

IDENTIFICATION AND MAPPING OF DUSUNG SYSTEM AS LOCAL CULTURE-BASED AGROFORESTRY IN AMBON CITY, MALUKU PROVINCE, INDONESIA

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Received: 7 February 2025 Revised: 10 June 2025 Accepted: 30 June 2025

IDENTIFICATION AND MAPPING OF DUSUNG SYSTEM AS LOCAL CULTURE-BASED AGROFORESTRY IN AMBON CITY, MALUKU PROVINCE, INDONESIA. *Dusung*, the cultural heritage of Maluku, is a unique traditional agroforestry system. Formed from shifting cultivation and patrilineal land ownership, *dusung* has adapted to the environment of small islands. *Dusung* agroforestry is an effective solution to various environmental problems in watersheds, as it has been proven to maintain soil fertility, regulate water flow, prevent erosion, increase farmers' income, and preserve biodiversity. However, so far data and information about the species, structure, composition, and distribution of *dusung* agroforestry in watershed areas are still limited. This research aims to identify and map the distribution pattern of *dusung* agroforestry based on local wisdom in the Wai Batu Gajah Watershed, Ambon City. The methods used in this study include surveys and field observations. Structured interviews with 30 *dusung* farmers were conducted to explore local knowledge and *dusung* management practices. Vegetation analysis was carried out to determine the dominant species and species diversity. Furthermore, spatial analysis was applied to visualize and analyze the distribution pattern of *dusung* in more detail. The results show that the *dusung* agroforestry system has a medium plant species diversity, with the dominance of durian (*Durio zibetinus*), gandaria (*Bouea macrophylla*), mangosteen (*Garcinia mangostana*), kecap (*Sondoricum keotjape*), langsung (*Lancium domesticum*), aren palm (*Arenga pinnata*), and salak (*Salacca zalacca*). The mapping of *dusung* distribution patterns underscores the importance of local culture in the *dusung* system's natural resource management. Study of 25 *dusung* based on *dati* (land ownership), the central role of customary institutions in maintaining this system's sustainability is clearly seen. These findings imply the need for further research to comprehensively analyze the economic, ecological, and social impacts of the sustainability of *dusung* agroforestry through the integration of local culture.

Keywords: Traditional forest farming, biodiversity, conservation, local wisdom, small island

IDENTIFIKASI DAN PEMETAAN SISTEM DUSUNG SEBAGAI AGROFORESTRI BERBASIS BUDAYA LOKAL DI KOTA AMBON, PROVINSI MALUKU, INDONESIA. *Dusung*, warisan budaya Maluku, adalah sistem agroforestri tradisional yang unik. Terbentuk dari sistem lahan berpindah dan kepemilikan lahan patrilineal, *dusung* telah beradaptasi dengan lingkungan pulau kecil. Agroforestri *dusung* adalah solusi yang efektif untuk berbagai permasalahan lingkungan di daerah aliran sungai (DAS), karena terbukti mampu menjaga kesuburan tanah, mengatur aliran air, mencegah erosi, meningkatkan pendapatan petani, dan melestarikan keanekaragaman hayati. Namun permasalahannya data dan informasi mengenai jenis tanaman, struktur, komposisi dan sebaran agroforestri *dusung* pada kawasan DAS masih belum tersedia. Penelitian ini bertujuan untuk mengidentifikasi dan memetakan pola sebaran agroforestri *dusung* berbasis kearifan lokal di DAS Wai Batu Gajah, Kota Ambon. Metode yang digunakan dalam penelitian ini meliputi survei dan observasi lapangan. Wawancara terstruktur dengan 30 petani *dusung* dilakukan untuk menggali pengetahuan lokal dan praktik pengelolaan *dusung*. Analisis vegetasi dilakukan untuk menentukan jenis vegetasi dominan dan keanekaragaman spesies. Selanjutnya, analisis spasial diterapkan untuk memvisualisasikan dan menganalisis

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*pola sebaran dusung secara lebih rinci. Hasil penelitian menunjukkan bahwa sistem agroforestri dusung memiliki nilai keanekaragaman spesies yang tergolong sedang, dengan dominasi durian (*Durio zibetinus*), gandaria (*Bouea macrophylla*), manggis (*Garcinia mangostana*), kecap (*Sondoricum koetjape*), langsung (*Lancium domesticum*), aren palm (*Arenga pinnata*), dan salak (*Salacca zalacca*). Pemetaan pola sebaran dusung menggarisbawahi pentingnya kearifan lokal dalam pengelolaan sumber daya alam dalam sistem dusung. Hasil kajian terhadap 25 dusung yang berlandaskan pada kepemilikan lahan datar, terlibat jelas peran sentral kelembagaan adat dalam menjaga keberlanjutan sistem ini. Temuan ini mengimplikasikan perlunya penelitian lebih lanjut untuk menganalisis secara komprehensif potensi ekonomi, dampak ekologi, dan dampak sosial dari keberlanjutan agroforestri dusung melalui integrasi kearifan lokal.*

Kata kunci: Kearifan lokal, keanekaragaman hayati, konservasi, pertanian butan tradisional, pulau kecil

I. INTRODUCTION

Environmental degradation in various parts of the world, especially in watersheds, has become a global issue that requires immediate attention and action. One of the most pressing challenges in this context is climate change, which significantly impacts various aspects of life, including the availability and competition of natural resources. As the main resource providers of life on land, watersheds become the conflict arena between human needs and environmental sustainability. In many cases, human activities often ignore sustainability principles, resulting in ecosystem damage, pollution, and soil quality deterioration (Guerra et al., 2020; Li et al., 2023).

The impact of climate change is especially happen on small islands, where watersheds play a crucial role in sustaining people's lives. Small islands, with unique watershed ecosystem characteristics, have limited resources and carrying capacity, making them the most vulnerable to climate change. This is due to its isolated geographical conditions, large coastal areas, and low economic diversification (Vrontisi et al., 2022). The impact of climate change on watersheds on small islands needs concern, as watersheds play an important role in all aspects of ecosystems, including clean water provision, local climate regulation, and support for biodiversity (Pristianto & Butudoka, 2023). These impacts are diverse, ranging from rising sea strata and coastal erosion to changes in rainfall patterns and increased frequency of disasters from weather impacts. This affects

the quality and quantity of water, agricultural yields, food security, and surface water systems (Nagireddy et al., 2023). Therefore, sustainable management of natural resources in watersheds on small islands is crucial and requires more intensive conservation, mitigation, and adaptation efforts.

The Wai Batu Gajah Watershed, as a representation of the Ambon Island ecosystem, plays a crucial role in maintaining environmental balance, supporting the community's economy, and preserving its cultural values. As one of the water source for Ambon City, the Wai Batu Gajah Watershed is currently facing various environmental challenges. The narrow watershed area, coupled with steep topography, makes it vulnerable to disasters such as floods, landslides, and sedimentation (Talakua & Osok, 2017; Manakane et al., 2023). In addition, the decrease in land cover and the increase in residential areas are increasingly threatening the sustainability of this watershed. An adaptive, sustainable, and integrated land use management of the watershed is needed to minimize negative environmental impacts and overcome these challenges. One approach that can be applied is an agroforestry system.

An agroforestry system is a future land use solution and offers many benefits for the sustainability of natural resources and the environment (Prabawani et al., 2024). Agroforestry landscape is a sustainable land use system that maintains or increases total crop yields by combining food crops (annual) with tree crops (perennial) or livestock on the same

land unit either simultaneously or alternately and managing it according to the ecological, economic, social and cultural characteristics of the local community (Vergara, 1982). In various parts of the world, agroforestry systems have been shown to improve farmers' welfare (Sulistiyowati et al., 2023), increase soil fertility (Octavia et al., 2023; Muchane et al., 2020), regulate water systems (Zomer et al., 2023), conserve biodiversity (Salt & Freudenberger, 2009; Octavia et al., 2022), increase food security (Octavia et al., 2024), mitigate climate change (van Noordwijk et al., 2021), and overcoming land degradation (Leakey, 2020).

In Indonesia, the concept of agroforestry has been applied in various forms. In Maluku, this system is uniquely known as *dusung*, which is a cultural heritage left by ancestors to their descendants, in the form of woody plants (trees), fruit plants, sago plants, palm plants, spice plants, or medicinal plants (Hatulesila, 2022). *Dusung* is the transformation from shifting cultivation practice towards permanent tree crop cultivation with patrilineal land ownership. *Dusung* is an intangible asset that includes indigenous knowledge and indigenous technology. It has norms and rules, embodied in *Sasi* and *Kewang*, which are customary institutions that maintain the sustainability of ecological and cultural systems on small islands (Ririhena, 2015). According to Girsang et al. (2023), the *dusung* ecological system generally consists of five subsystems: *Ewang* (forest), *A'ong* (*dusung*), *K'abong* (food and vegetable crops), *Kintal* (home garden), and coastal.

Dusung, as a form of traditional agroforestry and local community wisdom, is one alternative development model with the potential to serve as a soil and water conservation pattern to address problems in the Wai Batu Gajah Watershed. This is consistent with the findings of Asdak et al. (2023), who emphasize the importance of maintaining and promoting local wisdom in water resource conservation management within the framework of national policy, given that each region has unique characteristics in treating its environment sustainably. *Dusung*

management by maintaining a minimum of 30% forest in land use in the watershed can produce a river discharge of 75.66 liters/second or 6537.02 m³/day. This figure shows a significant increase compared to the condition of *dusung* management without maintaining forests in land use, where the resulting river discharge is only 1,412.16 mm or equivalent to 1.41m³/second (Jacob, 2018).

The concept of *dusung* as a traditional agroforestry system, intended as a conservative agricultural pattern in the watershed area, is very promising, but its management is not optimal. This is because detailed information on its diversity, structures, the composition of *dusung* plants, and the distribution of *dusung* patterns in watershed areas based on local culture is still unavailable. In addition, *dusung* is still a subject of debate, primarily related to the complex relationship between land ownership rights (institutional), ecological, social, and cultural.

Several studies on agroforestry in global watershed areas have been conducted, but have focused only on conservative agricultural systems in addressing erosion, climate change, food crises, and economic value. Meanwhile, this study focuses on the study of *dusung* as a traditional agroforestry in the small island watershed area by identifying the species, composition, and structure of *dusung* agroforestry and mapping the distribution of *dusung* patterns based on local culture, which includes land ownership and customary institutions that help regulate the sustainability of *dusung* agroforestry. This research also seeks to see local communities' perceptions towards *dusung* agroforestry, how the community maintains *dusung*, and how the *dusung* pattern is formed in the community.

II. MATERIALS AND METHODS

This research has been approved by the Research Ethics Commission Involving Human Subjects of Bogor Agricultural University with the issuance of a Certificate of Passing the Ethical Assessment Number: 1420/IT3. KEPMSM-IPB/SK/2024 on August 28, 2024.

A. Location and time of research

The research was carried out in the *dusun* agroforestry area, Wai Batu Gajah Watershed, Sirimau District, Ambon City (Figure 1). The research took place from September to November 2024. The analysis was carried out at the Land Management Laboratory, Faculty of Agriculture, Pattimura University Ambon.

The Wai Batu Gajah Watershed has a catchment area of approximately 641.87 ha with a river length of 3,100 m (BPDAS 2019). The Watershed is located between the coordinates of 3°43'25"- 3°41'49"S and 128°12'22"-128°10'34"E. Administratively, the watershed covers several sub-district areas.

In the upstream part are *Negeri Soya*, *Negeri Hatalai*, and *Negeri Urimessing*. Meanwhile, in the central part, there are urban villages of Batu Gajah and Batu Meja, and in the downstream, there are urban villages of Urimessing, Ahusen, Honipopu, Waihaong, Silale, and Uritetu.

The entire Wai Batu Gajah Watershed resembles a fan, with tributaries flowing into the main river from both the left and right sides. The tributaries flow concentrated to one point in the *Negeri Soya*. Based on the Oldeman classification system (1975), the Wai Batu Gajah Watershed is a climate type A1, classified as a very wet area, with tropical rainforests having >9 wet months and <2 dry months.



Figure 1. Research location map

Table 1. Area in the upstream of the Wai Batu Gajah Watershed

No	Region	District	Area (ha)	%	Number of Dusun (land ownership)
1	Negeri Soya	Sirimau	301,87	72	14
2	Negeri Hatalai	South Leitimur	64,67	15	5
3	Negeri Urimessing: Tuni Village	Nusaniwe	36,65	9	2
4	Negeri Urimessing: Kusu-kusu Village	Nusaniwe	18,33	4	4
Total			421,52	100	25

This research was carried out with a focus on the upstream area of the watershed, where secondary dryland forests, known as *dusung*, are the dominant land use, covering 300.9 ha, or 46.88% of the total watershed area. Administratively, the upstream of the Wai Batu Gajah Watershed consists of three negeri (region), namely Soya, Hatalai, and Urimessing. Negeri Urimessing consists of four villages, two of which are located within the watershed area: Tuni Village and Kusu-kusu Village (Table 1). Ambon City still adheres to the government system of negeri. The term *negeri* refers to a village or region. Negeri is a communion of indigenous peoples, both genealogically and territorially, based on customs and culture (Ririhena, 2015).

B. Methods

1. Tools and materials

The equipment used in this study was Global Positioning System (GPS), roller meters, raffia ropes, machetes, computers with ArcGIS software, Avenza Maps application, Microsoft Office and Microsoft Excel, and cameras. The materials used were land unit maps (fieldwork maps), questionnaires, and plant identification books.

2. Types and collection of data

The study employed both primary and secondary data. Primary data included physical environmental data such as soil characteristics, topography, slope, land use, and plant species, while secondary data includes rainfall data and maps.

Primary data collection was carried out using transects and quadrat methods, while socio-cultural data collection used structured interviews with 30 sample participants. The participant sample selection technique was purposive sampling, with criteria including: (1) being the owner of the *dusung*, (2) aged 35-70 years, (3) active in the *dusung*, (4) having a clear land ownership status. Secondary data collection was carried out by visiting related agencies and collecting data: 1) Wai Batu Gajah Watershed

Boundary Map; 2) Ambon Island Demnas Map; 3) Geological Map of Ambon Sheet; 4) Land Classification Map of Ambon City; 5) Indonesian Base Map of Ambon Sheet; 6) Bing Map Satellite Image Map and ESRI ArcGIS Imagery of Ambon City; 7) Image of SPOT 7 2024 - Ambon City; 8) Ambon City Regional Spatial Plan Map; 9) Geomorphological Map of Ambon Island Watershed; 10) Bulk and Agroclimatological Data of Ambon City in 2013-2023.

3. Participant characteristics

The selection of participants was carried out deliberately among farmers with the following criteria: a) having status as *dusung* owners; b) having more activities in *dusung*; c) having more than one *dusung*; d) having diverse plant species in *dusung*; e) the primary source of income is from crops in *dusung*. The selected sample of participants in the upstream area of the Wai Batu Gajah Watershed comprised 30 farmers aged 40-76 years. The basis for determining participants in this study followed the Central Limit Theorem, which states that 30 samples are the minimum required to approximate a normal distribution. This theory is supported by Thomson's (2010) statement that to obtain more in-depth data with a strong foundation, the number of participants can be increased to 30. Thus, researchers can identify more complex patterns, concepts, and dimensions.

Participants came from three *negeri*. There were 15 participants from *Negeri Soya*, 10 participants from *Negeri Urimessing*, and 5 participants from the *Negeri Hatalai*. Most participants had the latest strata of education in elementary, junior high, and higher education.

C. Analysis

1. Delineation of land units and transects

The delineation of land units was carried out based on the integration or overlay of several maps using ArcGIS, and then the land unit map output would be used as a fieldwork map. The overlay maps were land-use maps from the interpretation of ESRI

ArcGIS Imagery of Ambon City; Geological Maps of Maluku Province; Demnas Maps of Ambon Island; Land Classification Maps of Ambon Island; Terrain Maps; Maps of the Wai Batu Gajah Watershed; and Raw Water Resources Maps. After the land unit map was obtained, transect line plots were prepared for each *negeri* and village based on it. The use of transect lines allows researchers to capture spatial variation in vegetation composition and environmental conditions along elevation gradients, which is particularly important given the diverse topography of the watershed (Li, 2023). Transect lines were established in each *negeri*, starting from a point along the river and moving uphill to hilly areas. This transect line method is in line with the work of Iqbal et al. (2023), who described the delineation of transects derived from river morphology, taken from the midpoint of the river that extends to different upstream and downstream areas, thus providing a basis for understanding ecological interactions on elevation gradients. In total, 4 transect lines were established, with 1 (one) transect each in each *negeri* and village.

2. Vegetation analysis in the *dusung* agroforestry system

Vegetation analysis was carried out to see the species, structure, and composition of *dusung* agroforestry plants and determine the dominant species. The determination of dominant vegetation was carried out by calculating the Summed Dominance Ratio (SDR), which was a value that described the ability of a specific type of vegetation to control the existing mean of growth, and then calculating the Important Value Index (IVI), which was a value that showed the role of a plant species in the community (Mueller, 1974). In each of the selected *dusung* agroforestry transect routes, research plots were made using the quadrant plot method with sizes of 20x20m for tree, 10x10m for pole, 5x5m for sapling, and 2x2m for seedling (Figure 2). The number of replications in each plot was adjusted to the area and the number of *dusung* in each *negeri* (Table

1). This study grouped measurements into plants stages of seedling, sapling, pole, and tree based on the height and diameter of the stem. With this method, the researcher aims to obtain accurate and representative data regarding plant species diversity in each *dusung*.

20 m x 20 m

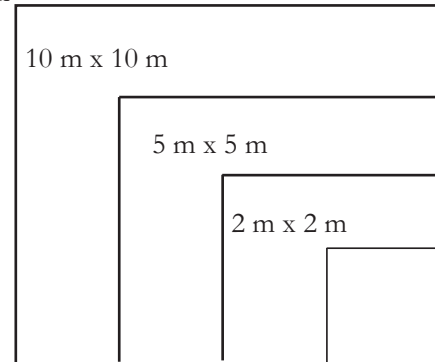


Figure 2. Plot form of quadrant plot sampling (Gondard, 2006)

Vegetation data obtained in the field is then analyzed by calculating:

- a) The density, frequency, dominance, and IVI of plant species in *dusung* agroforestry studied based on Cox (1985) and SDR based on Janiya and Moody (1989) are as follows:

$$\text{Density (D)} = \frac{\text{Number of individuals}}{\text{Area of the sample}} \tag{1}$$

$$\text{Relative Density (RD)} = \frac{\text{Density of a type}}{\text{Density of all types}} \times 100 \tag{2}$$

$$\text{Frequency (F)} = \frac{\text{Number of tiles found in a type}}{\text{number of all sample tiles}} \tag{3}$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of a type}}{\text{Frequency of all types}} \times 100 \tag{4}$$

$$\text{Dominance (D)} = \frac{\text{The Basic area of a type}}{\text{Location of sample plot}} \tag{5}$$

$$\text{Relative Dominance (RD)} = \frac{\text{Dominance of a type}}{\text{Dominance of all types}} \times 100 \tag{6}$$

$$\text{IVI for trees and poles} = \text{RD} + \text{RF} + \text{RD} \tag{7}$$

$$\text{IVI for saplings and seedlings} = \text{RD} + \text{RF} \tag{8}$$

$$\text{SDR for trees and poles} = \frac{\text{IVI}}{3} \tag{9}$$

$$\text{SDR for saplings and seedlings} = \frac{\text{IVI}}{3} \tag{10}$$

3. Analysis of plant species diversity

The diversity of vegetation was determined using Shannon-Wiener index analysis of each quadrat sample along each transect line. Species diversity is calculated by the Shannon index formula (H') (Ludwig and Reynolds 1988) as follows:

$$H' = -\sum_{i=1}^n \left(\frac{n_i}{N}\right) \ln\left(\frac{n_i}{N}\right)$$

Information:

n_i : Number of species

N : Total of all species

H' : Shannon-Wiener diversity index

The value of Shannon-Wiener species diversity (H') indicates the stability and complexity of a community. Odum (1993) classified the categories of the Shannon-Wiener (H') diversity index into three categories: $H' > 3$ (high), $1 \leq H' \leq 3$ (medium), dan $H' < 1$ (low).

4. Mapping the distribution pattern of dusung agroforestry based on local culture

The distribution pattern of *dusung* agroforestry was mapped using a qualitative method with participatory observation through interviews with 30 *dusung* owners, a review of questionnaires, and field ground checks to obtain coordinate points for several *dusung* land holdings. After obtaining coordinate points, information on the use of *dusung*, socio-cultural values, limitations on *dusung* ownership, and *dusung* management in local culture, then the digitization process was carried out in two stages: 1) manual digitization (sketch) on the map sheet of land units on a scale of 1: 15:000, carried out with a Focus Discussion Group (FGD) approach between key informants: they were 4 *dusung* owners, 1 *Kewang*, and 2 *negeri* apparatus. *Kewang* (customary police) is a customary institution that functions to protect

the land as a customary right of *negeri* in the land area; 2) after the *dusung* sketch was obtained, it was spatially poured using ArcGIS software based on the coordinate points that had been taken previously. The stages in the GIS analysis process consisted of the data input, processing, analysis, and result or output stages. The output of the GIS analysis was a map of the distribution of *dusung* agroforestry with a scale of 1: 15,000.

III.RESULT AND DISCUSSION

A. Identification of species, composition, and structure of agroforestry plant in the Wai Batu Gajah Watershed, Ambon City

Dusung agroforestry in the Wai Batu Gajah Watershed area is mostly used for producing agricultural and forestry products (Hairiah et al., 2003). The species of *dusung* plants are very diverse, ranging from long-lived plants (perennial) and short-lived plants (annual) with a mixture random planting patterns (Figure 3). This planting pattern is characterized by irregular planting of trees (not following runs or paths between food crops). This form is often found in traditional agriculture, where trees grow from natural regeneration and not through direct cultivation (Sahureka et al., 2024).

The species of *dusung* agroforestry found at the research site consisted of forestry plants such as: gomu (*Artocarpus communis*), sago (*Metroxylon sago*), bamboo (*Bambusa sp.*), gayam (*Inocarpus edulis*), palm (*Arenga pinnata*), salawaku



(a)



(b)

Figure 3. *Dusung* with a random mixture pattern: (a) View from inside the *dusung*, (b) View of the *dusung* canopy

(*Paraserianthes falcataria*), waru tree (*Hibiscus tiliaceus*), timber titi (*Gmelina moluccana*), katimaha (*Kleinhofia hospital*), ganitri wood (*Elaeocarpus saphaericus*), galoba (*Alpinia sp.*), timo wood (*Timoneus sericeus*), fir (*Casuarina equisetifolia*), linggua (*Pterocarpus indicus*), agarwood (*Aquilaria spp.*), and noni (*Morinda citrifolia*). Agricultural tree crops such as: coconut (*Cocos nucifera*), cloves (*Syzygium aromaticum*), nutmeg (*Myristica fragrans*), langsung (*Lancium domesticum*), gandaria (*Bouea macrophylla*), durian (*Durio zibethinus*), melinjo (*Gnetum gnemon*), cashew (*Anacardium occidentale*), jackfruit (*Artocarpus heterophyllus*), breadfruit (*Artocarpus communis*), and kecapi (*Sandoricum koetjape*), while lower crops are banana (*Musa sp.*), pineapple (*Ananas comosus*), cassava (*Manihot esculenta*), taro (*Xanthosoma sagittifolium*), and galangal (*Alpinia galanga*).

B. Important Value Index and Summed Dominant Ratio of dominant plants

The Important Value Index (IVI) and Summed Dominant Ratio (SDR) are parameters used to express the stage of dominance of species in a plant community. The higher the IVI and SDR values of a species relative to other species, the higher the role or stage of

mastery of the species in the community (Mueller, 1974).

1. IVI and SDR of *dusun* agroforestry plant in Negeri Soya

Negeri Soya dominates the Wai Batu Gajah Watershed upstream, with an area of 301.87 ha or 72% of its total area. Such a significant area indicates a considerable potential to support biodiversity in *dusun* agroforestry practices. Observations in *Negeri Soya* show differences in plant species dominance across growth stages. The tree stage are dominated by durian (*Durio zibethinus*), the pole stage by the kecapi (*Sandoricum koetjape*), the sapling stage by salak (*Salacca zalacca*), and the seedling stage are dominated by ferns (*Selaginella wildani*) (Figure 4). The dominance of fruit crops, especially durian and kecapi, in the stage of trees and pole is in line with the findings of Ririhena (2015) study, which shows that *dusun* farmers in *Negeri Soya* are more likely to cultivate fruit and spice crops because of their economic value.

Result of the interviews found that *dusun* farmers more focused on the economic value in selecting the crops they plant. This is because *dusun* agroforestry is the main source of

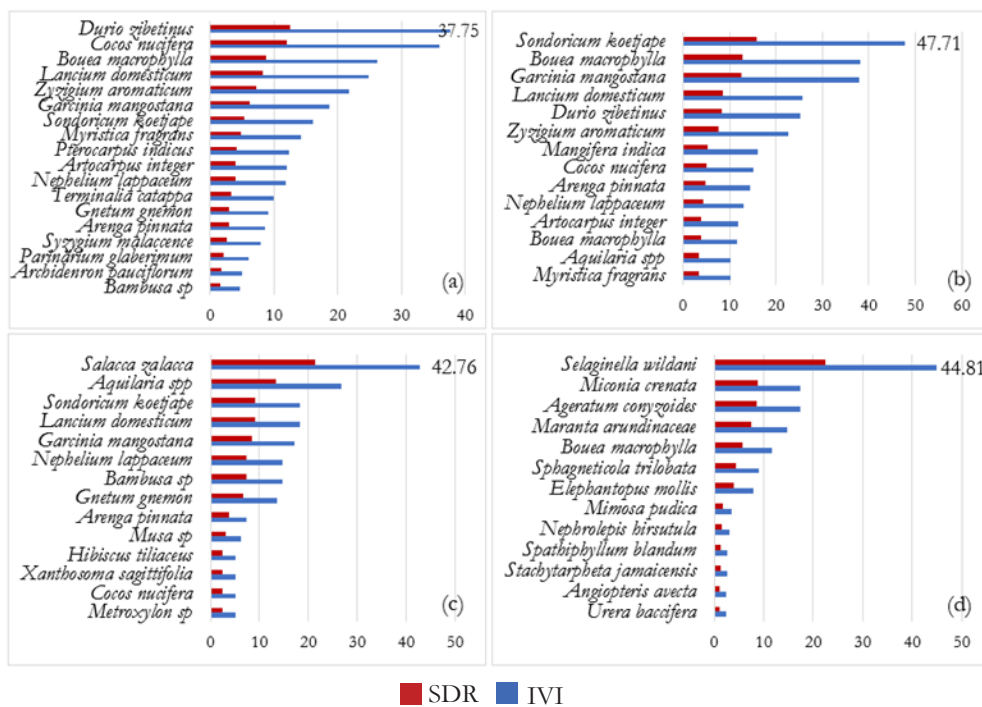


Figure 4. IVI and SDR of *dusun* agroforestry plant in *Negeri Soya*: (a) Treestage, (b) Pole stage, (c) Sapling stage, (d) Seedling stage

income for most households in the region, so farmers tend to choose crops with promising market potential. Agroforestry practices, as emphasized by Prastiyo et al., (2018), has been proven to increase crop production, which in turn ensures the stability and sustainability of farmers' income. In line with this, Maalalu (2020) also emphasized that the sustainability of hamlets is highly dependent on farmers' ability to meet their economic needs.

Other species of fruit plants that are cultivated by farmers and have economic value include gandaria (*Bouea macrophylla*), rambutan (*Nephelium lappaceum*), and langsung (*Lansium domesticum*). In addition, there are also spice plants species, such as cloves (*Zyzygium aromaticum*) and nutmeg (*Myristica fragrans*) commonly planted in *dusung*. Apart from its economic value, fruit plant species have an important ecological function as well for land conservation. This is in line with the findings of Prastiyo et al., (2020) which showed that about 38% of agroforestry plant species in the tree strata that dominate the growing area function as conservative plants in maintaining ecosystem stability, such as reducing sedimentation accumulation, preventing erosion, and as buffer plants on

steep topography. One example of a local plant in Maluku that has a conservation function is kecapi (*Sondoricum koetjape*), whose deep root system can function for reforestation and rehabilitation of critical land (Ririhena, 2015). The results of the calculation of the dominant value of the species found that kecapi dominates the land cover in *Negeri Soya*, which is shown by its appearance in the stage of trees, poles, and saplings. Furthermore, seedling stage analysis shows the existence of 28 species of grass with a total of 395 individuals. The dominance of this grass species in the underlayer indicates its important role in preventing erosion, reducing run off, and maintaining soil fertility. In addition, dominant grass species such as *Selaginella wildani* and *Ageratum conyzoides* indicate the potential for further utilization as a source of biopharmaceuticals (Silalahi, 2019).

2. IVI and SDR of *dusung* agroforestry plant in *Negeri Hatalai*

Diversity of plant species in *Negeri Hatalai* is high in various growth stage. There are 17 species in the tree stage, 9 species in the pole stage, 10 species in the sapling stage, and 14 species in the seedling stage (Figure 5), with an

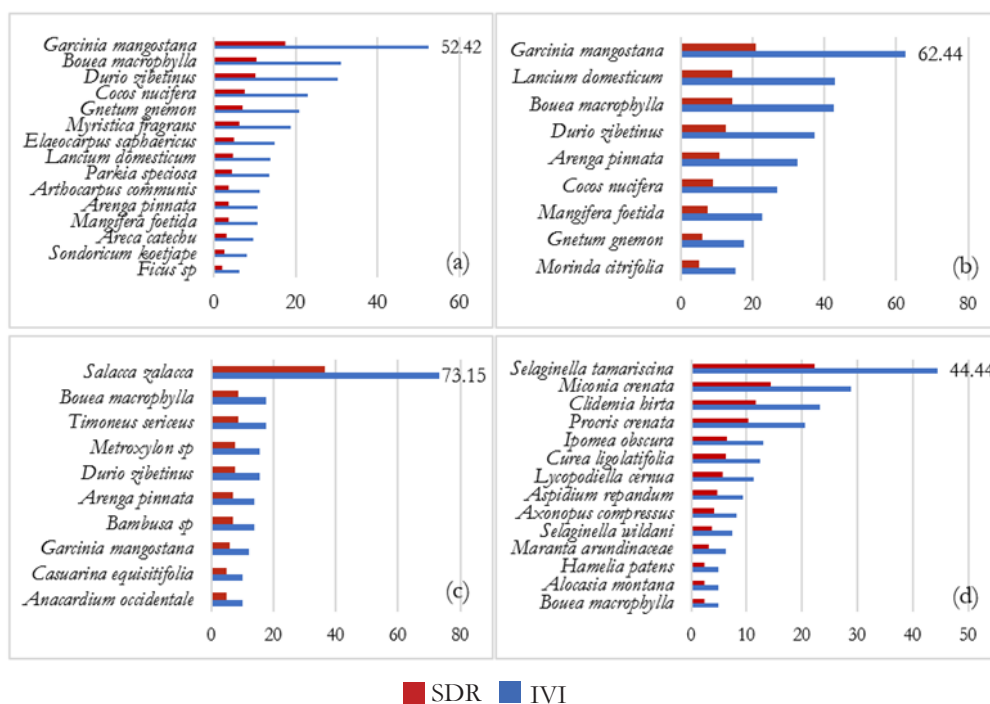


Figure 5. IVI and SDR of *dusung* agroforestry plant in *Negeri Hatalai*. (a) Tree stage, (b) Pole stage, (c) Sapling stage, (d) Seedling stage

area of 64.67 ha or 15% of the total upstream area of the watershed. The results of IVI and SDR calculations show that the plant species that dominate this area are fruit plants, namely mangosteen (*Garcinia mangostana*) in the tree and pole stage and salak (*Salacca zalacca*) in the sapling stage. Meanwhile, the seedling stage are dominated by fern grass, *Selaginella tamariscina*. The interview results indicate that mangosteen is the primary commodity cultivated by Hatalai Dusung farmers. Mangosteen, a heritage and well-adapted plant to the local environment, has significant economic value for the income of the farmer's family.

In addition to mangosteen, durian, gandaria, coconut, breadfruit, langsat, nutmeg, and salak are also important cultivated crops in this region. Moreover, the region is rich in biodiversity, including various species of forestry plants such as palm (*Arenga pinnata*), pine (*Casuarina equisetifolia*), ganitri wood (*Elaeocarpus saphaericus*), and gohi (*Ficus sp.*). The dominance of *Selaginella tamariscina* species is detected at the seedling stage, followed by *Miconia crenata*, *Clidemia hirta*, *Curea ligolatifolia*, and *Procris crenata*. The diversity of these grass species indicates great potential as a source of

biopharmaceuticals (Silalahi, 2019; Youn, 2024) and plays a vital role in preserving soil. This aligns with a study by Moncada (2022), which states that grass species at the seedling stage can increase soil resistance to erosion. They achieve this by strengthening soil aggregates through dense root networks and root secretions that act as natural adhesives. In addition to erosion resistance, plants with a distinct structure and dense canopy arrangement buffer surface run-off, thereby increasing soil infiltration and groundwater capacity. This is particularly important for watersheds on small islands characterized by steep topography, which are sensitive to drought due to limited water resources and the threat of erosion, which can significantly affect water quality and quantity. Thus, diverse grass species at different stages of growth in watershed areas can improve soil stability and protect water resources on small islands (Silaya & Latupapua, 2024).

3. IVI and SDR of *dusung* agroforestry plant in Tuni Village

Tuni Village is part of the *Negeri* Urimessing, which covers 36.65 ha, or 9% of the watershed's upstream area. There are 20 plants species found at the tree stage, 12 species at the pole

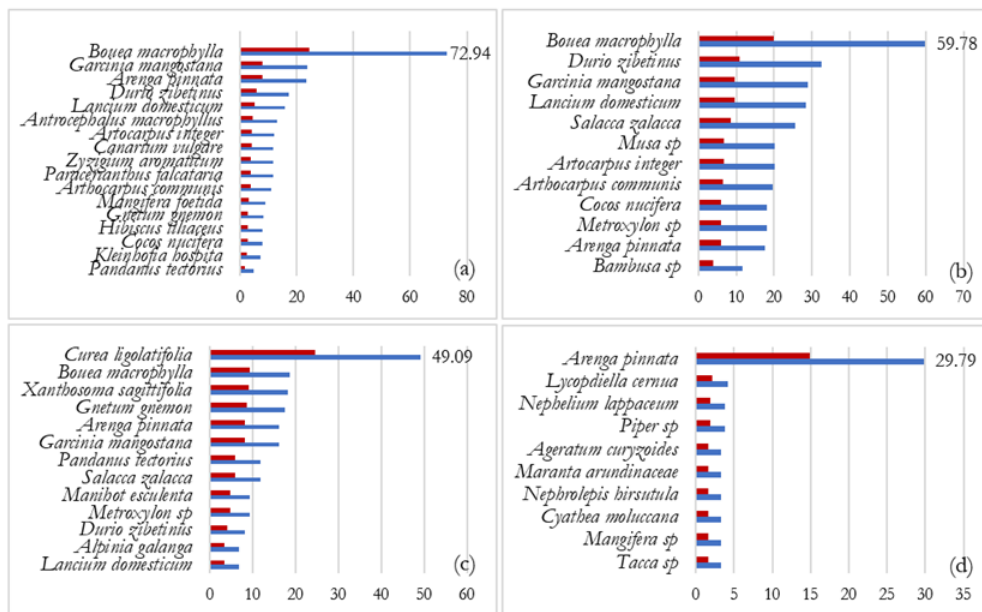


Figure 6. IVI and SDR of *dusung* agroforestry plant in Tuni Village. (a) Tree stage, (b) Pole stage, (c) Sapling stage, (d) Seedling stage

stage, 13 species at the sapling stage, and 25 species at the seedling stage. The results of IVI and SDR calculations found that the plant species that dominate *Dusung* Tuni are gandaria (*Bouea macrophylla*) at the tree and pole stage, kora-kora (*Curea ligolatifolia*) at the sapling stage and palm (*Arenga pinnata*) at the seedling stage (Figure 6). Gandaria dominates almost of all growth stage, and has the highest Important Value Index (IVI). In that case, gandaria shows high growth stability in the ecosystem than other species. Thus, the dominance of gandaria reflects its adaptability to the environment and its significant contribution to the diversity and balance of the surrounding ecosystem (Silaya & Latupapua, 2024).

Results of interviews with Tuni *Dusung* farmers revealed that there is an interesting cultivation pattern. Although gandaria (*Garcinia mangostana*) dominates the ecosystem with high IVI values, local communities rely on palm plants (*Arenga pinnata*) as an important commodity. Palm sugar (*nira*) is processed into a traditional *sageru* drink, which has high socio-cultural value for the people in Maluku and is known as a symbol of *simplicity and togetherness* (Ririhena, 2015). Uniquely, the sugar palm

has a long harvest cycle and stable economic value, making it a sustainable source of income for farmers. The economic potential of this palm plant is supported by various studies, including Azhar et al. (2022), which showed that farmers' total income in a year amounted to 15,600,000 IDR with an R/C value of 2.84, and a study by Titabano, Pattinama, and Thenu (2018) that showed the average farmers' income from production of palm sap for *sageru* was 3,099,284 IDR with a BCR value of *sageru* processing by 1.60. This indicates that the business of processing palm derivative products, such as palm sugar and *sageru*, has high economic feasibility.

4. IVI and SDR of *dusung* agroforestry plant in Kusu-kusu Village

Kusu-kusu Village, has an area of only 18.33 ha or 4% of the total upstream area of the Wai Batu Gajah Watershed. Even though it is the smallest area, Kusu-kusu Village also has a relatively high diversity of plant species. Observations indicate 11 species of trees, 6 species of poles, 11 species of saplings, and 8 species of seedlings. Despite having a relatively small area, Kusu-kusu Village contributes to the biodiversity in the upstream watershed area.

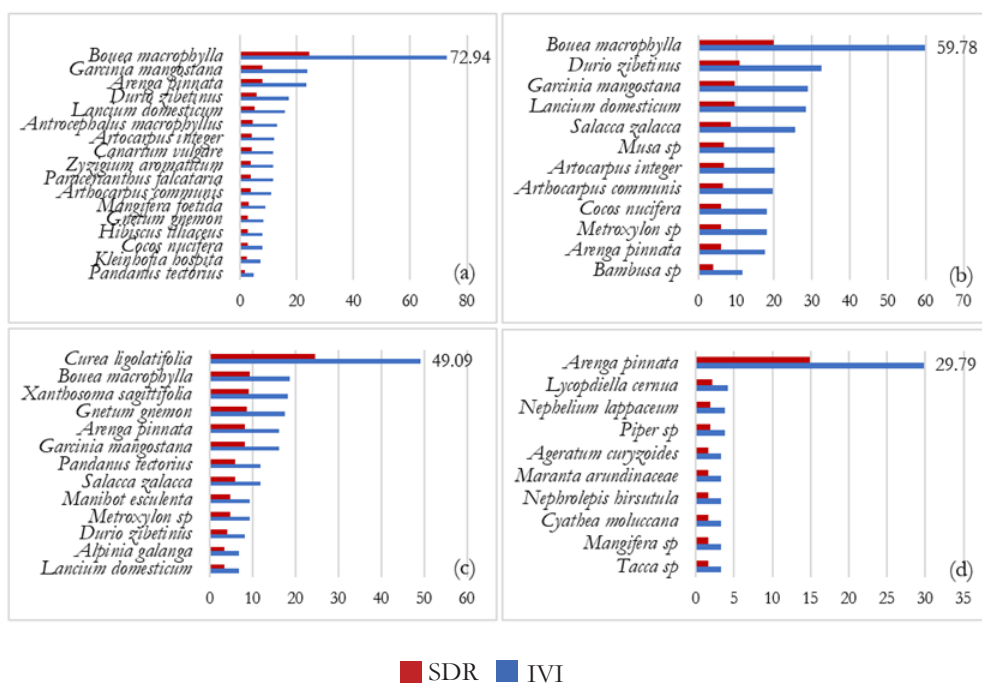


Figure 7. IVI and SDR of *dusung* agroforestry plant in Kusu-kusu Village. (a) Tree stage, (b) Pole stage, (c) Sapling stage, (d) Seedling stage

The results of IVI and SDR calculations show that fruit crops that dominate the area are durian (*Durio zibetinus*) at the tree stage, gandaria (*Bouea macrophylla*) at the pole stage, langsung (*Lancium domesticum*) at the sapling stage, and pakis merak (*Selaginella wildani*) at the seedling stage (Figure 7).

The results of the vegetation analysis in Kusu-kusu Village show a pattern similar to that of the other three villages, which have high diversity of plant species. The vegetation composition includes a wide range of species, from perennials to annuals. The structure of the dusung agroforestry canopy in this village is complex, with clear stratification and diverse root systems. This characteristic indicates that dusung agroforestry is a sustainable land management system, able to increase biodiversity (Salt & Freudenberg, 2009), increase carbon storage capacity (Filqisthi et al., 2017), and plays an important role in mitigating natural disasters such as erosion and landslides (van Noordwijk et al., 2021). In addition, this system also contributes to the preservation of soil fertility (Muchane et al., 2020; Octavia et al., 2023).

C. Species diversity index (H') of *dusung* agroforestry vegetation in the Wai Batu Gajah Watershed

Based on observations, it was found that the richness of plant species in the upstream part of the Wai Batu Gajah Watershed is relatively high, with 95 species of trees belonging to 35 families. The dominance of plant species in the *dusung* agroforestry in this region is shown by the Myrtaceae family, which includes species such as cloves, rose apple, malay apple, and guava, as well as the Arecaceae family, which includes palm, sago, salak, coconut, and areca nut. The plant diversity index obtained ranges from 1.93 to 2.42, indicating a medium stage of species diversity with a value of $1 \leq H' \leq 3$ (Odum, 1993) (Table 2). This medium Shannon-Wiener index value indicates that *dusung* agroforestry exhibits a fairly diverse number of species with relatively even species abundance. This diversity is reflected in the variety of species found in the *dusung* fields across each growth stratum within each *negeri*. Furthermore, the medium diversity index of *dusung* agroforestry suggests that the *dusung* ecosystem maintains considerable stability. This is supported by the research of

Table 2. Species diversity index at different growth stages

Negeri/Village	Growth rate	Total		Species diversity index (H')	Category
		Species	Individual		
Soya	Tree	19	118	2.58	Medium
	Pole	13	75	2.17	Medium
	Sapling	14	85	2.28	Medium
	Seedling	28	397	2.67	Medium
Hatalai	Tree	17	101	2.26	Medium
	Pole	8	43	1.95	Medium
	Sapling	10	54	1.77	Medium
	Seedling	14	159	2.20	Medium
Tuni	Tree	20	118	1.90	Medium
	Pole	12	60	2.06	Medium
	Sapling	13	79	2.10	Medium
	Seedling	25	216	2.53	Medium
Kusu-kusu	Tree	10	43	2.10	Medium
	Pole	6	18	1.61	Medium
	Sapling	11	26	2.20	Medium
	Seedling	8	55	1.83	Medium

Kaswanto and Nakagoshi (2014) and Prastiyo et al. (2020), which states that even with medium plant diversity in agroforestry within watershed areas, the overall ecosystem condition remains relatively balanced and ecological pressure is still controlled.

The medium species diversity index of *dusung* agroforestry is due to community consideration on the plant economic value. Previous study by Irwanto et al. (2023) and Markum et al. (2021) showed that there is a tendency for people to choose and plant the plants that have high economic value, such as multipurpose tree species (MPTS), in the hope of increasing income quickly. As a result, natural forest vegetation is often replaced by the dominance of cultivated plant species. However, each region has unique agroclimatic characteristics, so the leading agricultural commodities in each *negeri* and village varies. Therefore, the development of agricultural commodities needs to be adjusted to the characteristics of the local agroforestry landscape to improve community welfare (Kaswanto et al., 2021)

Negeri Soya has the highest value of species diversity in all growth stage. The lowest value of species diversity is in the *Negeri Urimessing*, Kusu-kusu Village at the stage of pole and seedlings. In contrast, at the sapling stage, a low diversity index is found in *Negeri Hatalai*. The low value of species diversity is due to the low number of individuals of the cultivated plant species. Considering that Ambon Island is a small island with limited land carrying capacity, it is important to increase the species diversity of *dusung* species to maintain the richness of biodiversity and protect the island from the threat of erosion and climate change.

Overall species diversity is highest at the tree level and decreases at the pole, sapling, and seedling levels. However, plant species diversity has increased and is categorized as very high at the seedling level in *Negeri Soya*, *Negeri Hatalai*, and *Tuni Village*. High species diversity values indicate that *dusung* system agroforestry practices can maintain biodiversity on small islands.

D. Distribution pattern of dusung agroforestry based on local culture in the Wai Batu Gajah Watershed

1. Negeri Government System

The study results show that *dusung* agroforestry is concentrated in the upstream part of the watershed, which covers 3 *negeri*, *Negeri Soya*, *Negeri Urimessing*, and *Negeri Hatalai*. Ambon City still adheres to the *negeri* government system, which refers to villages or regions. *Negeri* is a communion of indigenous peoples, both genealogically and territorially, based on customs and culture (Ririhena, 2015). *Negeri* is led by the *Bapa Raja*, who is elected based on the lineage of the King (*patriarchal*). In his reign, the King was assisted by customary institutions with precise functions in the structure of the *Negeri* government, namely *Raja/Pati*, *Saniri Besar*, and *Saniri Negeri*.

Saniri Besar is a customary forum at the *negeri* consisting of government apparatus *negeri*, *jujaro* (adult female), and *mungare* (adult male). This forum serves as a communication channel between the King, *negeri* government officials, and the community. *Saniri Negeri* is a customary institution at the *negeri* consisting of the King, *Kepala-kepala Soa*, *Marinyo*, *Kewang*, *Tuan Tanah*, and *Kapitang*. *Saniri Negeri* serves as a *Negeri* legislative institution that makes various decisions for the King and the people of *Negeri*. *Kepala Soa* is the leader of several *negeri* clan functions to assist the King in handling customary problems and various administrations of *negeri*. *Kepala Soa* also acts as a spokesperson for the clan he leads. *Kapitang* is a warlord in charge of coordinating the community when facing attacks from outside that threaten the internal security of *negeri*. In the Maluku cultural tradition, *Kapitang* is a title given to a leader or tribal chief who has an important role in regulating the community's life and maintaining the security of his territory. The primary duties of *Kapitang* include leading traditional ceremonies and resolving conflicts. *Tuan Tanah* has the power to regulate the rights of the land of the landowners. Its main task

is to organize and solve problems with other *negeri*, such as determining land boundaries and petuanan (territorial) land disputes. *Kewang* (customary police) is a customary institution that safeguards petuanan as a customary right (*beschikkingrecht*) located inland areas and on the coast. *Marinyo* was tasked with helping the King to convey various information about the existence of *negeri*, conveying various decisions and programs taken by the King and *Saniri Negeri* to be implemented. *Marinyo* and *Kepala Soa* are the King's assistants in the field of administration.

2. Land ownership system and *dusung* agroforestry mapping in the Wai Batu Gajah Watershed

The land ownership system for *dusung* agroforestry in the research area is named *dati* or customary rights. The term *dati* has been used since the Dutch colonial era to the present. Hamlet or land *dati* have registered *dati* since 1814 in *Eigendom Verponding*, which is the right to land ownership that must be adjusted through the provisions of the conversion of the Basic Agrarian Law (*Undang-undang Pokok Agraria/UUPA*) (Pontoh et al., 2022). Land distribution of *dusung* based on land ownership

in each *negeri* presented in Figure 8 and Table 3.

Based on the results, most of *dusung* agroforestry land ownership at *Negeri Soya*, *Hatalai*, and *Urimessing* are *dusung dati*. In addition, there are also *dusung negeri*, *dusung pusaka*, *dusung babalian* and *dusung atiting* on some land *dusung* at *Negeri Soya*. *Dusung dati*, *pusaka*, *atiting*, and *babalian* are *dusung* with customary ownership or genealogis. Traditionally, genealogical members have the right to manage or clear the land. This right consists of the right to the land owned by *negeri* or controlled by the genealogical (*matarumah* or family refers to the clan).

The results of interviews and FGDs show that all land ownership in the upstream part of the watershed is customary land, which was inherited from the elders (previous generations that can still be traced). *Dusung* agroforestry with a customary land ownership system, or *dati*, has a special name that has been given since the beginning of inheritance. The name *dusung* usually refers to the area or region where the *dusung* is located, such as the name of a place or source of a spring, and it is a special name in the indigenous language. Each *dusung dati* owned by several *matarumah* that have a genealogical or kinship relationship.

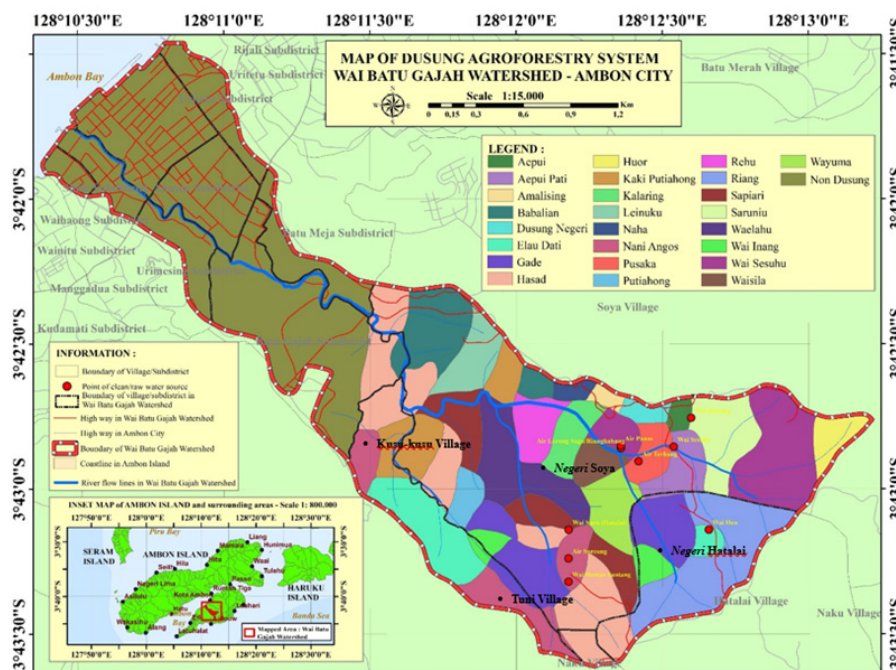


Figure 8. Distribution map of *dusung* agroforestry based on local culture

Table 3. Distribution of *dusung* land ownership in the Wai Batu Gajah Watershed

<i>Negeri</i>	<i>Dusung name</i>	<i>Matarumah (Households)</i>	<i>Types of dusung</i>
Negeri Soya	Babalian	Latuheru	<i>Babalian</i>
	Leinuku	Soplanit	<i>Dati</i>
	Naha	Nussy	<i>Dati</i>
	Babalian	Pessiwarisa	<i>Babalian</i>
	Waelahu	Rehatta	<i>Dati</i>
	Reru	Pattileuw	<i>Dati</i>
	Kalaring	Sopacua	<i>Dati</i>
	Amalising	Tamtelahitu	<i>Dati</i>
	Waisila	Maitimu	<i>Dati</i>
	Wayuma	Hijiaubessy	<i>Dati</i>
	Wai Sesuhu	Kebun Kelapa Soplanit	<i>Dati</i>
	<i>Dusung Negeri</i>	Kebun Kelapa <i>Negeri</i>	<i>Negeri</i>
	Aepui	Huwaa	<i>Dati</i>
	Pusaka	Sapteno, Soplanit, Salampessy	<i>Pusaka</i>
	Wai Sesuhu	Soplanit	<i>Dati</i>
	Huor	Soplanit	<i>Dati</i>
	Negeri Hatalai	Aepui Pati	Air Terbang Huaang
Saruniu		Rehatta	<i>Dati</i>
Elau <i>Dati</i>		Puturuhu	<i>Dati</i>
Gade		Muskita	<i>Dati</i>
Riang		Paays	<i>Dati</i>
Negeri Urimessing	Wai Inang	De Lima	<i>Dati</i>
	Riang	Kastanya	<i>Dati</i>
	Hasad	Alfons	<i>Dati</i>
	Nani Angos	Huwae	<i>Dati</i>
	Kaki Putihong	Persulesy	<i>Dati</i>
	Elau <i>Dati</i>	Puturuhu	<i>Dati</i>
	Putiahong	Parera	<i>Dati</i>
	Sapiari	Gomies	<i>Dati</i>

Remark: *Dati* (ownership of *dusung* based on *matarumah*/clan), *Babalian* (purchased *dusung* from *negeri*), *Pusaka* (*dusung* jointly owned by a group of heirs), *Negeri* (*dusung* owned by *negeri*).

The total amount of *dusung* agroforestry spread in the upstream part of the Wai Batu Gajah Watershed are 25 *dusung* consisting of 14 *dusung* of petuanan *Negeri Soya*, 5 *dusung* of petuanan *Negeri Hatalai* and 6 *dusung* of petuanan *Negeri Urimessing*. The most common type of *dusung* land ownership found in the upstream area of the Wai Batu Gajah Watershed is the ownership of *dati*. This is because *dusung* agroforestry lands are already under the ownership of family land that has been registered in the national register. Many *negeri*-owned *dusung* have also been sold to related families, so the ownership rights of *dusung* have changed. *Dusung* with *dati* ownership means that, in one *dati*, several families, such as *dusung* or *matarumah*, have been separated following the ownership of each family. Each family is responsible for its *dusung*, except for the *dusung pusaka*. *Dusung pusaka* is a *dusung* jointly owned by a group of heirs inherited from generation to generation and based on patrilineal principles. The group of heirs is a combination of several households or *matarumah*, and there is no general land division as in *dusung dati*. Conflicts often arise when managing and utilizing the yield in *dusung pusaka* because there are no clear rules about the distribution of inherited crops in *dusung pusaka*. The findings of this study are in line with Silaya & Pietersz's (2019) research, which states that conflicts often occur in *dusung pusaka* because each household group positions itself as the most interested party in the management of *dusung pusaka*.

3. *Sasi* and *Kewang* customary institutions

Agroforestry landscape practices of *dusung* are very important and strategic for the survival of the *dusung* owner and the environment. This is due to the close relationship between *dusung* and local culture. For example, the history of *dusung* area ownership, the practice of local culture (*Sasi*), and the existence of a local institution called *Kewang* (customary police) are believed to be able to control the preservation of resources of *dusung* (Ririhena, 2015; Silaya & Waistsz, 2019).

Sasi is a form of community-based natural resource management rules in Maluku. *Sasi* is a traditional culture that exist in customary regulations that prohibit the extraction of specific natural resources to conserve the quality and population of biological resources (Kissya, 1993). Customary regulations have become local rule for local communities that have been followed for generations and declared as a prohibition to maintain a resource's sustainability (Baguna et al., 2015). Meanwhile, *Kewang* is a customary institution that protects petuanan (land) as a customary right in the *negeri* inland and coastal areas. The research found that *sasi* customary law has experienced a decline in implementation and even disappeared from the culture of the community. For example, in *Negeri Soya* and *Tuni Village*, the community does not use *sasi* customary law in *dusung* cultivation. This indicates that: 1) *sasi* customary law in *dusung* cultivation was influenced by modernization, *Negeri Soya* is near the center of Ambon City, so that the socio-culture of the community is eroded; 2) the community is already responsible for their respective *dusung* products in management so that there is no theft of produce or crop failure; 3) *dusung* boundary conflicts rarely occur because of mutual understanding between the *dusung* owners regarding the boundaries of their respective land. This clear understanding has been built through social interaction and hereditary experience and is reinforced by local land use rules.

4. *Dusung* agroforestry cultivation system based on local culture

Agroforestry is an intangible asset in Ambon City, included among indigenous knowledge and technologies adapted to the island environment (Ririhena, 2015; Hatulesila, 2022). Therefore, *dusung* farmers at the research site have used traditional methods to manage *dusung* agroforestry land. This traditional approach is relevant to the concept of optimal indigenous land management, which integrates technical, economic, social, and ecological aspects

to achieve forest landscape sustainability (Nugroho et al., 2017). The cultivation of *dusung* plants based on the local culture of the local community is carried out in the following stages: 1) land clearing (weeding), 2) land tillage, 3) making planting holes and leaving them open for 3 days, 4) making compost by burning dry plant litter, 5) putting compost (ash from burning) into the planting hole, 6) planting plant seedlings, 7) watering, 8) maintenance with weeding. Ash from combustion is traditionally understood to contain calcium, which neutralizes acidic soil.

The practice of *dusung* agroforestry cultivation carried out by farmers, in terms of local culture, is greatly influenced by the values of cooperation known as *masohi*. *Masohi* is a tangible manifestation of the spirit of community togetherness in collectively managing natural resources. This activity involves all community members in various stages of cultivation, from land clearing to harvesting. As Sahureka et al. (2018) emphasized, *masohi* is not just a physical activity but also a manifestation of the socio-cultural values of the Maluku people. Through *masohi*, the bond of brotherhood between families is getting closer, as seen in the *dusung* agroforestry production process, that involving all family members (Kroons et al., 2022; Hatulesila, 2022). In addition to strengthening social ties, *masohi* contributes to the efficiency of managing the *dusung* agroforestry because heavy tasks can be completed together. This saves costs and ensures the sustainability of the *dusung* agroforestry system (T'joa et al., 2022).

IV. CONCLUSION

Dusung agroforestry in the Wai Batu Gajah Watershed area is the use of agrisilviculture land with a mixture-random pattern that has significant potential in improving the ecological, economic, and socio-cultural sustainability of the community. Vegetation analysis shows that there are 95 species of *dusung* agroforestry at the tree, pole, sapling, and seedling stages belonging to 35 families. The vegetation analysis shows

that this system's species diversity is medium, with Shannon-Wiener index (H') ranging from 1.93 to 2.42. Vegetation that dominates *dusung* land with high INP and SDR values consists of fruit plants, namely durian (*Durio zibetinus*), gandaria (*Bouea macrophylla*), kecap (*Sondoricum koetjape*), mangosteen (*Garcinia mangostana*), langsung (*Lancium domesticum*), aren palm (*Arenga pinnata*) and salak (*Salacca zalacca*). Meanwhile, grass species such as peacock fern (*Selaginella willdani*) and fan grass (*Selaginella tamariscina*). Based on the land ownership and the distribution pattern of *dusung* based on local culture, there are 25 *dusung* spread in the upstream watershed consisting of 14 *dusung* in Negeri Soya, 5 *dusung* in Negeri Hatalai, and 6 *dusung* in Negeri Urimessing. The traditional *dusung* agroforestry management is still heavily influenced by *sasi* customary law and *kewang* customary institutions. This system regulates using natural resources in *dusung* agroforestry to ensure environmental sustainability and community welfare.

Mapping the *dusung* agroforestry landscape patterns based on local culture reveals the close relationship between traditional agricultural practices and natural resource management. As an agroforestry system rooted in local culture, *dusung* establishes norms and rules that support ecological sustainability and sustain social systems that have been internalized in the community's lives.

This study recommends regular replanting of *dusung* vegetation to increase the biodiversity of *dusung* agroforestry. Improved management, such as optimal spacing and selection of superior commodities, is essential to increase species' productivity and richness. To strengthen the role of *sasi* and *kewang*, it is necessary to activate and empower *kewang*, a customary institution with the authority to supervise and enforce *sasi* implementation. In addition, a strategic step is to mandate *dusung* owners as environmental guardians, supported by clear reward mechanisms and incentives, so that *dusung* agroforestry is sustainable. Government support is needed through counseling,

training, and assisting the *dusung* farmers in implementing sustainable agricultural practices (Good Agricultural Practices). With proper management, the *dusung* agroforestry system can become a sustainable agricultural model that not only increases farmers' productivity and income but also plays an important role in mitigating climate change, improving food security, and preserving the ecosystem of small islands. The results of this study imply the need for further research to comprehensively analyze the economic potential, ecological impacts, and social impacts of the sustainability of *dusung* agroforestry through the integration of local culture, in order to optimize the role of *dusung* in sustainable development in small islands.

ACKNOWLEDGEMENT

The researcher expressed his gratitude to the Government of Negeri Soya, Hatalai, Urimessing, and the local community in the Wai Batu Gajah Watershed area, Sirimau District, Ambon City, for their cooperation and assistance during data collection. Gratitude was also addressed to the lecturer staff of the Agricultural Cultivation Study Program of Pattimura University for their support during the research and to the Endowment Fund for Education Agency (LPDP) for the research funding assistance.

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