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Diversity, composition, and role of woody Non-Timber Forest Products in Tawangmangu, Central Java, Indonesia

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Abstract. *Haqqin F, Arkan F, Ibriza NM, Fadhilah RN, Safira RN, Dewangga A, Kusumaningrum L, Thenya T, Setyawan AD. 2024. Diversity, composition, and role of woody Non-Timber Forest Products in Tawangmangu, Central Java, Indonesia. Asian J Ethnobiol 7: 68-78.* Forests have an important role in supporting biodiversity and providing various ecosystem services vital for human welfare; besides that, forests are also an important resource for Non-Timber Forest Products (NTFP), which are forest products other than timber used by local communities. NTFP can be categorized into fodder, firewood, food wrapping, medicinal plants, ornamental plants, spices, and food. The aim of this research was to analyze biodiversity and the use of NTFP in the villages of Plumbon, Nglebak, and Sepanjang, located in Tawangmangu Sub-district, Karanganyar District, Central Java, Indonesia. Data collection included interviews and field surveys. In the course of the interviews, a total of 62 respondents were engaged. The results showed that 83 plant species belonging to 41 families had been identified for many NTFPs such as (i) medicinal plant, (ii) food, (iii) ornamental plant, (iv) fodder, (v) spices; (vi) firewood; and (vii) food wrapping. The research findings indicate that Plumbon Village (Station A) exhibited the highest NTFP woody plant biodiversity value, with the highest values for each index component, i.e., 2.8 (H'), 5.9 (Dmg), and 0.765 (E). Each village is characterized by distinct dominant plant species: *Melastoma malabatrichum* dominates Plumbon Village (Station A), *Manihot esculenta* dominates Nglebak Village (Station B), and *Calliandra houstoniana* dominates Sepanjang Village (Station C). Notably, the plant with the highest use value is *Tectona grandis*, which serves as a medicinal plant, firewood, and food wrapping material. This research provides a deeper understanding of the biodiversity and use of NTFPs in the region, which has important implications for natural resource management and the well-being of local communities.

Keywords: Forest, NTFP, plants, Tawangmangu, woody

INTRODUCTION

Forests play an important role in providing habitats and various ecosystem services essential for human well-being (Brockerhoff et al. 2017). Forests are not merely vegetation complexes but vital ecosystems with important ecological functions. One of them is as a guardian of the life support system (Ristić et al. 2019). In this capacity, forests regulate the hydrological cycle, reduce the risk of flooding, control soil erosion, mitigate climate change through carbon sequestration, and maintain low levels of seawater intrusion. In addition, forests are also responsible for oxygen production through photosynthesis, providing an essential contribution to all organisms (Aju et al. 2015). Besides that, forests protect against disease and provide natural medicinal ingredients that traditional communities have long used (Setiawan et al. 2021). The presence of forests also improves air quality by filtering pollutants and dust and providing shelter for various species that play a role in maintaining ecosystem balance (Atmajayani 2020).

Indonesian forests are one of the few countries in the world with a very high diversity of flora and fauna. As a country with the second largest area of tropical forest after Brazil, Indonesia is home to thousands of unique and ecologically and economically valuable plant and animal species (Husin 2022). Indonesian forests have the potential for diverse tropical trees; wood is one of the main commodities produced from trees as the main component of forests (Akbar et al. 2020). Apart from that, spices such as cloves, nutmeg, and pepper are also important trade commodities and have been an integral part of the history of international trade since ancient times (Abbas and Yunianto 2022). Apart from its economic value, the diversity of Indonesia's flora also has invaluable ecological value. Endemic plants that grow in Indonesian forests are important in maintaining ecosystem balance and providing ecosystem services that support human life (Nugroho et al. 2022). Indonesia's tropical forest ecosystems also have an important role in maintaining the water cycle, regulating regional climate, and providing other environmental services that support human survival (Artaxo et al. 2022).

The condition of forests in Indonesia shows several problems that must be faced. Forests in Indonesia are currently experiencing threats from deforestation, degradation, and forest conversion for oil palm plantations (Pridananti 2022). Various factors, including large-scale agriculture, the timber industry, and mining, cause deforestation in Indonesia. Deforestation in Indonesia occurs yearly and impacts changing natural conditions (Rohmaningtyas 2022). Uncontrolled forest-burning activities also cause deforestation and forest degradation in Indonesia, especially during the dry season (Segah et al. 2023). Human pressure on forests also causes deforestation and degradation. A decrease in the quantity and quality of forests causes a reduction in stored carbon, releases carbon emissions into the atmosphere, and reduces the ability of forests to absorb carbon (Kyere-Boateng et al. 2022). Apart from that, illegal practices such as illegal logging and poaching also contribute to forest destruction, which is increasingly worrying (Mujetahid et al. 2023). Forest sustainability is the result of various processes that occur in the life of forest ecology. Problems that arise, such as burning and deforestation, are some of the factors that can significantly impact the environment and human life (Ahada and Zuhri 2020).

Generally, Non-Timber Forest Products (NTFP) consist of by-products from a timber tree, such as fruit, sap, bark, leaves, resin, essential oils, and plants with unique properties, such as bamboo and rattan (Fitriyani et al. 2020). According to Sudarmalik et al. (2006), NTFP has an important role in ecological, economic, and regional development. NTFP plays a role in providing the main food source for human life and wild animals to create a balance in the food chain in an ecological aspect. Meanwhile, from an economic perspective, the NTFP plays a role in maintaining the stability of household income and national foreign exchange. The community's NTFP production, processing, and marketing processes generate income, which is used as capital for regional development. Considering the critical role of NTFP, this research aims to analyze biodiversity and the use of NTFP in the villages of Plumbon, Nglebak, and Sepanjang, which are located in Tawangmangu Sub-district, Karanganyar District, Central Java, Indonesia. Tawangmangu, located on the western slopes of Mount Lawu, has long been known as a highland tourist destination in Indonesia. Moreover, Mount Lawu has been promoted as one of the terrestrial national parks in Indonesia (Setyawan 2000, 2001).

MATERIALS AND METHODS

Study area

Tawangmangu Sub-district is one of the 17 sub-districts in Karanganyar District, Central Java Province, Indonesia. The distance from the district capital is 27 km east. Therefore, most people work as farmers and farm laborers. The primary commodities in Tawangmangu are rice, corn, cassava, and sweet potatoes (BPS 2023). The research was conducted in the Tawangmangu Sub-district, where three villages were chosen for the research, namely: Plumbon Village (Station A), Nglebak Village (Station B), and Sepanjang Village (Station C). The three villages are located around 800 m above sea level (Figure 1).

Forest conditions around Tawangmangu have somewhat sparse vegetation but relatively dense vegetation (Roziaty et al. 2023). Mount Lawu divides its area into two administrative provinces: the western slope and the eastern slope. The western slope is located in Central Java Province, covering Karanganyar, Sragen, and Wonogiri districts, while the eastern slope is located in East Java Province, covering Ngawi and Magetan districts (Purwanto and Titasari 2019). The western slope of Mount Lawu is located in the highlands with humid forest conditions (Witantri et al. 2015), and can store good water in its soil; apart from that, it is also supported by a neutral soil pH of around 7, which allows vegetation to grow well (Luthfiya et al. 2015).

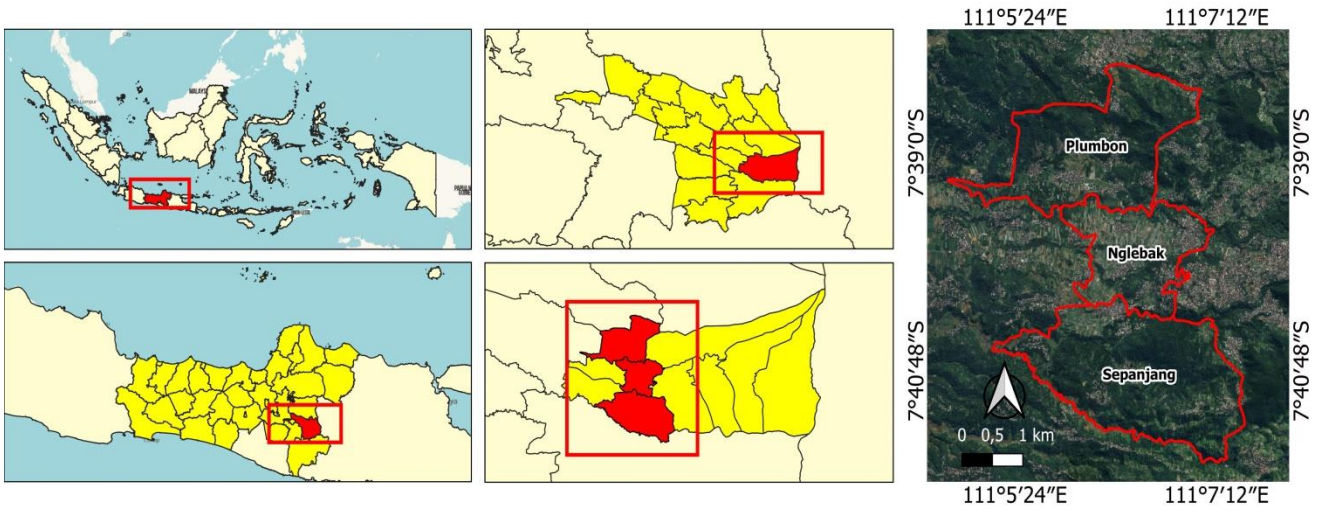

Figure 1. Map of the study area in Tawangmangu Sub-district, Karanganyar District, Central Java Province, Indonesia, including Plumbon Village (Station A); Nglebak Village (Station B); and Sepanjang Village (Station C)

Procedures

Research preparation

The tools and materials used to carry out the research were a list of questions, stationary, a tally sheet containing questions and tables to make data collection easier, and smartphones for documentation. Cameras and smartphone cameras are used for species documentation. Identification is carried out directly and indirectly for species whose identity is unknown, and documentation is carried out on the leaves, stems, flowers, and fruits. Taxonomic determination followed by the Global Biodiversity Information Facility (GBIF) (https://www.gbif.org), and the Plants of the World Online (POWO) (https://powo.science.kew.org/)

Data collection

The data collection methods used in this research were (i) semi-structured interviews and (ii) field surveys (Abebaw and Damme 2023). Respondents were selected by random sampling of local village communities, and the interview technique used was a questionnaire, which asked a list of questions related to the community's use of non-timber forest products in the villages of Plumbon, Nglebak, and Sepanjang. Field data were collected through cruising and purposive sampling for vegetation inventory (Efendi et al. 2024).

Data analysis

Data analysis was carried out descriptively and quantitatively. The data obtained from the interview results will determine the Use Value of the species found, while from the field survey results, the biodiversity index will be determined using predetermined formulas. These indices include the Shannon-Wiener diversity index (H'), evenness index (E), Margalef species richness index (Dmg), Sorensen similarity index (IS), and Simpson dominancy index (C). Taxonomic species identification was carried out using the Global Biodiversity Information Facility or GBIF website (https://gbif.org/), and the Plants of the World Online (https://powo.science.kew.org/).

Simpson dominancy index

The following information pertains to the Simpson Dominance Index, which determines the dominant species at each research station. The index is derived using the following formula (Simpson 1949):

$$C = (Ni/n)^2$$

Where:
C : Simpson dominance index
Ni : number of individuals of the i-th species
n : total number of individuals of all species.
Simpson assessment criteria:
C>1 : high dominance
C=0 : low dominance

Shannon-Wiener diversity index

Species diversity found in ecology can be determined from the Shanon-Wiener diversity index (Odum 1996) with the following formula:

$$H' = -\sum (ni/N) \ln (ni/N)$$

Where:
H' : Shannon-Wiener Index
ni : Number of individuals of the i-th species
N : Total number of individuals of all species
Diversity index classification
H' < 1 : low diversity
1<H'<3 : moderate diversity
H' > 3 : high diversity

Evenness index (E)

According to (Krebs 1989), the evenness index can be used to calculate the evenness of individual abundance for each species. The formula used to calculate the evenness index is as follows:

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

Where:
E : Evenness Index
H' : Diversity Index
S : Number of species identified
Evenness Index assessment criteria:
E > 0.6 : High species evenness
0.4<E<0.6 : Moderate species evenness
E < 0.4 : Low species evenness

Margalef species richness index (Dmg)

The species richness index can determine species richness in an ecosystem compared to the number of individuals. The formula used to calculate the Margalef Species Richness Index (Margalef, 1958) is as follows:

$$Dmg = \frac{(s-1)}{ln\ N}$$

Where:
Dmg : Margalef Species Richness Index
S : Number of identified species
N : Total number of individuals of all species
Margalef species richness assessment criteria:
Dmg < 2.5 : Low level of species richness
2.5<Dmg<4 : Moderate level of species richness
Dmg>4 : High level of species richness

Sorensen similarity index (Similarity)

The similarity index shows the similarities between stations or research areas. It can be calculated using the formula (Sorensen, 1948).

$$S = \frac{2C}{A+B} \times 100\%$$

Where:
A : Number of vegetation types in community A
B : Number of vegetation types in community B
C : Number of same vegetation types in communities A and B
Assessment criteria:
IS>90% : very high similarity
61%<IS<90%: high similarity
31%<IS<60%: moderate similarity
IS<30%: low similarity

RESULTS AND DISCUSSION

Respondent characteristics

The number of respondents is 62, dominated by men often found in home gardens (Table 1). Gender also indirectly influences the quality of work in farming activities. According to respondents' job characteristics, the majority of jobs are self-employment. It is because job opportunities are very limited in Tawangmangu Sub-district, so residents are encouraged to start businesses like farmers. The results showed that respondents with self-employed jobs reached 67.7%. The dominant occupation for women is housewife, with a percentage of 22.6%. The results also show that the age composition of respondents falls into the vulnerable age category for -blue-collar jobs requiring strong physical conditions, where 50% of respondents are over 50 years old. Even so, most respondents are still of a productive age and have high work enthusiasm. Elementary school accounted for 40.3% of the respondents' last level of education, while 24.2% did not graduate. Low education does not necessarily rule out the possibility that they possess more knowledge and experience in the workplace, particularly in areas such as forest management or agriculture.

Plant diversity

Based on the results of field surveys and interviews at three villages in Tawangmangu Sub-district, 83 plant species from 41 plant families were identified (Table 2). Family is a higher taxonomic unit than genus and species, and the existence of many families indicates significant ecosystem diversity in the region.

According to the results, the Fabaceae family has the highest number of species (Figure 2). The analysis identified 12 species within the Fabaceae family, i.e.: *Acacia mangium, Albizia chinensis, Calliandra houstoniana, Crotalaria juncea, Dalbergia latifolia, Dalbergia obovata, Falcataria falcata, Leucaena leucocephala, Mimosa pudica, Samanea saman, Sesbania grandiflora,* and *Zapoteca tetragona.* It is supported by the ability of Fabaceae plants to grow well on marginal land with sloping topography, soil dominated by parent material (rocky), little nutrient and organic material content, and low moisture content (Ma'ruf et al. 2023). The Fabaceae family generally includes cosmopolitan plants, meaning they can grow in tropical and subtropical areas in various habitats ranging from savanna deserts to tropical rainforests (Hariri et al. 2021). Fabaceae plants can grow in wild areas from the lowlands to the mountains (Jannah 2023). This family can be easily recognized by their pod-shaped fruit, most of which are trees and lianas, equipped with beautiful and colorful flowers, so many are used to decorate gardens (Opianida et al. 2020). Apart from that, Fabaceae plants are known to be able to carry out symbiosis with certain bacteria in their roots or stems to fix nitrogen directly from the air without going through soil fluids (Amin 2018). Fabaceae is known to have high economic value; it is widely//' cultivated by people as food, medicinal plants, ornamental plants, fruit producers, wood producers, natural dyes, erosion control, and land reclamation (Semiun and Mamulak 2024).

Table 1. Demographic characteristics of respondents

Parameter	Specification	Freq	Percentage (%)
Gender	Male	28	45
	Female	34	55
Age	<20	1	2
	21-30	4	6
	31-40	9	14
	41-50	15	24
	51-60	114	23
	>61	19	31
Education	No education	15	25
	Elementary School	25	41
	Junior High School	2	20
	Senior High School	7	12
	University	1	2
Job	Laborer	3	5
	Self-employed	42	68
	Private	3	5
	Housewife	14	22

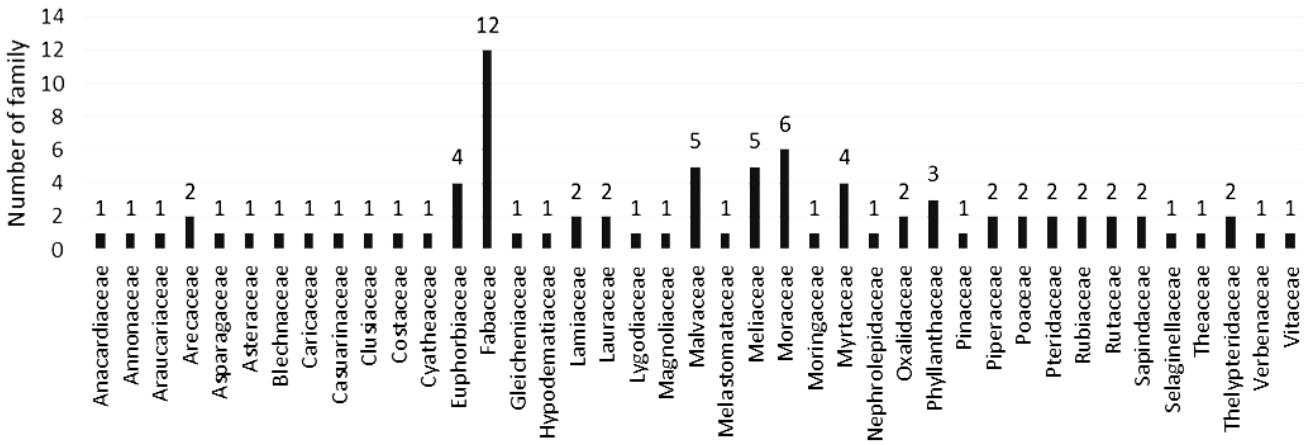

Figure 2. Number of woody plant species in each family

Table 2. Woody plants found in the study sites and their dominance index at each station

Family	Scientific name	Local name	Station		
			Plumbon	Nglebak	Sepanjang
Annonaceae	*Annona muricata* L.	*Sirsak*	-	-	0.003
Araucariaceae	*Agathis dammara* (Lamb.) Rich. & A.Rich.	*Damar*	-	-	0.017
Arecaceae	*Calamus melanochaetes* (Blume) Miq.	*Rotan penjalin*	0.007	-	-
Arecaceae	*Cocos nucifera* L.	*Kelapa*	0.027	-	-
Asparagaceae	*Cordyline fruticosa* (L.) A.Chev.	*Hanjuang*	0.032	0.005	-
Asteraceae	*Chromolaena odorata* (L.) R.M.King & H.Rob.	*Kirinyuh*	0.374	-	0.066
Blechnaceae	*Blechnum orientale* L.	*Paku lipan*	0.007	-	-
Caricaceae	*Carica papaya* L.	*Pepaya*	0.046	-	-
Costaceae	*Cheilocostus speciosus* (J.Koenig) C.D.Specht	*Pacing*	0.002	-	-
Cyatheaceae	*Cyathea contaminans* (Wall. ex Hook.) Copel.	*Pakis pohon*	0.025	0.025	-
Euphorbiaceae	*Manihot esculenta* Crantz	*Singkong karet*	0.034	**0.425**	0.033
Euphorbiaceae	*Macaranga* sp.	*Makaranya*	0.005	-	0.010
Euphorbiaceae	*Euphorbia hirta* L.	*Patikan kebo*	-	0.025	0.060
Fabaceae	*Falcataria falcata* (L.) Greuter & R.Rankin	*Sengon laut*	0.077	0.005	0.066
Fabaceae	*Leucaena leucocephala* (Lam.) de Wit	*Petai cina*	0.055	0.232	0.080
Fabaceae	*Dalbergia obovata* E.Mey.	*Simpur*	0.002	-	-
Fabaceae	*Dalbergia latifolia* Roxb.	*Sonokeling*	0.005	-	0.007
Fabaceae	*Samanea saman* (Jacq.) Merr.	*Trembesi*	0.175	-	-
Fabaceae	*Mimosa pudica* L.	*Putri malu*	0.016	-	-
Fabaceae	*Zapoteca tetragona* (Willd.) H.M.Hern.	*Kaliandra putih*	-	0.089	-
Fabaceae	*Calliandra houstoniana* (Mill.) Standl.	*Kaliandra merah*	0.080	0.020	**0.633**
Fabaceae	*Sesbania grandiflora* (L.) Poir.	*Turi*	-	0.035	-
Fabaceae	*Crotalaria juncea* L.	*Orok-orok*	-	0.005	-
Fabaceae	*Albizia chinensis* (Osbeck) Merr.	*Sengon jawa*	-	-	0.010
Fabaceae	*Mimosa pudica* L.	*Putri malu*	-	-	0.003
Gleicheniaceae	*Dicranopteris linearis* (Burm.fil.) Underw.	*Resam*	0.068	0.005	0.073
Hypodematiaceae	*Leucostegia immersa* C.Presl	*Leukostasia*	-	-	0.003
Lamiaceae	*Tectona grandis* L.f.	*Jati*	0.014	0.123	0.017
Lamiaceae	*Gmelina arborea* Roxb. ex Sm.	*Jati putih*	-	-	0.007
Lauraceae	*Cinnamomum verum* J.Presl	*Kayu manis*	-	0.010	-
Lauraceae	*Persea americana* Mill.	*Alpukat*	-	0.094	0.007
Lygodiaceae	*Lygodium* Sw.	*Ligodium*	0.002	-	0.003
Malvaceae	*Durio zibethinus* Murray	*Durian*	0.023	0.094	0.033
Malvaceae	*Ceiba pentandra* (L.) Gaertn.	*Randu*	-	0.005	-
Malvaceae	*Sida rhombifolia* L.	*Sidaguri*	-	0.060	-
Malvaceae	*Hibiscus tiliaceus* L.	*Waru*	-	-	0.003
Melastomataceae	*Melastoma malabatrichum* L.	*Senggani*	**0.403**	-	0.371
Meliaceae	*Swietenia mahagoni* (L.) Jacq.	*Mahoni*	0.109	0.010	0.073
Meliaceae	*Toona sinensis* (A.Juss.) M.Roem.	*Surian*	0.018	0.044	-
Meliaceae	*Toona sureni* (Blume) Merr.	*Pupus hijau*	0.096	0.049	0.073
Meliaceae	*Azadirachta indica* A.Juss.	*Mimba*	-	0.010	-
Moraceae	*Artocarpus heterophyllus* Lam.	*Nangka*	0.011	0.030	0.013
Moraceae	*Ficus fistulosa* Reinw. ex Blume	*Beringin benying*	0.009	-	-
Moraceae	*Artocarpus odoratissimus* Blanco	*Terap*	-	0.005	-
Moraceae	*Artocarpus altilis* (Parkinson) Fosberg	*Sukun*	-	0.020	-
Moraceae	*Ficus septica* Burm.fil.	*Awar-awar*	-	0.010	-
Moringaceae	*Moringa oleifera* Lam.	*Kelor*	-	0.059	0.003
Myrtaceae	*Syzygium myrtifolium* Walp.	*Pucuk merah*	-	0.025	-
Myrtaceae	*Syzigium aromaticum* (L.) Merr. & L.M.Perry	*Cengkeh*	-	-	0.010
Nephrolepidaceae	*Nephrolephis* sp.	*Paku pedang*	0.021	-	-
Oxalidaceae	*Averrhoa bilimbi* L.	*Blimbing wuluh*	-	-	0.010
Phyllanthaceae	*Breynia androgyna* (L.) Chakrab. & N.P.Balakr.	*Katuk*	0.002	-	-
Phyllanthaceae	*Bridelia tomentosa* Blume	*Bridelia*	0.002	-	-
Phyllanthaceae	*Phyllanthus urinaria* L.	*Meniran*	-	-	0.106
Pinaceae	*Pinus merkusii* Jungh. & de Vriese	*Pinus*	0.007	0.005	0.003
Piperaceae	*Piper betle* L.	*Sirih*	0.005	-	-
Piperaceae	*Piper aduncum L.*	*Sirih hutan*	-	-	0.020
Poaceae	*Bambusa vulgaris* Schrad. ex J.C.Wendl.	*Bambu*	-	0.010	-
Poaceae	Gigantochloa apus (Schult.f.) Kurz	*Bambu hijau*	0.021	0.020	-
Pteridaceae	*Pityrogramma calomelanos* (L.) Link	*Paku perak*	0.011	-	-
Pteridaceae	*Adiantum peruvianum* Klotzsch	*Suplir*	0.071	0.104	0.113
Rubiaceae	*Coffea arabica* L.	*Kopi*	-	0.005	-
Rutaceae	*Citrus reticulata* Blanco	*Jeruk*	-	-	0.003

Rutaceae	*Citrus* × *limon* (L.) Osbeck	*Lemon*	-	-	0.003
Sapindaceae	*Nephelium lappaceum* L.	*Rambutan*	0.009	-	-
Selaginellaceae	*Selaginella* sp.	*Cakar ayam*	-	0.015	-
Theaceae	*Schima wallichii* (DC.) Korth.	*Puspa*	-	-	0.010
Thelypteridaceae	*Cyclosorus* sp.	*Paku*	0.007	-	0.023
Thelypteridaceae	*Christella subpubescens* (Blume) Holttum	*Paku*	-	0.005	-
Verbenaceae	*Lantana camara* L.	*Tembelekan*	0.089	0.020	0.033
Vitaceae	*Leea indica* (Burm.fil.) Merr.	*Girang*	0.034	-	-

Notes: A: Plumbon Village; B: Nglebak Village; C: Sepanjang Village. The numbers in bold show which species has the highest dominance value at the research station

The Moraceae family has the most species, with a total of 6 species: *Artocarpus heterophyllus*, *Artocarpus odoratissimus*, *Artocarpus altilis*, *Ficus fistulosa*, *Ficus septica*, and *Morus alba* (Figure 2 and Table 2). The research identified three genera within the Moraceae family: *Ficus*, *Artocarpus*, and *Morus.* Samsudin (2020) stated that these three genera are the main ones in the Moraceae family. *Artocarpus* is mainly found in the Malesian region, while half of the species in the largest genus, *Ficus*, are also spread across the Malesian area. *Morus* is the dominant genus in the warm northern climate and is widespread in the tropical mountains of Asia and America and the lowlands of Africa. These findings align with Rasnovi et al. (2024), who stated that plants from the Moraceae family are generally found in tropical regions, subtropical regions, and only in limited numbers in temperate regions.

Ecological indices

The ecological index is obtained from field survey data containing information related to the biodiversity index.

Simpson dominance index

These findings provide a reasonably comprehensive picture of the diversity of flora in the Tawangmangu Sub-district, especially woody plants. *Melastoma malabatrichum* is the most commonly found species, with the number of individuals reaching 0.403 (in Station A, Plumbon) and 0.371 (in Station C, Sepanjang) based on Simpson index dominancy. Meanwhile, the family group found most to be the Fabaceae family, with 12 species (Figure 2). Based on the field survey results, station A (Plumbon) was dominated by *M. malabatrichum* (0.403). Station B (Ngeblak) is dominated by *Manihot esculenta* (0.425). Station C (Sepanjang) is dominated by *C. houstoniana* (0.633) (Table 2).

The analysis reveals that each village has distinct dominant plant species. Plumbon Village has the highest dominance index of 0.40, which is found in the *senggani* plant (*M. malabatrichum*). In contrast, Nglebak Village has the highest dominance index of 0.42, which is found in cassava (*M. esculenta*), and Sepanjang Village has the highest dominance index of 0.63, which is found in the red calliandra (*C. houstoniana*).

These three plant species demonstrate a wide range of adaptability, thriving even in challenging environments. *M. malabatrichum* is prevalent in coastal areas (Laia et al. 2019) and in the highlands (Putri 2023). In contrast, *M. esculenta* and *C. houstoniana* plants exhibit the capacity to flourish in various soil types, including arid soil, requiring no special treatment (Handayani and Sundari 2016). Consequently, they are pioneer plants (Fatimah et al. 2023).

Field surveys at three villages showed that these four species were consistently present at each location. Apart from that, there are additional species, such as *Lygodium japonicum*, *Durio zibethinus*, *Swietenia mahagoni*, *Toona sinensis*, *Toona sureni*, *A. heterophyllus*, and *Lantana camara*, which are also found in the three villages. The presence of the same species in various habitats is an important highlight in the context of adaptation and ecological success. This phenomenon highlights the species' ability to adapt to environmental fluctuations, reflected in its significant tolerance to environmental conditions. These observations support the idea that these species have strong genetic and physiological abilities to adapt to changing environments, reflecting extraordinary evolutionary skills in maintaining survival.

Shannon-Wiener diversity index

The plant diversity index values in the three villages are different (Table 3). These measurements were performed using Shannon Wiener's diversity index formula. In Shannon Wiener's calculations, there are three classification indicators to assess the diversity found in the three villages. According to Shannon Wiener's Diversity Index (H`) classification, all villages have moderate plant diversity. Plumbon Village has an index (H`) 2.8, indicating moderate plant diversity. Nglebak Village has an index value of 2.7, indicating moderate plant diversity. Sepanjang Village's diversity index is 2.5, indicating moderate plant diversity. The three villages show moderate biodiversity because there is no high dominance of one species, and they do not have many species.

Table 3. Values of Diversity (H`), Richness (Dmg), and Evenness (E)

Village	H'	Dmg	E
Plumbon	2.8	5.9	0.765
Ngeblak	2.7	5.06	0.76
Sepanjang	2.5	5.31	0.70

Notes: A: Plumbon Village; B: Nglebak Village; C: Sepanjang Village

Evenness index

The evenness index is a measure of species distribution within a specific area. Research results indicate that all research stations exhibited a high evenness index, surpassing a total value of 0.6. This index is directly correlated with the H' value. A high evenness index suggests that no single species poses a threat to others, as they can coexist spatially.

Despite the presence of species with a high dominance index at each station, there is no discernible impact on the surrounding plant communities. It suggests that dominant species at each station, such as *M. malabatrichum*, *M. esculenta*, and *C. houstoniana*, do not exhibit invasive growth tendencies within that environment. Furthermore, the environmental conditions in the area continue to provide robust support and vitality for the plant community within the ecosystem.

Species richness index

Meanwhile, the Species Richness Index is related to the species richness of each species in each community. Naturally, the species richness index includes a classification index that indicates the current state of species richness. The species richness table shows that all villages are categorized as having good species richness because they have an index value above 4. The highest value is in Plumbon Village because the village has the highest number of species, with a value of 6.04.

The number of species factor is directly proportional to the value of the species richness index (Dmg). The species richness index (Dmg) is an index that shows the richness value of a species found in one area or village. It is related to the proportion of a species found among all individuals in the observation area or village. The higher the value of species richness (Dmg), the proportion of the species has a greater ratio to the number of individuals found. The total value also depends on the number of individuals found.

Similarity index

From the similarity index of the three villages, the Plumbon and Sepanjang villages have the highest similarity index among the three villages (Table 4). It is because many of the same species are found in both villages. In addition, the small value of the sum of variables of Plumbon and Ngeblak in the formula, which acts as dividing variables and is inversely proportional, also contributes to the low value of the similarity index. The Similarity Index is used to see how similar the community structure is between one village and another (Ibrahim et al. 2018).

Use value

Ethnobotanical data shows that 31 species of woody plants are categorized into 19 families, which are non-timber forest products (Table 5). Analysis of interview data shows that using non-timber forest products is a daily activity in local communities. The parts of plants that are often used are leaves, fruit, seeds, stems, and other parts. Local communities have various categories for utilizing non-timber forest products. The use value survey employs eight use categories, i.e., fodder, firewood, food wrapping, medicinal plants, ornamental plants, spices and food (Table 5). The research results show that its use as food (47.5%) is most commonly found in the community in Tawangmangu (Figure 3). This food source is harvested directly from the forest, or the community takes seeds from it and plants them in agroforestry systems such as home gardens (*pekarangan*) and forest gardens (*kebun/alas*).

A higher use value indicates that the species has more benefits. The plant species with the highest use value is teak (*Tectona grandis*), which has three uses, i.e. wound healing, food wrapping and firewood. The teak leaves are used as a wound-healing medicine by boiling them and covering the wound. Teak leaves are also used as food wrapping. Wrapping food in teak leaves will give off a distinctive aroma and increase appetite. Teak wood can also be used for firewood. On the other hand, using teak leaves for food wrapping can reduce dependence on plastic wrapping and become a sustainable alternative (Metananda et al. 2023).

Other species that have high use value are *T. grandis*, *Annona muricata*, *Cocos nucifera*, *A. chinensis*, *Syzigium aromaticum*, and *Psidium guajava*. *T. grandis* serves multiple purposes, including medicinal use (fruit), as a source of firewood (wood/twigs), and for food packaging (leaves). *A. muricata*, *C. nucifera*, and *P. guajava* are valued for their medicinal and culinary properties. *P. guajava* leaves are specifically boiled and used for medicinal purposes, commonly called herbal medicine by the community. *A. muricata* is used as a medicinal plant and food. *A. muricata* leaves are used to treat gout by selecting old leaves to boil until half the water remains and drinking the boiled water.

Table 4. Similarity index between villages

Village	Plumbon	Nglebak	Sepanjang
Plumbon		0.41	1
Ngeblak			0.58

Notes: A: Plumbon Village; B: Nglebak Village; C: Sepanjang Village

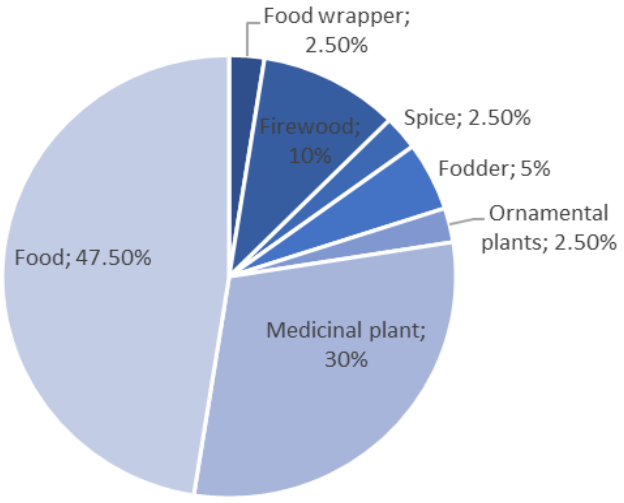

Figure 3. Percentage of plant use by the community

Table 5. Use value of species used by society

Family	Scientific name	Local name	Use	UV
Anacardiaceae	*Mangifera indica* L.	*Mangga*	2	0.02
	Mangifera odorata Griff.	*Kweni*	2	0.02
Annonaceae	*Annona muricata* L.	*Sirsak*	1, 2	0.03
Arecaceae	*Cocos nucifera* L.	*Kelapa*	1, 2	0.03
Casuarinaceae	*Casuarina equisetifolia* L.	*Cemara laut*	1	0.02
Clusiaceae	*Garcinia mangostana* L.	*Manggis*	2	0.02
Fabaceae	*Albizia chinensis* (Osbeck) Merr.	*Sengon*	6, 4	0.03
	Leucaena leucocephala (Lam.) de Wit	*Petai Cina*	2	0.02
	Acacia mangium Willd.	*Akasia*	1	0.02
	Sesbania grandiflora (L.) Poir.	*Turi*	2	0.02
	Zapoteca tetragona (Willd.) H.M.Hern.	*Kaliandra Putih*	4	0.02
Lamiaceae	*Tectona grandis* L.f.	*Jati*	1, 6, 7	0.05
Lauraceae	*Persea americana* Mill.	*Alpukat*	2	0.02
Magnoliaceae	*Magnolia ×alba* (DC.) Figlar	*Kantil*	3	0.02
Malvaceae	*Durio zibethinus* Murray	*Durian*	2	0.02
	Hibiscus tiliaceus L.	*Waru*	1	0.02
	Ceiba pentandra (L.) Gaertn.	*Randu*	6	0.02
	Swietenia mahagoni (L.) Jacq.	*Mahoni*	1	0.02
	Toona sinensis (A.Juss.) M.Roem.	*Surian*	1	0.02
	Artocarpus heterophyllus Lam.	*Nangka*	2	0.02
	Morus alba L.	*Mulberry*	2	0.02
Moringaceae	*Moringa oleifera* Lam.	*Kelor*	1	0.02
Myrtaceae	*Psidium guajava* L.	*Jambu Biji*	1, 2	0.03
	Syzygium aromaticum (L.) Merr. & L.M.Perry	*Cengkeh*	1, 5	0.03
	Syzygium aqueum (Burm.fil.) Alston	*Jambu Air*	2	0.02
Oxalidaceae	*Averrhoa carambola* L.	*Belimbing*	2	0.02
	Averrhoa bilimbi L.	*Belimbing wuluh*	2	0.02
Pinaceae	*Pinus merkusii* Jungh. & de Vriese	*Pinus*	6	0.02
Rubiaceae	*Coffea arabica* L.	*Kopi*	2	0.02
Rutaceae	*Citrus ×limon* (L.) Osbeck	*Lemon*	1, 2	0.03
Sapindaceae	*Nephelium lappaceum* L.	*Rambutan*	2	0.02
	Dimocarpus longan Lour.	*Kelengkeng*	2	0.02

Note: UV: Use Value, 1: Medicinal plants; 2: Food; 3: Ornamental plants; 4: Fodder; 5: Spices; 6: Firewood; 7: Food wrapper

Additionally, *A. muricata, C. nucifera,* and *P. guajava* are consumed directly as food without processing. Furthermore, *A. chinensis* is utilized as animal feed and as a source of firewood, whereas the *S. aromaticum* plant is highly regarded for its medicinal and culinary applications. Flowers can be made into *S. aromaticum* oil as a medicine for toothache. The *S. aromaticum* oil can be made by mixing olive oil and boiling it, then leaving it for 2-3 weeks, after which it is filtered, and the oil can be applied to external areas.

Medicinal plants

30% of plant types are categorized as medicinal plants. For treatment, the leaves of the P. guajava plant are processed by pounding them, then adding boiled water, then the mixture is filtered and drunk. Soursop leaves are also used as a gout medicine by boiling the leaves until half of the initial volume remains, after which the water is drunk. According to the community, the plants used for medicinal plants such as *T. grandis, A. muricata, P. guajava, S. aromaticum, Citrus × limon, C. nucifera, S. macrophylla,* and *Moringa oleifera*. These plants' leaves are also commonly used for medicinal purposes. The leaves most widely used in medicine are also described in Wonoharjo Village, Pangandaran, West Java (Nisyapuri et al. 2018). They believe that the use of leaves has high benefits, is easy to obtain, does not interfere with tree growth, can sprout again, and has soft fibers. Leaves are also a part of the plant that contains high carbohydrates, minerals, and vitamins (Abbas et al. 2017). People use plants by eating them directly, boiling them, sticking them on, and smearing them; they can also be used for bathing, soaking, and gargling (Nahdi and Kurniawan 2019).

Food

Based on interview results, utilization as food has the largest percentage, namely 47.50% (Figure 3). People in Tawangmangu use plants as food quite diversely because they can be processed/cooked or consumed directly/raw. The types of food consumed directly or raw are generally fruit such as *Mangifera indica, A. muricata, Mangifera odorata, C. nucifera, D. zibethinus, Dimocarpus longan, Nephelium lappaceum.* Meanwhile, the type of plant consumed through the processing process is *C. arabica,* which requires a drying and grinding process before being brewed with water and drunk; *Pinus merkusii* is prepared by roasting the seeds (strobilus) until golden and then mixing them into vegetables; Then there is the processing of *A. heterophyllus (nangka)* seeds to make flour by

cleaning the seeds from their skins, then drying them, then grinding them and filtering them.

Ornamental plant

It turns out that the use of plants as ornamental plants is quite rare among the Tawangmangu Community. Based on interview results, this type of NTFP use is only found in 2.5% of plant species. *Magnolia alba*, or what local people call *kantil*, is one of the ornamental plants for the Tawangmangu people. Apart from having a beautiful flower appearance, this type of plant is also famous for the delicious aroma of the flowers. Some beliefs say that this type of flower has a ritual function so that wherever you are, you will still have an attachment even though you are in a different world because this philosophy makes these flowers a source of pride for the people of Central Java (Kasirah et al. 2017). This type of flower is also used by the Karang Intan community in South Kalimantan as an ornamental plant (Ningsih et al. 2017).

Fodder

Albizia chinensis (*sengon Jawa*) and *Z. tetragona* (*kaliandra putih*) are two plants used as fodder. In research by Marhaeniyanto et al. (2019), it was explained that *sengon* leaves and white calliandra leaves have a crude protein content of >18%, which can increase productivity. This type of fodder is also used by the people of Malang, East Java (Marhaeniyanto et al. 2019) and Gowa, South Sulawesi (Suryanto and Prsetyawati 2014).

Spices

Plants used as spices or flavorings are only *S. aromaticum*. The use of this type of NTFP is found in the Tawangmangu community, namely 2.5%. Apart from being used as a kitchen spice, one way of processing *S. aromaticum* is through processing clove oil. The Tawangmangu people usually mix clove flowers with boiled olive oil and then let it sit for about 2-3 weeks, after which the oil is filtered and can be used. The benefits of non-timber forest products that can be used include *S. aromaticum* as a spice. Consuming spice plants will improve health. Considering the nutraceutical benefits of spice plants, there has been an increase in the commercialization of spices in various countries (Idowu et al. 2021).

Firewoods

Plants used as firewood include *T. grandis*, *A. chinensis*, *P. merkusii*, and *Ceiba pentandra*. For firewood and cooking, people use fallen or dry branches. One of them is teak, which has a softer texture with a higher water content, making the wood more flexible and flammable (Munib et al. 2021). The community of Wawonii Island in Southeast Sulawesi demonstrates discerning criteria when selecting firewood, seeking wood that ignites quickly even in damp conditions, emits minimal smoke, and sustains a prolonged burn. Typically, the preferred sources of firewood include standing timber within the forest, residual logs from canoe production, and trees within cultivated gardens and dry-fields (Sunarti and Ruqayah 2009).

Food wrapper

Use as a food wrapper is only found for teak plants. The part used is the leaves. The use of *T. grandis* as a food wrapper is also found in Gunungkidul, Yogyakarta, because it is considered an environmentally friendly alternative food wrapper (Arista et al. 2022). Apart from that, Southeast Asian people also use *T. grandis* leaves as food wrappers, especially for liquid foods such as cereal, soups, raita, and dhal, and used as food wrappers when steamed (Kalina et al. 2024).

In conclusion, this research produced important findings regarding the diversity and use of non-timber forest products (NTFP) in three villages in the Tawangmangu Sub-district. 79 plant species from 40 families were found in the three villages. Among Plumbon, Nglebak, and Sepanjang villages, a moderate H' index is observed, with the highest H' value recorded in Plumbon Village. This trend is also reflected in the Dmg and E values, which are highest in Plumbon Village. Then, woody plant species were also obtained and classified based on their utilization value. The use value varies for each species due to the amount of use. Based on the number of uses, it was found that the teak species had the highest use value. The Tawangmangu community effectively utilizes teak plants for purposes beyond furniture production. Teak, classified as NTFP, serves various functions, including medicinal use, food packaging, and as a source of firewood.

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