while 27% had 2,000 m2. Only 9% owned larger land of 10.000 m2. The remaining farmers owned land ranging from 600 m2 to 5,000 m2. The primary occupation for 53% of the respondents was farming. According to the 2019 village potential data, most Tamansari Village residents worked as laborers, followed by farmers. The village also had significant potential for plantations and livestock, likely contributing to the high number of people working as farmers. Additionally, there was a tradition in the Tamansari Village community of passing down occupations from generation to generation, ensuring the continuity of certain types of jobs across generations.

Agroforestry Land Management

Interview results with 30 respondents in Tamansari Village indicated that each member employed a different management method. A summary of these interview findings is illustrated in Figure 4.

Most respondents planted *Pohpohan* at a spacing of 15 cm × 15 cm (Fig. 4). Only 4% used a spacing of 15 cm × 20 cm. Most respondents arrived at these planting distances through years of trials and errors, allowing them to determine the optimal spacing for their crops. Additionally, most respondents used synthetic fertilizer for their crops about 9 times a year, with others fertilizing between 8 and 11 times annually.

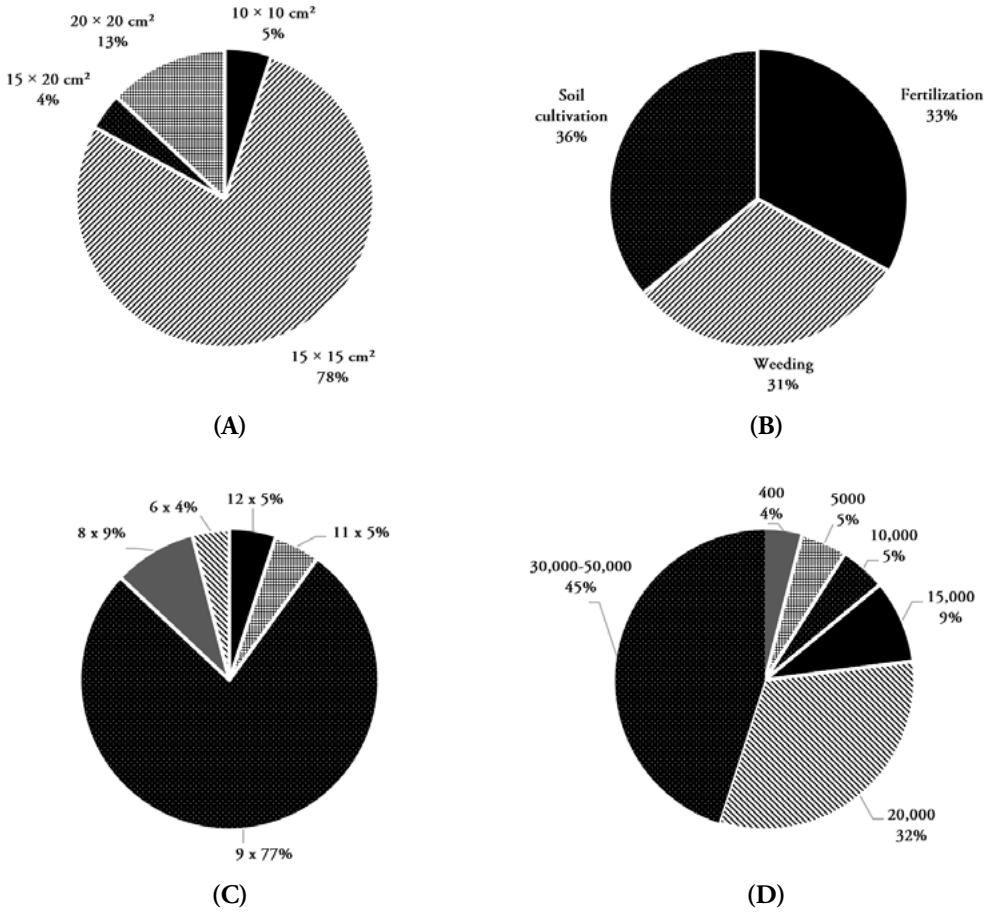

Figure 4 Agroforestry land management

Notes: (a) Plant spacing; (b) Plant maintenance; (c) Fertilization frequency per-year; (d) Production (bunch/harvest).

Regarding harvesting, the production output varied among the community members, reflecting differences in plant spacing, management practices, and total land areas. Most respondents (45%) produced between 30,000 and 50,000 bunches/harvest. As many as 32% of respondents produced 20,000 bunches/harvest. The remaining respondents produced between 400 and 15,000 bunches in one harvest. Each bunch of *Pohpohan* weighed between 15-20 g and was valued at approximately USD 0.00054 or Rp10, which meant that the income received by the community from *Pohpohan* farming ranged from about USD 154 to USD 256 per month or Rp2,400,000 – Rp4,000,000 per month. The farmers sold *Pohpohan* through some methods, such as direct sales to consumers, directly to traditional markets, and through middlemen (tengkulak).

CONCLUSION

There were 54 species from 37 families found in the rehabilitation zone of TNGHS. Rubiaceae, Malvaceae, Fabaceae, and Phyllanthaceae families were the most common families found in this study. *Pinus merkusii, Agathis dammara*, and *Maesopsis eminii* had the highest important value index (IVI). The understory and seedlings were categorized as low in H' due to the dominant presence of *Pohpohan* planting. Most respondents were farmers aged 35-55 (70%) with a farming area of 1,000 m2, who cultivated *Pohpohan* by conducting plant spacing, plant maintenance (e.g., soil cultivation, weeding, fertilization), and harvesting. Most farmers conducted fertilization 9 times a year. Farmers produced 30,000-50,000 bunches/harvest. The price of a bunch of *Pohpohan* was USD 0.00054, which made their income about USD 154 - 256 per month.

REFERENCES

Adalina Y. 2014. Implikasi modal sosial masyarakat terhadap pengelolaan taman nasional (Studi kasus Taman Nasional Gunung Halimun Salak) [The implications of community social capital on national park management (A case study of Gunung Halimun Salak National Park)]. [Dissertation]. Bogor (ID): Institut Pertanian Bogor.

Adalina Y, Nurrochmat DR, Darusman D, Sundawati L. 2014. Harvesting of non-timber forest products by the local communities in Mount Halimun-Salak National Park, West Java, Indonesia. JMHT 20(2):103-11. DOI: 10.7226/jmht.20.2.103

Adhiningsih L, Basuni S, Munawir A, Hidayati S, Hartoyo APP, Sunkar A. 2022. Sustainable utilizations of *Pohpohan* (*Pilea melastomoides* (Poir.) Wedd) in Tamansari Village, West Java- Indonesia. IOP Conf. Ser: Earth Environ Sci 1109:012091. DOI: 10.1088/1755-1315/1109/1/012091

[BTNGHS] Balai Taman Nasional Gunung Halimun Salak. 2021. Statistik Balai Taman Nasional Gunung Halimun Salak Tahun 2020 [2020 Statistics of Gunung Halimun Salak National Park]. Sukabumi (ID): Balai Taman Nasional Gunung Halimun Salak.

Darusman D. 2000. Dimensi Kemasyarakatan dalam Pengelolaan Hutan [Social Dimensions in Forest Management]. Bogor (ID): Institut Pertanian Bogor.

Ekayani M, Nuva, Rizqiyyah Y, Sinaga F, Maaruf LOM. 2014. Wisata alam Taman Nasional Gunung Halimun Salak: Solusi kepentingan ekologi dan ekonomi [Ecotourism in Gunung Halimun Salak National Park: A solution for ecological and economic interests]. JIPI 19(1):29-37.

[GHSNMP-JICA] Gunung Halimun Salak National Mountain Park-Japan International Cooperation Agency. 2007. Gunung Halimun Salak National Park, The Misty Mountains of Halimun Salak. Sukabumi (ID): Gunung Halimun Salak National Park.

Hartoyo APP, Kairunnisa S, Pamoengkas P, Solihkin A, Supriyanto, Siregar IZ, Prasetyo LB, Istomo. 2022. Estimating carbon stocks of three traditional agroforestry systems and their relationships with tree diversity and stand density. Biodiversitas 23(12):6137-46. DOI: 10.13057/biodiv/d231207

Hendarti L. 2008. Menepis Kabut Halimun: Rangkaian Bunga rampai pengelolaan sumber daya alam [Dispelling the Halimun Mist: A collection of essays on natural resource management. Jakarta (ID): Yayasan Obor Indonesia.

Hilwan I, Irfani E. 2018. Pola penyebaran dan regenerasi jenis saninten (Castanopsis argentea Blume) di Resort Selabintana, Taman Nasional Gunung Gede Pangrango [Distribution pattern and regeneration of saninten species (Castanopsis argentea Blume) in Selabintana Resort, Gunung Gede Pangrango National Park]. J Silvikultur Tropika 9(1):53-9.

Hilwan I, Mulyana D, Pananjung WG. 2013. Keanekaragaman jenis tumbuhan bawah pada tegakan sengon buto (Enterolobium cyclocarpum Griseb.) dan trembesi (Samanea saman Merr.) di lahan pasca tambang batubara PT Kitadin, Embalut, Kutai Kartanegara, Kalimantan Timur [Diversity of understory plant species in sengon buto (Enterolobium cyclocarpum Griseb.) and trembesi (Samanea saman Merr.) stands on post-coal mining land at PT Kitadin, Embalut, Kutai Kartanegara, East Kalimantan. J Silvikultur Tropika 4(1):6-10.

Ibadurrohmah N. 2016. Pola penyebaran dan regenerasi puspa (Schima wallichii (DC.) Korth.) di Resort Selabintana Taman Nasional Gunung Gede Pangrango [The distribution patterns and regeneration of puspa (Schima wallichii (DC.) Korth.) in the Selabintana Resort of Gunung Gede Pangrango National Park]. [Theses]. Bogor (ID): Institut Pertanian Bogor.

Indriyani L, Flamin A, Erna E. 2017. Analisis keanekaragaman jenis tumbuhan bawah di Hutan Lindung Jompi [Analysis of the diversity of understory plant species in the Jompi Protected Forest]. J Ecogreen 13(1):49-58.

Indriyanto. 2015. Ekologi hutan [Forest ecology]. Jakarta (ID): PT Bumi Aksara.

Ismail MH, Fuad MFA, Zaki PH, Jemali NJN. 2017. Analysis of importance value index of unlogged and logged peat swamp forest in Nenasi Forest Reserve, Peninsular Malaysia. Bonorowo Wetlands 7(2):74-8. DOI: 10.13057/bonorowo/w070203

Jørgensen SE, Costanza R, Xu FL. 2005. Handbook of ecological indicators for assessment of ecosystem health. Boca Raton (US): CRC Press.

Karim SN. 2017. Komposisi dan struktur tegakan hutan alam di areal kerja IUPHHK-HA PT Ratah Timber Kalimantan Timur [Composition and structure of natural forest stands in the working area of IUPHHK-HA PT Ratah Timber, East Kalimantan]. [Theses]. Bogor (ID): Institut Pertanian Bogor.

Kawulich BB. 2005. Participant observation as a data collection method. FQS 6(2). DOI: 10.17169/fqs-6.2.466

Magurran AE. 2004. Measuring biological diversity. Oxford (UK): Blackwell Publishing.

Margalef R. 1972. Homage to Evelyn Hutchinson, Or Why There is an Upper Limit to Diversity?. New Heaven (US): Connecticut Academy of Arts and Sciences.

Olivi R, Qurniati R, Firdasari. 2015. Kontribusi agroforestri terhadap pendapatan petani di Desa Sukoharjo 1 Kecamatan Sukoharjo Kabupaten Pringsewu [The contribution of agroforestry to farmer income in Sukoharjo 1 Village, Sukoharjo District, Pringsewu Regency]. J Sylva Lestari 3(2):1-12. DOI: 10.23960/jsl231-12

Putri SM, Indriyanto. 2021. Keanekaragaman tumbuhan penyusun vegetasi hutan lindung Bengkunat di Resor III KPH Unit I Pesisir Barat [Diversity of plant species in the protective forest vegetation of Bengkunat in Resort III Unit Management of I Pesisir Barat] J Hutan Tropis 9(1):212-21. DOI: 10.20527/jht.v9i1.10496

Rahayu GA, Buchori D, Hindayana D, Rizali A. 2017. Keanekaragaman dan peranan fungsional serangga pada area reklamasi pascatambang batubara di Berau, Kalimantan Timur [Diversity and functional roles of insects in post-mining coal reclamation areas in Berau, East Kalimantan]. J Entomologi Indonesia 14(2):97-106. DOI: 10.5994/jei.14.2.97

Rahmawati R, Subair, Idris, Gentini, Ekowati D, Setiawan U. 2008. Pengetahuan lokal masyarakat adat Kasepuhan: Adaptasi konflik, dan dinamika sosio-ekologis [Local knowledge of the Kasepuhan indigenous community: Adaptation, conflict, and socio-ecological dynamics]. J Transdisiplin Sosiologi, Komunikasi, dan Ekologi Manusia 2(2):151-90. DOI: 10.22500/sodality.v2i2.5886

Rawana, Wijayani S, Masrur MA. 2022. Indeks nilai penting dan keanekaragaman komunitas vegetasi penyusun hutan di Alas Burno SUBKPH Lumajang [Importance value index and diversity of vegetation community components in the Alas Burno Forest, SUBKPH Lumajang]. J Wana Tropika 12(2):80-9. DOI: 10.55180/jwt.v12i02.215

Reed MS, Graves A, Dandy N, Posthumus H, Hubacek K, Morris J, …, Stringer LC. 2009. Who's in and why? A typology of stakeholders analysis methods for natural resource management. J Environ Manage 90(5):1933-49. DOI: 10.1016/j.jenvman.2009.01.001

Sari DP, Lestari DI, Saputra A, Prabowo CA, Harlita. 2022. Keanekaragaman avifauna daerah terbuka dan tertutup di wilayah Kampus Kentingan Universitas Sebelas Maret [Diversity of avifauna in open and closed areas in the Ketingan Campus area of Universitas Sebelas Maret]. BIOMA 7(1):56-67. DOI: 10.20956/bioma.v7i1.19294

Simpson EH. 1949. Measurement of diversity. Nature 163:688. DOI: 10.1038/163688a0

Smith GT. 1977. The effect of environmental change on six rare birds. Emu-Austral Ornithology 77(4):173-79. DOI: 10.1071/MU9770173

Soerianegara I. 1996. Ekologi, Ekologisme dan Pengelolaan Sumberdaya Hutan [Ecology, Ecologism, and Forest Resource Management]. Bogor (ID): IPB Press.

UNESCO. 2009. Learning and knowing in indigenous societies today. Bates P, Chiba M, Kube S, Nakashima D (Editors). Paris (FR): UNESCO. 128 p.

Wahyuningsih E, Faridah E, Budiadi, Syahbudin A. 2019. Komposisi dan keanekaragaman tumbuhan pada habitat ketak (Lygodium circinatum (Burm. (SW.)) di Pulau Lombok, Nusa Tenggara Barat [Composition and diversity of plants in the habitat of ketak (Lygodium circinatum (Burm. (Sw.)) on Lombok Island, West Nusa Tenggara]. J Hutan Tropis 7(1):92-105. DOI: 10.20527/jht.v7i1.7285