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Research Article

# Angiosperms Diversity on the Slopes of Mount Argowayang, Tahura Raden Soerjo, Indonesia

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**ABSTRACT**
Vegetation data in the Argowayang Mountain section of Tahura Raden Soerjo has not been comprehensively recorded, indicating a decline in documented endemic plant diversity. This study aimed to inventory angiosperm vegetation on Mount Argowayang and calculate the Importance Value Index (IVI). Quadrat line transect sampling was conducted in August 2024 and May 2025 at elevations of 1,400-1,600 m asl. The study area covered 5.8 ha (10 % of Tambik Block), with 40 plots (20×20 m each) distributed across 8 transects. For tree stratum, the highest IVI was recorded for Mallotus barbatus Müll.Arg (20.98 %), followed by Trema orientale (L.) Blume (14.48 %) and Homalanthus populneus (Geiseler) Pax (16.28 %). For the shrub stratum, Lithocarpus sundaicus (Blume) Rehder exhibited the highest IVI (97.91 %), followed by Montanoa hibiscifolia Benth. (50.59 %) and Begonia palmata D.Don (31.54 %). Two threatened species were documented: Saurauia bracteosa DC. (VU) and Canthiumera glabra (Blume) K.M. Wong & Mahyuni (NT). These findings underscore the urgent need for strict protection measures, community-based conservation programs, and enhanced monitoring systems to preserve the high biodiversity value of this tropical montane forest ecosystem.

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## INTRODUCTION

Tropical rainforests are among the most diverse and productive terrestrial ecosystems on Earth (Anggraini 2018). Tropical rainforests consist of evergreen woody vegetation that forms a thick canopy so dense that it is impossible to see the ground through the trees (Jacobs 1988). Each type of tropical forest has its own distinct vegetation and wildlife, and provides a variety of ecosystem services to human populations worldwide, such as providing clean water, regulating the climate, and providing food and medicinal plants (Groombridge & Jenkins 2010; Brandon 2014). The world's tropical forests contain more tree species than ever before (Burslam et al. 2001) play a crucial role in conserving biodiversity, maintaining ecosystems, and mitigating climate change (Komolafe et al. 2020).

The world's tropical rainforests harbour a wealth of endemic biodiversity. Indonesia is blessed with vast and biologically rich forests, considered megadiverse, a term used to refer to countries with the highest biodiversity in the world (Coracero & Malabrigo Jr 2020; Gunawan et al. 2022). This diversity includes flora and fauna, which are spread throughout Indonesia (Eliasmi & Widodo 2023). These forests offer extraordinary biodiversity. Furthermore, Indonesia's forest area is projected to reach approximately 27.43 million hectares by 2024 (Mahfudz 2025).

Various factors, including competition for sunlight, influence biodiversity. Competition for light contributes to the diversity of tropical forests' plant species and their robust growth. Furthermore, under sufficient light, tropical forests exhibit unique plant diversity, forming strata of trees, shrubs, herbs, mosses, and other plants (Hutasuhut 2018). Indonesia's flora boasts high levels of diversity because, at the family level, its richness is extraordinary. Furthermore, Indonesia boasts an estimated 25,000 plant species, representing more than 10 % of the world's flora. No less than 40 % of these species are endemic, or species found only in Indonesia and nowhere else in the world (Ulinniam et al. 2022).

Java is the most populated island in the world. Despite covering only 7 % of Indonesia's land area, it is a home to 145 million people, accounting for more than 56 % of Indonesia's total population (Rinandio et al. 2022). Moreover, Java has many forests of various heights. According to Backer and Bakhuizen van den Brink (1965), forests in Java show a strong altitudinal gradient, including lowland forests (<1000 m asl), lower montane forests (1000-1600 m asl), and upper montane forests (1500-2400 m asl), followed by submontane forests. On the island of Java, there are many conservation areas, one of which is Taman Hutan Raya (Tahura). Based on Law No. 32 of 2024, a Taman Hutan Raya (Tahura) is a nature conservation area for the of collection of natural or artificial plants and/or animals, native or non-native species, that is utilised for research purposes. Furthermore, one of the Taman Hutan Raya on the island of Java is the Taman Hutan Raya (Tahura) Raden Soerjo.

There are several studies on plant diversity in Taman Hutan Raya (Tahura) Raden Soerjo. Sulisetijono et al. (2020) found that there are seven *Pteris* species found in Cangar at elevations of 1000-3000 m asl. Additionally, Fathoni et al. (2021) found that the tree community at Sumber Cangar contained 12 tree species. Furthermore, Jihans et al. (2021) found that there are 13 species of *Epiphytic fern* in Mojokerto district, the study of Khairunisa and Wisanti (2023) obtained 33 species of *Pteridophyta* in Coban Supit Urang, a research by Nuraini and Wisanti (2022) found 37 species of *Pteridophyta* in Tretes Waterfall, and Soetopo et al. (2021) acquired 53 species of *Epiphytic orchids* in Watu Ondo. Moreover, Sari et al. (2021) obtained 33 species from 17 families from *Magnoliophyta*, *Spermatophyta*, and *Pteridophyta* divisions in Rangsang Block, Prigen, Pasuruan Regency. Lastly, Kurniawan and Agustin

(2025) recorded 25 species of *Epiphytic orchids* in Coban Talun.

Based on interviews conducted by the head of the Taman Hutan Raya Raden Soerjo, revealed that, given its vast area, plant diversity data for Tahura Raden Soerjo remain incomplete, especially in West Malang. The vast area of Tahura Raden Soerjo is inseparable from the destruction of habitat and plant diversity carried out by the surrounding society. Researchers observed that Tambik Block in Tahura Raden Soerjo, Pujon, West Malang, has undergone changes: forest land utilisation has shifted to community plantations, endemic plants have been exploited, and the lack of reforestation has led to declines, or even losses, of many plants, especially endemics.

The Tambik Block is located in the Arjuno-Welirang-Anjasmoro Mountains, part of the 27,868 ha Raden Soerjo Natural Park (Tahura Raden Soerjo) which is dominated by protected forests. Diverse elevations (1500-2700 m asl) form vegetation from pine forests to endemics such as pasang (Lithocarpus sp.), with steep topography that supports in-situ conservation of Angiosperms vulnerable to socio-economic pressures. However, angiosperm diversity data in the Tambik Block, Pujon, West Malang—especially elevation-specific composition—remain unrecorded; thus, this study aims to address this gap as a basis for conservation and the Raden Soerjo Natural Park Flora Taxonomy Book.

Biodiversity in the Tambik Block, Tahura Raden Soerjo, has been under significant pressure since 2021, with a 2022 KSDAE survey finding 441 flora specimens from 179 collections in the Cangar area, including important families such as Asteraceae and Poaceae, which are vulnerable to loss due to deforestation. The 2021 conservation priority identification by the Tahura Technical Implementation Unit (UPT) emphasized the rehabilitation of 5,439 hectares of open areas to save endemics such as Quercus sp. and forest orchids. In-situ conservation of angiosperms here not only preserves 1,925 recorded plant species but also supports biodiversity-based ecotourism, which was rated as having the highest national effectiveness in 2023-2025, preventing flooding for 2 million Malang residents.

## MATERIALS AND METHODS

### Study area

Tahura Raden Soerjo is one of the conservation areas located in Malang Regency, Malang City, Mojokerto Regency and Pasuruan Regency. Taman Hutan Raya Raden Soerjo ranges in altitude of 1000-3339 metres above sea level. The research method used is a straight-line transect in Tahura Raden Soerjo (Muller-Dombois & Ellenberg 2016). Transects were conducted in the Taman Hutan Raya (Tahura) in the Tambik Block, West Malang, on August 26-28, 2024, and May 10-13, 2025, during the dry and the rainy seasons, respectively. The Tambik Block covers an area of 58.46 hectares, of which 10 % of the area was sampled. The second period was conducted to observe dry and rainy conditions and to search for at least complete plant organs, such as flowers and seeds, of the observed species.

### Sampling Design

The determined location was a protected conservation area with an altitude of 1400-1600 meters above sea level. The research area used is 5.8 ha, which is 10 % of the Tambik Block area. Systematically distributed plot design allows representative estimates for elevations of 1400-1600 m above sea level. A straight line was made from the first point with the provision of a distance of 100 m between transects. The sample plots used were 20 x 20 m in size with a spacing between plots is 10 m, the distance in one transect was 100 m. Forty plots were used. Plots of 20 x 20 m targeted trees and shrubs. The study site map is shown in Figure 1.

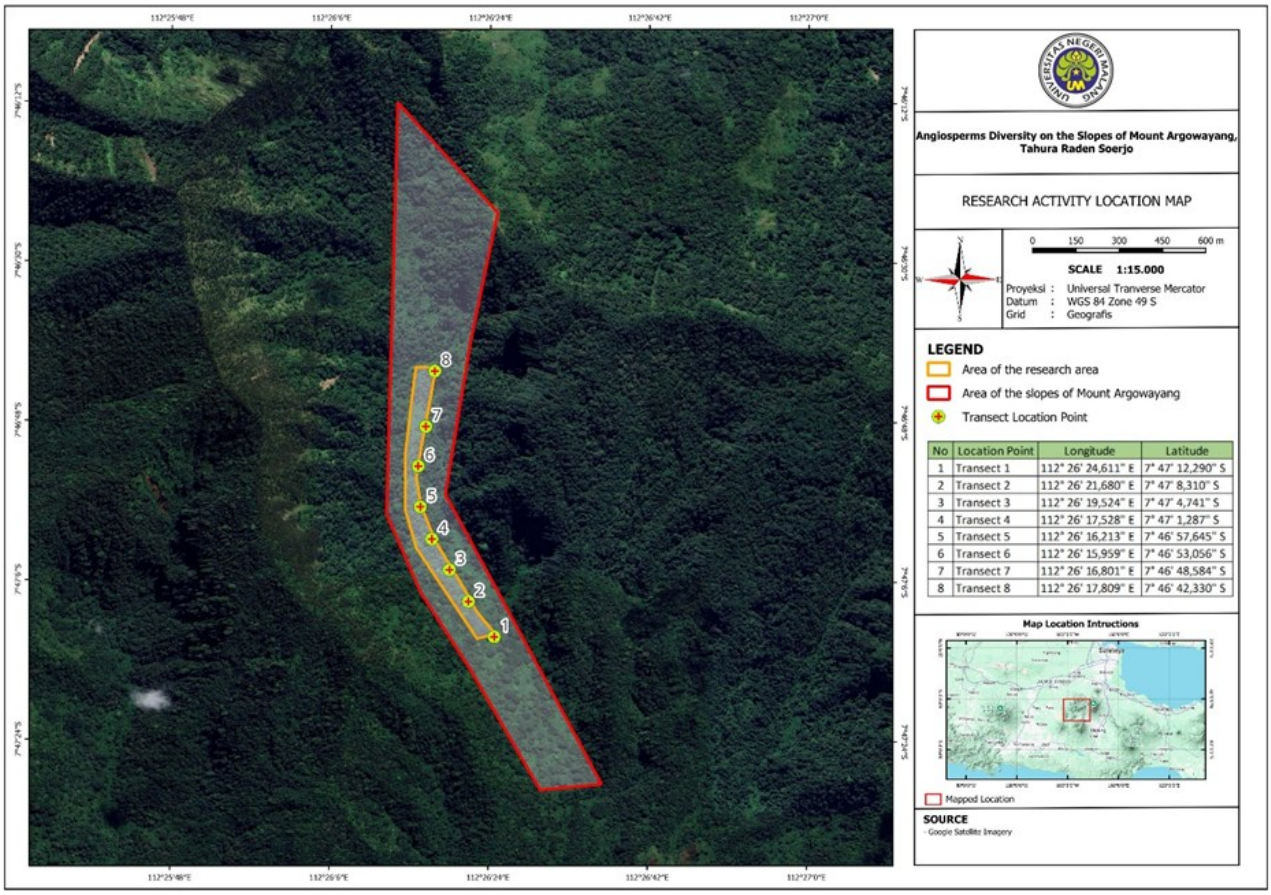



**Figure 1.** Sampling Location.

## Procedures

In this research, key terms include vegetation, vegetation sampling, vegetation parameters, and sampling methods such as relevé, transect, and plot. Here are some definitions based on Muller-Dombois and Ellenberg (2016).

- **Vegetation Definition**
  Vegetation refers to an assemblage of plants from one-to-many species growing across varying area sizes. Classification requires identifying geographic vegetation segments that exhibit a certain level of homogeneity within each segment.
- **Vegetation Sampling**
  Vegetation sampling involves detailed studies to describe the composition, structure, and distribution of plant communities in the field. Distinct vegetation segments are selected based on field observations and analysed using representative samples from those predefined segments, yielding a comprehensive understanding of plant community dynamics.
- **Vegetation Parameters**
  Vegetation parameters are categorised into four types: trees (dbh $\geq$ 20 cm), poles (10 $\leq$ dbh $<$ 20 cm), saplings (dbh $<$ 10 cm), and seedlings (plant height $\leq$ 1.5 m).
- **Relevé Sampling Method**
  The relevé method is a direct field observation technique to describe the composition, structure, and distribution of plant species in a community representatively. It is commonly used in ecological studies to determine the minimum plot area encompassing all dominant plant species, with quadrat sizes tailored to the selected quantitative parameters and overall sampling intensity adjusted to vegetation segment variability.
- **Transect Method**
  A transect in vegetation ecology is a narrow path or straight line laid

across a study area to observe changes in plant composition, structure, and distribution across different zones.

- **Plot Method**
  Vegetation plots, or quadrat sampling, involve creating fixed square plots (e.g., 20 x 20 m for trees) in the study area to count all plant individuals by strata such as trees, shrubs, and herbs.

The plant observation samples used were the trees with a dbh ≥ 20 and shrub. This was based on field conditions where most angiosperm species were in the pole and tree life phases. Seedlings were not counted. In one transect line, a quadrat was created with 5 repeat plots. There was a distance of 100 m between one transect and another. This yielded eight transects and 40 quadrat plots across 5.8 ha.

Vegetation was analysed using the quadrat method. The following are the procedure of the quadrat method: (1) Placing 20 m² (20 m x 20 m) quadrat in a specific vegetation patch, (2) Determining the percentage of a species in the quadrat, (3) Counting the number of species found, (4) Identifying the species name of the plants found.

## Identification

Post-collection, leaf, fruit, and seed samples were separated and identified. These were processed into dry and wet herbaria. Afterwards, the identification process was carried out at the Herbarium Malangenese (e.g., dry specimen nos. ANR-2025-001 to ANR-2025-040; wet specimen nos. ANR-W-2025-001 to ANR-W-2026-004). The identification process was confirmed with the books Flora of Java, Flora of the Java Mountains, and Flora Malesiana and assisted with plant identification platforms, such as GBIF (Global Biodiversity Information Facility).

## Data Analysis

After sampling and identifying plants have been conducted, the observed vegetation density, dominance, and frequency were calculated. The formula used in this study refers (Muller-Dombois & Ellenberg 2016):

$$Relative\ density = \frac{number\ of\ individuals\ of\ a\ species}{total\ number\ of\ individuals} \text{ X } 100$$

$$Relative\ dominance = \frac{dominance\ of\ a\ species}{dominance\ of\ all\ types} \text{ X } 100$$

$$Relative\ frecuency = \frac{frequency\ of\ a\ type}{total\ frequency\ of\ all\ types} \text{ X } 100\ \%$$

Importance Value Index (IVI) = Relative Density (RD) + Relative Frequency (RF) + Relative Dominance (RDom)

In addition to calculating the important value index, Shannon-Wiener diversity index, Evenness Index (Evennes), and Margalef index were calculated. The following are the formulas:

**Shannon Wiener Index (H)** (Shannon 2006):

$$\mathbf{H' = -\sum(pi \times \ln pi)}$$

*pi* = proportion of individuals of species *i* relative to the total; sum over all species. It measures species diversity by accounting for abundance and evenness. Criteria of Shannon Wiener Index can be seen in Table 1.

**Evenness Index (E)** (Pielou 1966):

$$E = \frac{H'}{ln.S}$$

$H'$ = Shannon-Wiener index; S$S$ = total number of species. It measures how evenly individuals are distributed among species, ranging from 0 to 1.
When E approaches 0, the distribution of individuals between species is uneven, reflecting unequal species abundance distribution conditions. Conversely, when E approaches 1, individuals are evenly distributed between types, indicating stable species abundance distribution conditions. This index helps assess community structure in biodiversity studies (Pielou 1966).

**Margalef Index (D)** (Magurran 1988):

$$D = \frac{S - 1}{ln. \mathrm{N}}$$

$S$ = number of species; N = total number of individuals. It measures species richness considering sample size.
Low species richness applies when the index value is less than 2.5, reflecting limited species diversity in the community. Medium species richness occurs for index values between 2.5 and 4, suggesting moderate biodiversity. High species richness is present when R exceeds 4, indicating a diverse assemblage of species (Wahyuningsih et al. 2019).

**Table 1.** Shannon- Wiener Diversity Index Criteria (Jacobs 1988).

| Diversity Index (H') | Community Structure | Category |
|---|---|---|
| H' ≥ 2.41 | Very Stable | Excellent |
| 1.8 ≤ H' < 2.41 | More Stable | Good |
| 1.21 ≤ H'< 1.8 | Stable | Medium |
| 0.61 ≤ H' < 1.21 | Stable Enough | Bad |
| H' < 0.6 | Unstable | Very Bad |

## RESULTS AND DISCUSSION

### The General Condition of the Flora of Tahura Raden Soerjo

Taman Hutan Raya (Tahura) is an area created in an effort to preserve nature that functions like a botanical garden. The main difference is in the collection of the park. In addition, conservation forests are areas with certain characteristics that have main function of preserving the diversity of plants and animals and their ecosystems according to Law No. 41 of 1999 concerning Forestry. These forests typically derive from natural forests that have diversity of plant species. Moreover, high plant species diversity helps the forest maintain its ecological balance. The area of Taman Hutan Raya (Tahura) is located in five regions, namely Mojokerto Regency, Malang Regency, Jombang Regency, Pasuruan Regency and Batu City, East Java Province, Indonesia with an area of 27,868.30 ha consisting of Protected Forest Areas and 22,908.3 ha, also Arjuno-Lalijiwo Nature Reserve Area (PHPA) 4960 ha (Yulianto 2024). Sulasmi et al. (2020) reported that Tahura Raden Soerjo has elevations between 1456-1809 m asl, temperature of 18-22 °C, and humidity of 33-77 %. This aligns with abiotic measurements taken in sampling, temperature of 20-25 °C, humidity of 60-80 %, and sunlight of 1300-47,500 lux.

Plants rarely encounter the optimal quantities or intensities of all essential abiotic factors. It is very important to realise that plant growth reflects responses to its environment. Flowering and fruiting determine a plant's success in reproduction and propagation and can also be used as a measure of its reaction to the environment. Optimal intensities and concentrations of these may also differ, not only for individual organisms, but also for particular organs of the same organism (Schulze et al. 2002). The list of plants found can

be seen in the Table 2.

## Plant Diversity of Tambik Block, Pujon, West Malang

During the research, abiotic conditions were measured. The temperature ranged from 20 to 25 °C, humidity 60 to 80 %, soil pH 7, and sunlight intensity 1300 to 47,500 lux. The followings are the tables of vegetation results found in Tambik Block, Pujon, West Malang.

**Species Trees Highest IVI:**

Based on Figure 2, *Mallotus barbatus* recorded the highest IVI among tree species with a value of approximately 21, followed by *Trema orientale* (~17) and *Litsea glutinosa* (~16). The remaining species, including *Ficus fulva*, *Ficus virens*, *Ficus ampelos*, *Claoxylon indicum*, and *Acer laurinum*, showed relatively similar IVI values ranging between 13 and 15, indicating a fairly even distribution of ecological importance among those species.

**Shrub Species with the Highest IVI:**

Among shrub species, *Lithocarpus sundaicus* dominantly stood out with an exceptionally high IVI of nearly 100, far exceeding all other shrub species recorded. *Montanoa hibiscifolia* and *Pinanga coronata* ranked second and third with IVI values of approximately 50 and 32, respectively. Species such as *Arisaema triphyllum*, *Calamus heteroideus*, *Cinnamomum burmanii*, and *Lasianthus laevigatus* showed comparatively low IVI values below 20, suggesting limited ecological dominance within the shrub layer.

The vegetation H'ER calculation yielded H' 3.79, E 1.04, and R 7.64 (Table S1). This classification indicates that the vegetation community structure in Raden Soerjo Grand Forest Park is very stable, with evenly distributed individual values and very high vegetation richness.

**Table 2.** List of Local Plants and Scientific Names.

| Local Name | Species | Familia | Habitus | Total | IUCN Status |
|---|---|---|---|---|---|
| | *Lasianthus laevigatus* Blume | *Rubiaceae* | *Shrub* | 1 | LC - Least Concern |
| | *Arisaema triphyllum* (L.) Schott | *Araceae* | *Shrub* | 1 | LC - Least Concern |
| Anggrung | *Trema orientale* (L.) Blume | *Cannabaceae* | *Tree* | 5 | LC - Least Concern |
| Dampul | *Ficus fistulosa* Reinw. ex Blume | *Moraceae* | *Tree* | 3 | LC - Least Concern |
| Didil | *Saurauia bracteosa* DC. | *Actinidiaceae* | *Tree* | 3 | VU – Vulnerable |
| Grasak | *Ficus ampelos* Burm.f. | *Moraceae* | *Tree* | 4 | LC - Least Concern |
| Iprik | *Ficus virens* Aiton | *Moraceae* | *Tree* | 4 | LC - Least Concern |
| Jemporang Rumput | *Trevesia sundaica* Miq. | *Araliaceae* | *Tree* | 2 | LC - Least Concern |
| Kapasan | *Acer laurinum* Hassk. | *Sapindaceae* | *Tree* | 4 | LC - Least Concern |
| Kayu Kenangan | *Aglaia argentea* Blume | *Meliaceae* | *Tree* | 5 | LC - Least Concern |
| Kebek | *Ficus fulva* Reinw. ex Blume | *Moraceae* | *Tree* | 5 | LC - Least Concern |
| Keningar | *Cinnamomum burmannii* (Nees & T.Nees) | *Lauraceae* | *Shrub* | 1 | LC - Least Concern |
| Kepel | *Clausena excavata* Burm.f. | *Rutaceae* | *Tree* | 1 | LC - Least Concern |

**Table 2.** Contd.

| Local Name | Species | Familia | Habitus | Total | IUCN Status |
|---|---|---|---|---|---|
| Ketupuk | *Claoxylon indicum* (Reinw. ex Blume) Hassk. | *Euphorbiaceae* | *Tree* | 4 | LC - Least Concern |
| Kijang | *Begonia palmata* D.Don | *Begoniaceae* | *Shrub* | 2 | LC - Least Concern |
| Kimeng | *Ficus microcarpa* L.f. | *Moraceae* | *Tree* | 1 | LC - Least Concern |
| Kopen | *Canthiumera glabra* (Blume) K.M.Wong & Mahyuni | *Rubiaceae* | *Tree* | 3 | NT - Near Threatened |
| Kukruk | *Engelhardia spicata* Lechen ex Blume | *Juglandaceae* | *Tree* | 2 | LC - Least Concern |
| Lamer | *Breynia microphylla* (Kurz ex Teijsm. & Binn.) Müll.Arg. | *Phyllanthaceae* | *Tree* | 2 | LC - Least Concern |
| Lembayungan | *Sambucus nigra* L. | *Viburnaceae* | *Tree* | 2 | LC - Least Concern |
| Mencok Jurang | *Debregeasia longifolia* (Burm.f.) Wedd. | *Urticaceae* | *Tree* | 4 | LC - Least Concern |
| Nyampoh | *Litsea glutinosa* (Lour.) C.B.Rob. | *Lauraceae* | *Tree* | 5 | LC - Least Concern |
| Parijoto | *Medinilla alpestris* (Jack) Blume | *Melastomataceae* | *Shrub* | 2 | LC - Least Concern |
| Pasang | *Lithocarpus sundaicus* (Blume) Rehder | *Fagaceae* | *Shrub* | 7 | LC - Least Concern |
| Pelolong | *Montanoa hibiscifolia* Benth. | *Asteraceae* | *Shrub* | 2 | LC - Least Concern |
| Piji | *Pinanga coronata* (Blume) Blume | *Arecaceae* | *Shrub* | 2 | LC - Least Concern |
| Pupu Ketek | *Nauclea pobeguinii* (Pobég.) Merr. | *Rubiaceae* | *Tree* | 1 | LC - Least Concern |
| Rotan | *Calamus heteroideus* Blume | *Arecaceae* | *Shrub* | 1 | NE - Not Evaluated |
| Sembung Hutan | *Strobocalyx arborea* (Buch.-Ham.) Sch.Bip. | *Asteraceae* | *Tree* | 2 | LC - Least Concern |
| Suren | *Toona sinensis* (A.Juss.) M.Roem. | *Meliaceae* | *Tree* | 2 | LC - Least Concern |
| Tutup Abang | *Homalanthus populneus* (Geiseler) Pax | *Euphorbiaceae* | *Tree* | 5 | LC - Least Concern |
| Tutup Lumbu | *Homalanthus giganteus* Zoll. & Moritzi | *Euphorbiaceae* | *Tree* | 4 | LC - Least Concern |
| Tutup Walang | *Mallotus barbatus* Müll.Arg. | *Euphorbiaceae* | *Tree* | 6 | LC - Least Concern |
| Urang-urangan | *Elatostema integrifolium* (D.Don) Wedd. | *Urticaceae* | *Tree* | 4 | LC - Least Concern |
| Walisongo | *Didymopanax morototoni* (Aubl.) Decne. & Planch. | *Araliaceae* | *Tree* | 4 | LC - Least Concern |

## Discussion

### Results of Sampling using Relevé Sampling Method

Vegetation data collection was conducted using the 20 × 20 m quadrat method, which is a standard size in tropical forest vegetation inventories. In one transect line, a quadrat was created with 5 repeat plots. There was a distance of 100 m between one transect and another. This produced eight transects and 40 plots over 5.8 ha. During data collection, only 2-4 individuals met the observation criteria, resulting in a total of 106 individuals. A 400 $m^2$ (20 × 20 m) plot size has been widely used in vegetation diversity studies because it can effectively capture species variability and provide an adequate representation of plant community structure (Monge-González et al 2021). The quadrat method is known as one of the most important approaches in ecological re-

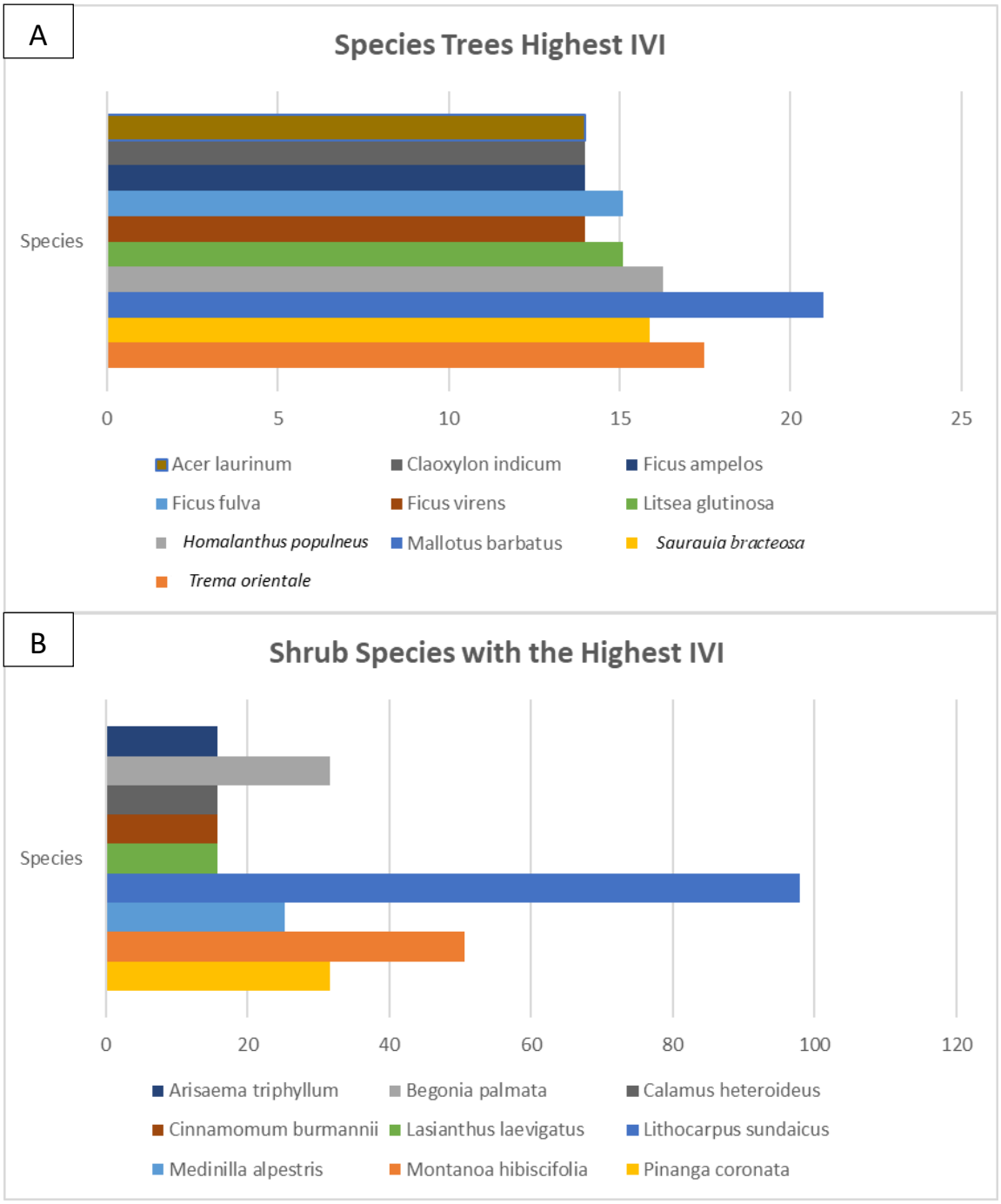



**Figure 2.** Species Trees Highest IVI **(A),** Shrub Species with the Highest IVI **(B)**.

search for assessing species diversity, analyzing species associations, and estimating biomass across various vegetation types (Lisner & Lepš 2020). From the inventory results in this research plot, 35 species were recorded with a total of 106 individuals. The finding of 35 species in a 400 $m^2$ plot indicates a fairly good level of species richness, considering that species richness is strongly influenced by plot size and the sampling method used (De Stefano et al 2021; de Souza et al 2021).

The number of species recorded in this study reflects the condition of vegetation diversity at the study location and can be used as baseline data for monitoring changes in vegetation composition in the future (Mansingh et al 2025). The results of vegetation sampling predominantly comprised members of Angiospermae, as no Gymnospermae individuals were encountered during field surveys. This finding aligns with the ecological characteristics of mid-elevation tropical mountain forests like Blok Tambik in Tahura Raden Soerjo, where angiosperm dominance (e.g. Lithocarpus sp., Montanoa sp., Homalan-

thus sp.) prevails due to favourable conditions for broadleaf species over conifers. The absence of Gymnospermae underscores the localized floristic composition, reinforcing the need for targeted in-situ conservation of Angiospermae diversity in such rehabilitated protected areas.

## Results of Importance Value Index and H'ER

The Importance Value Index (IVI) is used to give an idea of the ecological dominance level of each species in the community. From the data obtained, it can be seen that the species *Mallotus barbatus* Müll.Arg. has the highest IVI value of 20.98 %, making it the most dominant species in the tree community. This value far exceeds other species, indicating that *Mallotus barbatus* Müll.Arg has huge influence on community structure and dynamics at tree level (Selfiany 2020; Rawana et al. 2023; Malonga 2024). The next species with a high IVI value is *Trema orientale* (L.) Blume with an IVI of 14.48 %, which also shows fairly strong dominance, although not as great as *Mallotus barbatus* Müll.Arawarg. Meanwhile, *Homalanthus populneus* (Geiseler) Pax ranked third with an IVI value of 16.28 %, reflecting its significant but not dominant role in the community. Its ecological roles include participation in the structure of tropical tree communities, contribution to biodiversity relationships, and potential as a source of raw materials or plant materials for a number of traditional applications in the South to Southeast Asia.

In tropical forestry and ecology studies, *Mallotus barbatus* is often recorded with other species as part of a community of trees with relatively small to medium stem sizes and often grows in forest edge landscapes or areas with little disturbance (Uji 2005). The loss of this dominant species can cause major changes in community and ecosystem function (Lelewa et al. 2023). Most of other species had IVI values below 10 %, with the majority only around 3 %. This indicates that its presence in tree community is relatively small and its contribution to overall community structure is modest. These low IVI values indicate that these species have low presence, small coverage, and low contribution to overall community structure.

Meanwhile, in shrub vegetation, the highest IVI was produced by the species *Lithocarpus sundaicus* (Blume) Rehder 97.91 %, in second place *Montanoa hibiscifolia* Benth 50.59 %, and in third place *Begonia palmata* D.Don 31.54 %. The IVI calculation is also influenced by the frequency of the species found. When environmental disturbances occur in tropical forest landscapes and the occurrence of certain species changes frequently, the frequency of keystone species can decrease or increase. Declines in the frequency of ecologically important species tend to reduce their IVI, which in turn can alter tree community structure, energy flows, and ecosystem services. Conversely, increases in the frequency of species that are well-adapted to disturbances can increase their IVI and trigger changes in ecosystem function, for example in biological productivity or carbon storage capacity (Jainuddin 2023; Damiti et al. 2025). These low IVI values indicate that these species have low presence, small coverage, and limited distribution in the study site. Species with low IVI usually act as minor components in the community. Therefore, its influence on ecosystem structure and function is smaller than that of dominant species (Pramayanti et al. 2024).

In general, the results of the IVI calculation indicate that the structure of tree community in the observation site is strongly dominated by one main species, namely *Mallotus barbatus* Müll.Arg, with only few other species making moderate contribution, while the majority species have low ecological role. This pattern of dominance may reflect habitat conditions that strongly favour the growth of particular species, or environmental pressures that limit successful regeneration of other species (Istomo & Fardian 2021). Abiotic and biotic environmental factors that influence this dominance pattern include soil

temperature, moisture, tree density, interspecies interactions, and natural or anthropogenic disturbances (Huda et al. 2020).

H', E, and R values are the main parameters in plant vegetation analysis to assess diversity, evenness, and species richness. These values contribute to understanding the structure of plant communities, habitat conditions, and ecological dynamics of specific forest area or other vegetation (Setiarno et al. 2022). From the calculations obtained, the value of H' = 3.79, E = 1.04, R = 7.63 with the interpretation of the value of H' > 2,41, which indicates high diversity, the value of E> 0.6, which indicates stable and balanced community, and the value of R> 5, which indicates high species richness. A high H' value represents a community with many species and relatively balanced distribution of individuals, reflecting stable and healthy ecosystem (Ahsan et al. 2021). A high E value indicates that no single species dominates excessively, making the community more stable and adaptive to environmental changes (Wandi et al. 2016; Dewi et al. 2024). A high R value reflects a species-rich and potentially more ecologically stable community (Setiarno et al. 2022).

Strict protection is a top priority, with areas of high biodiversity being immediately designated as protected areas with maximum levels of protection and clear zoning. Wilson et al. (2007) emphasise that conservation effectiveness increases significantly when areas with high biodiversity value receive strong legal protection and consistent enforcement, with core zones free from extractive activities to prevent irreversible degradation. Given their high ecological value and vulnerability to anthropogenic threats, delays in establishing protected status could result in irreversible biodiversity losses. Continuous monitoring using modern technologies such as environmental DNA, camera traps, and remote sensing must be implemented immediately to detect changes in species composition and identify potential threats before they cause permanent damage. Moreno et al. (2017) emphasises that long-term monitoring is crucial for understanding biodiversity trends and implementing timely adaptive interventions. Landscape-based conservation is also urgently needed, given that habitat fragmentation is a major threat to highly diverse ecosystems. Sari (2025) demonstrated that loss of connectivity can lead to a drastic decline in R and H' values within a short time; therefore, the development of ecological corridors and buffer zones must be an immediate priority to ensure long-term population viability and genetic exchange between habitats.

Engaging local communities as conservation stewards is a critical strategy that cannot be postponed. Community-based conservation approaches that integrate local interests and knowledge have proven more sustainable and effective in the long term (Wilson et al. 2007). Capacity building programs, conservation education, and the development of sustainable alternative livelihoods must be initiated immediately to foster community ownership and support for conservation efforts. Payment for ecosystem services and benefit-sharing mechanisms can create economic incentives directly felt by communities, thereby reducing exploitation pressure on these valuable ecosystems.

Climate change mitigation and invasive species control require immediate preventive action. Although highly diverse ecosystems are more resilient, rapid climate change and the invasion of alien species can dramatically alter community structure. She et al. (2023) showed that areas with high H' values often serve as important climate refugia, making their protection strategically valuable not only for the present but also for the future. Strict biosecurity programs, early detection, and rapid response to invasive species must be implemented immediately because, according to Moreno-Mateos et al (2020) early control is far more cost-effective than eradication after the species has become established. Communities with high evenness (E ≈ 1.04) are highly vulnerable to disruption by biological invasions, which can quickly destabilise

the ecosystem.

Strong policies and governance must be established immediately as the foundation for implementing all conservation strategies. Wilson et al. (2007) identified that conservation failures are often not due to a lack of scientific knowledge, but rather to weak political will and governance. The high urgency requires adequate resource allocation, effective inter-institutional coordination, and consistent enforcement mechanisms implemented without delay. Integrating biodiversity conservation into broader development policies and transparency in decision-making are crucial for building long-term support. The area's exceptionally high ecological value (H' = 3.79, R = 7.63) makes it an irreplaceable biodiversity asset and requires the highest conservation commitment before it experiences irreversible degradation.

### *Angiosperms* with NT and VU status

Two angiosperm species were assessed as VU and NT. These species are *Saurauia bracteosa* DC. and *Canthiumera glabra* (Blume) K.M. Wong & Mahyuni. These two species were not found in one adjacent plot, but were far apart (*Saurauia bracteosa* DC. on transects 2 and 4, and 5 while *Canthiumera glabra* (Blume) K.M. Wong & Mahyuni on transects 1, 3, and 5). Although they currently have low-risk rarity status, if conservation is not carried out on these species, it is possible that these species will become rare or even extinct in the future. The International Union for Conservation of Nature (IUCN) Red List provides criteria and categories for evaluating the extinction risk and threat status of species that have guided conservation efforts for more than five decades (Betts et al. 2020). The types of rarities that concern conservation biologists are specifically related to the potential vulnerability to extinction. Commonly recognized types of rarity (Rabinowitz 1981; Cropper 1993) include species with:

- Small populations, wide geographic range, and occurrence in multiple habitats.
- Large populations, wide geographic range, but occurrence in specific habitats. (Cropper 1993).
- Small geographic range, but locally abundant in certain habitats.
- Small geographic range, and rarely found in certain habitats. This is perhaps the most critically endangered species, as small populations restricted to small, specific habitats are particularly vulnerable to extinction.
- Small populations are a concern in any region, even if populations exist elsewhere.
- Small populations of new species (Cody 1989).

These rare plants can be developed and propagated with the aim of carrying out reintroduction activities to their natural habitat and ultimately preserve the species. (Usmadi et al. 2018). Indonesia terrain only covers about 1.3 % of the earth surface, but it has very high level of biodiversity. For plants, Indonesia is estimated to have 25 % of the world flowering plant species, making Indonesia the seventh largest country with a total of 20,000 species, 40 % of which are endemic or native to Indonesia. Exploitation of biodiversity, illegal logging, forest conversion, poaching and illegal trade are some of the factors that cause biodiversity to be threatened. To encourage efforts to save existing natural resources, and the reality of the increasing threat and extinction of biological natural resources, the rarity status of a species is established (Kusmana & Hikmat 2015).

*Saurauia bracteosa* DC. and *Canthiumera glabra* (Blume) K.M. Wong & Mahyuni have a role in human life. *Saurauia bracteosa* DC contains anticholesterol, antioxidant, antidiabetic, analgesic, antimicrobial, antihyperlipidemic, wound healing agent, and immunostimulatory activities and tradi-

tionally used to treat various open wounds, itching, and boils. *Canthiumera glabra* (Blume) K.M. Wong & Mahyuni has been used for construction, especially in mountainous areas. Threats faced by *Saurauia bracteosa* DC. and *Canthiumera glabra* (Blume) K.M. Wong & Mahyuni are forest fires and exploitation of *Saurauia bracteosa* DC. and *Canthiumera glabra* (Blume) K.M. Wong & Mahyuni for furniture needs of the surrounding society. Conservation measures that can be taken are protecting those two species, conducting socialisation to the surrounding society, cooperating with the society to maintain *Saurauia bracteosa* DC. and *Canthiumera glabra* (Blume) K.M. Wong & Mahyuni, and establishing law enforcement in order to protect the plants in Tahura Raden Soerjo by law.

### Conservation Efforts in *Angiosperms* Inventory

Humans are very dependent on plants to carry out their daily lives. Biodiverse populations are currently under increasing threat of extinction as the human population increases. About 1.6 billion people live within 5 km of forests, and many of them, including indigenous peoples, depend on the ecological functions of forests (Newton et al. 2020). For forest-dependent society, the value of forests lies in cultural identity, shelter, and lifestyle that will be lost in case the degradation or removal of forests occurred (Savilaakso et al. 2021). However, customary management does not necessarily maintain forest integrity in true sense, as the dichotomy between conservation and development is not reflected in the understanding of forest utilisation with stewardship approach as practiced by many indigenous societies (Smith 2015). In addition, the high rate of deforestation also results in higher level of threat to plant species within the forest (Usmadi et al. 2018). The drive to fulfill human needs has led to overexploitation of biological resources, resulting in many species facing the threat of extinction. Therefore, sustainable conservation measures are needed in order to prevent the worsening of the current condition (Magandhi & Lestari 2023). Concrete conservation efforts can be implemented through regular monitoring of land use and land cover, reforestation, limiting human activities, involving local communities through education and participatory management (Boussema et al. 2022), integrating local knowledge (Pratama et al. 2024), and adopting Integrated Landscape Approaches (IPCC 2019).

## CONCLUSION

This study found 35 local plant species on the slopes of Mount Argowayang, Pujon, Tahura Raden Soerjo. The plant diversity index indicates high diversity, a stable and balanced community, and high species richness. The dominant species in this discovery are *Lithocarpus sundaicus* (Blume) Rehder and *Mallotus barbatus* Müll.Arg. Then there are also two taxa that are included in the threatened taxa, namely *Saurauia bracteosa* DC. and *Canthiumera glabra* (Blume) K.M. Wong & Mahyuni. Some recommendations for conservation planning include engaging with surrounding communities, fostering cooperation to maintain the trees, and establishing law enforcement to protect the trees in Tahura Raden Soerjo.

## AUTHORS CONTRIBUTION

A.N.R. designed the research and wrote the manuscript. S.S. corrected the draft manuscript and validated results. M.S.S. created the manuscript outline.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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