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# Traditional knowledge and utilization of non-medicinal plants in homegardens of a tropical karst landscape in Central Java, Indonesia

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**Abstract.** *Reza AD, Firdausi E, Kusuma LA, Sabrina MA, Fadhillah EN, Md Naim D, Setyawan AD. 2025. Traditional knowledge and utilization of non-medicinal plants in homegardens of a tropical karst landscape in Central Java, Indonesia. Intl J Trop Drylands 9: 20-35.* Homegardens in tropical karst landscapes of Central Java, Indonesia represent vital biocultural systems that conserve plant biodiversity and traditional ecological knowledge while supporting rural livelihoods. This study documents the diversity, uses, and cultural significance of 143 non-medicinal plants across homegardens in Johunut, Paranggupito, and Gudangharjo Villages of Paranggupito Sub-district, Wonogiri District, Central Java. Through interviews with 100 respondents and field observations, plants were categorized into five functional groups: food (45.6%), ornamental (34.7%), spice (12.2%), fodder (8.8%), and other uses (6.8%). Use Value (UV) analysis identified *Mangifera indica*, *Carica papaya*, and *Zingiber officinale* as culturally keystone species. The predominance of trees (39.5%) and utilization of fruits (37.4%) and leaves (15.6%) demonstrate adaptive strategies to karst-specific constraints like shallow soils and seasonal droughts. Inter-village comparisons revealed localized variations, with Paranggupito emphasizing spice plants (e.g., *Capsicum annuum* UV=0.4) and Gudangharjo prioritizing fodder species, reflecting ecological and cultural adaptations. Notably, 26.5% of species served multiple purposes, exemplified by *Cocos nucifera* (food, construction, rituals) and *Musa acuminata* (food, fodder, ceremonial use). The study highlights homegardens as dynamic, multifunctional landscapes where biodiversity conservation intersects with cultural preservation. However, knowledge concentration among elders (51-60 years age group) signals erosion risks. We emphasize the urgency of intergenerational knowledge transfer and community-based conservation to sustain these resilient agroecosystems amidst socioeconomic and environmental changes in fragile karst regions.

**Keywords:** Ethnobotany, homegardens, karst landscape, non-medicinal plants, traditional knowledge, use value

## INTRODUCTION

Homegardens represent one of the oldest and most resilient agroforestry systems practiced globally, particularly in tropical regions, and are not just about plants. These small-scale, multispecies, and multifunctional land-use systems serve as an important reservoir of plant biodiversity and traditional ecological knowledge (Kefale 2020; Ivanova et al. 2021). In rural communities, homegardens not only supply households with food, spices, fodder, and materials but also play essential roles in cultural expression, ecological sustainability, and local economies. Their significance in cultural expression is a testament to the deep connection between people and their environment. Studies across Southeast Asia have shown that the composition of homegarden flora reflects both ecological conditions and cultural practices of the inhabitants (Ashari et al. 2012; Mekonen et al. 2015).

Most ethnobotanical studies in Indonesia have emphasized the medicinal uses of plants due to the rich tradition of herbal medicine and its economic relevance (Arsyad 2018; Hanun et al. 2023). However, a significant proportion of plants cultivated or protected by local communities fall outside the medicinal domain. These non-medicinal plants—including edible fruits, vegetables, ornamental species, fodder plants, spices, and construction materials play a crucial role in the local economy. They are often undervalued in scientific discourse despite their daily importance to rural livelihoods (Borelli et al. 2020). The nuanced understanding of their roles, especially in biodiversity-rich but economically marginalized settings such as karst landscapes, remains limited.

Karst ecosystems are recognized as globally important biodiversity hotspots, shaped by highly porous limestone geology, shallow soils, seasonal droughts, and uneven nutrient availability (Widyaningsih 2017; Mane et al. 2019). In Indonesia, tropical karst areas are characterized by unique ecological constraints and a strong dependence of local communities on surrounding biological resources. Limited arable land and distant access to markets have encouraged subsistence practices centered around homegardens and forest margins. As a result, plant selection in homegardens of karst areas is often adapted to micro-environmental conditions and long-established cultural preferences (Tolentino et al. 2020; Farikha et al. 2025).

Paranggupito Sub-district in Wonogiri, Central Java, represents a typical karst region where communities heavily depend on local plant resources for daily subsistence. While previous studies in Java have extensively documented medicinal plants (Nofrianti et al. 2021; Rahman et al. 2022; Nurcahyo et al. 2024), research on non-medicinal species remains limited, despite their greater species richness and more frequent daily use. These plants fulfill essential roles in nutrition, cultural practices, spiritual symbolism, and environmental adaptation.

Traditional knowledge about these plants is orally transmitted across generations and embedded in agricultural systems, ceremonies, and social norms (Tynsong et al. 2020; Malapane et al. 2024). However, this knowledge system faces threats from rapid socioeconomic changes, land conversion, and eroding intergenerational transfer. Younger generations in Paranggupito's karst villages show declining familiarity with traditional plant uses, while commercial agricultural inputs and market foods increasingly replace local varieties, reducing both plant diversity and agroecological resilience (Borelli et al. 2020; Hanun et al. 2023).

Documenting traditional knowledge of non-medicinal plants is critical for four key reasons: (i) it provides a comprehensive understanding of ethnobotanical diversity beyond medicinal applications; (ii) it identifies culturally significant and ecologically adaptive species for conservation priorities; (iii) it reveals sustainable land management practices tailored to karst environments; and (iv) it helps preserve Indonesia's rural biocultural heritage.

Despite their ecological and cultural importance, non-medicinal homegarden plants are frequently overlooked in scientific inventories and national biodiversity assessments. There is an urgent need for inclusive ethnobotanical surveys that systematically record all plant use categories - including food, construction, aesthetics, ritual, and livelihood support. Quantitative approaches like Use Value (UV) analysis (Zenderland et al. 2019; Wulandari et al. 2024), while well-established in medicinal plant research, remain underutilized for non-medicinal species. Implementing such methods could significantly enhance our understanding of these plants' relative importance to local communities.

This study aims to address these gaps by documenting the diversity, use categories, and local knowledge associated with non-medicinal plants in the homegardens of Paranggupito Sub-district, a karst region in Central Java, Indonesia. The specific objectives are: (i) to identify non-medicinal plant species cultivated or protected in rural homegardens, (ii) to categorize their primary and secondary uses, (iii) to analyze their relative importance using the UV index, and (iv) to explore the cultural and ecological implications of their continued use. By focusing on an ecologically constrained and culturally rich karst landscape, this study contributes to a deeper understanding of human-plant relationships beyond medicinal use. It supports efforts to integrate traditional knowledge into conservation and rural development planning.

## MATERIALS AND METHODS

### Study area

The research was conducted in three rural villages—Johunut, Paranggupito, and Gudangharjo—within the administrative boundaries of Paranggupito Sub-district, Wonogiri District, Central Java, Indonesia (Figure 1). These villages are located in the southernmost part of Central Java and form part of the tropical karst landscape of southern Java Island. The karst terrain is typified by rugged limestone hills, steep slopes, and shallow, discontinuous, fertile soils interspersed with porous bedrock. The area experiences a dry tropical climate, with distinct wet and dry seasons and limited water retention capacity due to its geological features.

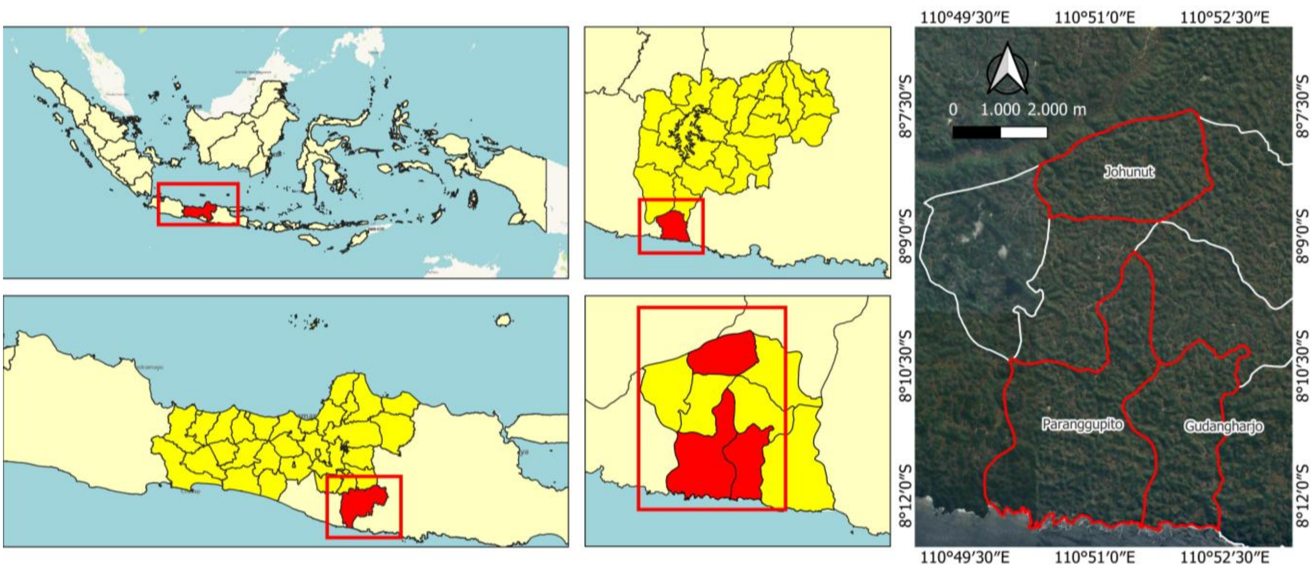


**Figure 1.** Map of the study area in Paranggupito Sub-district, Wonogiri, Central Java, Indonesia

Geographically, the study sites lie at an elevation of approximately 195 meters above sea level and are situated close to the Indian Ocean, with a combined coastal length of about 15 kilometers. Such proximity to the sea, coupled with karst topography, contributes to diverse microhabitats and challenges for conventional agriculture. According to official statistics (BPS 2023), the population densities in Johunut, Paranggupito, and Gudangharjo Villages are 307.85, 241.53, and 201.54 persons per square kilometer, respectively (Table 1). Due to limited market access, irregular road infrastructure, and seasonal water scarcity, many households in this area maintain large and functionally diverse homegardens as part of their subsistence strategy. These homegardens serve not only as a source of food, fodder, and fuel but also as a space for preserving culturally important plant species adapted to the karst environment.

**Data collection**

Data collection was conducted during October 2024 using two complementary methods: semi-structured interviews and direct field observations. These methods were employed to document local knowledge, species diversity, and utilization patterns of non-medicinal plants cultivated or maintained in homegardens.

*Respondent selection*

The study applied a purposive sampling technique to identify knowledgeable informants in each village. A total of 100 respondents were selected based on the following criteria: (i) minimum age of 17 years, (ii) ownership or active involvement in managing a homegarden, and (iii) recognized by neighbors or village leaders as knowledgeable about plant uses. The sample size was determined using Slovin's formula with a 10% margin of error based on an estimated adult population across the three villages. Table 3 presents the demographic profile of respondents, including gender, age, education level, and occupation. Interviews were conducted in Indonesian and Javanese, depending on respondents' preferences. All interviews were audio recorded with informed consent, and responses were immediately transcribed to structured tally sheets.

*Interview themes*

Each interview covered multiple dimensions of plant use and cultural knowledge transmission. (i) Respondents were first asked to identify both the local and scientific names of plants cultivated or managed in their homegardens. (ii) This was followed by documentation of the plant parts utilized, such as fruits, leaves, stems, roots, or wood. (iii) Informants then described the mode of use, whether the plants were consumed raw, cooked, dried, or used ornamentally. (iv) The interviews also explored the primary and secondary functions of each species, including roles as food, animal feed, spice, or material source. (v) Additional information was collected on cultivation methods, as well as the exchange or sharing of plant materials among community members. (vi) Finally, the process of knowledge transmission—how plant-related information and practices were passed across generations—was discussed to understand the continuity of ethnobotanical knowledge within households.

*Field observation*

Simultaneously, field observations were conducted in respondents' homegardens to verify the physical presence and condition of plants mentioned during interviews. Observations included photographing the plants, identifying growth forms (herb, shrub, tree, or climber), and recording site conditions (e.g., shade, slope, distance from the house). Some informants also demonstrated usage practices directly in the field.

**Plant identification**

All plant species mentioned by respondents during interviews and observed directly in the homegardens were recorded and preliminarily identified using their local (vernacular) names, with field notes and photographs supporting the identification process. Scientific identification of each species was carried out through a multi-step procedure involving: (i) cross-referencing vernacular names with standard references such as Heyne (1987) and relevant regional floras (Backer and Bakhuizen van den Brink 1963; Whitten et al. 1996), as well as morphological comparison using field images matched against botanical databases; (ii) morphological comparison using field images matched against online herbarium databases and botanical identification keys; and (iii) verification through international taxonomic databases, primarily the Global Biodiversity Information Facility (GBIF) (https://www.gbif.org) and Plants of the World Online (POWO) (https://powo.science.kew.org).

**Table 1.** Geographic and demographic characteristics of study villages in Paranggupito Sub-district, Wonogiri District, Central Java, Indonesia

| Village | Coordinates | Elevation (m asl) | Population density (people/km²) | Coastal proximity |
|---|---|---|---|---|
| Johunut | 8°08′10.5″ S, 110°51′40.5″ E | ~195 | 307.85 | Yes |
| Paranggupito | 8°11′18.5″ S, 110°50′57.6″ E | ~195 | 241.53 | Yes |
| Gudangharjo | 8°10′58.0″ S, 110°51′50.0″ E | ~195 | 201.54 | Yes |

For taxa that could not be identified at the species level due to morphological ambiguity, the identification was limited to the genus or family level. Only species with valid scientific names matched to accepted taxonomic entries in GBIF or POWO were included in the final dataset and used for subsequent UV calculations. Plant life forms (e.g., trees, shrubs, herbs, climbers) were recorded based on field observations and confirmed through secondary literature, with growth forms contributing to the interpretation of ecological functions and domestication status. Voucher specimens were collected for taxa with uncertain identities, while digital photographs were archived to ensure proper documentation and enable future verification.

**Data analysis**

Data collected from interviews and field observations were analyzed using both descriptive statistics and quantitative ethnobotanical methods, with a focus on evaluating the diversity and importance of non-medicinal plant species in homegardens.

*Categorization of plant use*

All recorded species were categorized based on their primary function in daily household use, with classification into five mutually exclusive categories: (i) food plants, including fruits, vegetables, and tubers; (ii) ornamental plants, cultivated for aesthetic or landscaping purposes; (iii) cooking spices, used as seasoning or flavoring in household dishes; (iv) animal feed, particularly for goats, cattle, or poultry; and (v) other uses, encompassing construction materials, firewood, and insect repellents. Each species was assigned to a single category based on informant consensus and its dominant mode of use.

*Use Value (UV) calculation*

To quantify the relative importance of each species across informants, the Use Value (UV) index was calculated for all identified plants following the standard formula (Phillips and Gentry 1993)

$$UV = \frac{\sum U_i}{N}$$

Where:

$U_i$: Total number of use reports cited for species $i$ by all informants

$N$: Total number of informants (n=100)

UV values range from 0.01 (mentioned by only one respondent with a single use) to a maximum of 1.00 (mentioned by all 100 respondents). Higher UV scores indicate greater cultural salience and frequency of use within the community.

Only species that were directly observed and correctly identified were included in the UV analysis. Species mentioned inconsistently or with uncertain identification were excluded to maintain data integrity.

*Data tabulation and visualization*

All data were tabulated using Microsoft Excel, and basic statistical summaries (e.g., number of species per use category, most-used plant parts, dominant growth forms) were generated. Visualizations such as bar charts and pie charts were developed to illustrate distribution patterns (e.g., most-used plant parts, UV-ranked species).

## RESULTS AND DISCUSSION

**Socio-demographic profile of respondents**

A total of 100 respondents participated in the study, representing households from Johunut, Paranggupito, and Gudangharjo Villages. The gender distribution consisted of 56% female and 44% male, indicating that women play a dominant role in the management and utilization of homegardens. This aligns with findings from other rural ethnobotanical studies, where women are often the custodians of household-level plant knowledge and practice.

The respondents' age distribution revealed that the majority were in the older age groups, with 28% aged 51-60 years and 25% above 60 years. This demographic pattern suggests that knowledge of non-medicinal plant uses is concentrated among middle-aged and elderly residents. Meanwhile, younger individuals (<30 years) made up less than 10% of participants, reflecting potential gaps in intergenerational knowledge transmission.

Regarding educational background, 39% of respondents had completed only elementary school, followed by 36% with senior high school education and 5% with university degrees. This range illustrates the varied literacy levels within the community, which may influence how plant knowledge is acquired and shared, either orally or through more formal learning channels.

In terms of occupation, the majority of respondents identified as farmers (45%), followed by housewives (29%), and the rest engaged in informal or mixed livelihoods such as small traders or construction workers. The strong representation of farming households underscores the reliance on homegardens not only for food but also as a multifunctional component of subsistence agriculture and household resource management. These socio-demographic characteristics support the validity of the ethnobotanical data, as respondents were actively involved in plant cultivation and use. The demographic composition is summarized in Table 3.

**Diversity and utilization of non-medicinal homegarden plants**

A total of 143 plant species belonging to 111 genera and 55 families were documented from the homegardens of respondents across the 3 study villages (Table 2). These species are cultivated, protected, or maintained primarily for non-medicinal purposes, reflecting the multifunctionality of homegardens in rural karst environments. Plant diversity was consistently high across all locations despite the ecological constraints of shallow soils and irregular rainfall common to karst landscapes. A summary of plant distribution by use category is presented in Table 2, with food plants being the most represented group

**Table 2.** Categorized utilization of homegarden plants in Paranggupito Sub-district, Wonogiri District, Central Java, Indonesia (N=143)

| Scientific name | Local name | Family | Life-form | Used part | Mode of preparation | UV | Category | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | F | O | C | A | Other uses |
| *Allium fistulosum* L. | *Bawang daun* | Amaryllidaceae | Herb | Leaf | Cooked | 0.4 | + | - | + | - | - |
| *Allium tuberosum* Rottler ex Spreng. | *Kucai* | Liliaceae | Herb | Leaf | Cooked | 0.2 | + | - | - | - | - |
| *Amaranthus caudatus* L. | *Bayam* | Amaranthaceae | Shrub | Leaf | Cooked, boiled | 0.2 | + | - | - | - | - |
| *Anacardium occidentale* L. | *Jambu mete* | Anacardiaceae | Tree | Seed | Fried | 0.4 | + | - | - | + | - |
| *Annona squamosa* L. | *Srikaya* | Annonaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Apium graveolens* L. | *Seledri* | Apiaceae | Shrub | Leaf | Boiled | 0.2 | + | - | - | - | - |
| *Artocarpus altilis* (Parkinson) Fosberg | *Sukun* | Moraceae | Tree | Fruit | Steamed, fried | 0.2 | + | - | - | - | - |
| *Artocarpus camansi* Blanco | *Kluwih* | Moraceae | Tree | Fruit | Cooked | 0.2 | + | - | - | - | - |
| *Artocarpus heterophyllus* Lam. [1)] | *Nangka* | Moraceae | Tree | Fruit, wood | Raw | 0.2 | + | - | - | - | + |
| *Averrhoa bilimbi* L. | *Belimbing wuluh* | Oxalidaceae | Tree | Fruit | Raw, cooked | 0.4 | + | - | + | - | - |
| *Averrhoa carambola* L. | *Belimbing* | Oxalidaceae | Tree | Fruit | Raw, boiled | 0.2 | + | - | - | - | - |
| *Carica papaya* L. | *Pepaya* | Caricaceae | Herb | Fruit, leaf | Raw | 0.4 | + | - | - | + | - |
| *Citrus aurantifolia* (Christm.) Swingle | *Jeruk nipis* "Jawa" | Rutaceae | Tree | Fruit, leaf | Raw, cooked, squeezed | 0.2 | + | - | - | - | - |
| *Citrus hystrix* DC. | *Jeruk purut* | Rutaceae | Tree | Fruit | Raw, squeezed | 0.2 | + | - | - | - | - |
| *Citrus limon* (L.) Osbeck | *Lemon* | Rutaceae | Tree | Fruit | Raw, squeezed | 0.2 | + | - | - | - | - |
| *Citrus maxima* (Burm.) Merr. | *Jeruk bali* | Rutaceae | Shrub | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Citrus paradisi* Macfad. | *Jeruk manis* | Rutaceae | Shrub | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Citrus reticulata* Blanco | *Jeruk keprok* | Rutaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| Citrus *sinensis* (L.) Osbeck | *Jeruk sunkist* | Rutaceae | Tree | Fruit | Raw, squeezed | 0.2 | + | - | - | - | - |
| *Cnidoscolus aconitifolius* (Mill.) I.M. Johnst. | *Pepaya jepang* | Euphorbiaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Cocos nucifera* L. | *Kelapa* | Arecaceae | Tree | Fruit | Raw, shredded | 0.2 | + | - | - | - | - |
| *Coffea arabica* L. | *Kopi* | Rubiaceae | Shrub | Seed | Dried, mashed, brewed, fried | 0.2 | + | - | - | - | - |
| *Cosmos sulphureus* Cav. | *Kenikir* | Asteraceae | Shrub | Leaf | Raw, boiled | 0.2 | + | - | - | - | - |
| *Cucurbita* sp. | *Labu* | Cucurbitaceae | Climber | Fruit | Raw, steamed | 0.2 | + | - | - | - | - |
| *Dimocarpus longan* Lour. | *Kelengkeng* | Sapindaceae | Tree | Fruit | Raw | 0.4 | + | - | - | - | + |
| *Durio zibethinus* L. | *Durian* | Malvaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Ficus septica* Burm. f. | *Awar-awar* | Moraceae | Shrub | Leaf | Raw | 0.2 | + | - | - | - | - |
| *Garcinia mangostana* L. | *Manggis* | Clusiaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Gnetum gnemon* L. | *Melinjo* | Gnetaceae | Tree | Fruit, leaf, seed | Boiled, cooked | 0.4 | + | - | + | - | - |
| *Hylocereus undatus* (Haw.) Britton & Rose | *Buah naga* | Cactaceae | Climber | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Ipomoea aquatica* Forssk. | *Kangkung* | Convolvulaceae | Herb | Leaf | Boiled, cooked | 0.2 | + | - | - | - | - |
| *Ipomoea batatas* (L.) Lam. | *Ketela rambat* | Convolvulaceae | Climber | Tuber | Steamed, baked | 0.2 | + | - | - | - | - |
| *Leucaena leucocephala* (Lam.) de Wit | *Petai cina* | Fabaceae | Tree | Seed | Raw | 0.4 | + | - | - | + | - |
| *Mangifera indica* L. | *Mangga* | Anacardiaceae | Tree | Fruit | Raw | 0.4 | + | - | - | + | - |
| *Manihot esculenta* Crantz | *Singkong* | Euphorbiaceae | Shrub | Tuber, leaf | Steamed, fried, boiled, fed directly | 0.2 | + | - | - | + | - |
| *Manilkara kauki* (L.) Dubard | *Sawo kecik* | Sapotaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Manilkara zapota* (L.) P. Royen | *Sawo manila* | Sapotaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Momordica charantia* L. | *Pare* | Cucurbitaceae | Shrub | Fruit | Cooked | 0.2 | + | - | - | - | - |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Morinda citrifolia* L. | *Mengkudu* | Rubiaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Moringa oleifera* Lam. | *Kelor* | Moringaceae | Shrub | Leaf | Cooked | 0.2 | + | - | - | - | - |
| *Morus alba* L. | *Murbei* | Moraceae | Shrub | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Muntingia calabura* L. | *Kersen* | Muntingiaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Musa acuminata* Colla var. pisang susu | *Pisang susu* | Musaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Musa acuminata balbisiana* Colla | *Pisang kepok* | Musaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Musa paradisiaca* L. | *Pisang raja* | Musaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Musa* × *paradisiaca* L. | *Pisang ambon* | Musaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Nephelium lappaceum* L. | *Rambutan* | Sapindaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Ocimum basilicum* L. | *Kemangi* | Lamiaceae | Herb | Leaf | Raw | 0.2 | + | - | - | - | - |
| *Parkia speciosa* Hassk. | *Petai* | Fabaceae | Tree | Seed | Raw, cooked | 0.2 | + | - | - | - | - |
| *Persea americana* Mill. | *Alpukat* | Lauraceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Phoenix dactylifera* L. | *Kurma* | Arecaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Psidium guajava* L. | *Jambu biji* | Myrtaceae | Tree | Fruit | Raw | 0.4 | + | - | - | + | - |
| *Psophocarpus tetragonolobus* (L.) DC | *Kecipir* | Fabaceae | Herb | Fruit | Cooked | 0.2 | + | - | - | - | - |
| *Punica granatum* L. | *Delima* | Punicaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Sauropus androgynus* (L.) Merr. | *Katuk* | Phyllanthaceae | Shrub | Leaf | Cooked | 0.2 | + | - | - | - | - |
| *Sesbania grandiflora* (L.) Pers. | *Turi* | Fabaceae | Tree | Flower | Cooked | 0.2 | + | - | - | + | - |
| *Solanum indicum* L. | *Terong kuning* | Solanaceae | Shrub | Fruit | Cooked | 0.2 | + | - | - | - | - |
| *Solanum lycopersicum* L. | *Tomat* | Solanaceae | Herb | Fruit | Raw, cooked | 0.2 | + | - | - | - | - |
| *Solanum melongena* L. | *Terong* | Solanaceae | Shrub | Fruit | Cooked | 0.2 | + | - | - | - | - |
| *Solanum nigrum* L. | *Leunca* | Solanaceae | Shrub | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Solanum torvum* Sw. | *Takokak* | Solanaceae | Shrub | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Syzygium aqueum* (Burm. f.) Alston | *Jambu air* | Myrtaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Syzygium malaccense* (L.) Merr. & L.M. Perry | *Jambu jamaika* | Myrtaceae | Tree | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Vigna unguiculata* (L.) Walp. | *Kacang panjang* | Fabaceae | Climber | Fruit | Cooked | 0.2 | + | - | - | - | - |
| *Vigna unguiculata* subsp. *unguiculata* (L.) Walp. | *Kacang tunggak* | Fabaceae | Climber | Fruit | Cooked | 0.2 | + | - | - | - | - |
| *Vitis lincecumii* Buckley | *Anggur* | Vitaceae | Climber | Fruit | Raw | 0.2 | + | - | - | - | - |
| *Zea mays* L. | *Jagung* | Poaceae | Herb | Fruit | Cooked, boiled | 0.4 | + | - | - | + | - |
| *Aglaonema commutatum* Schott | *Sri rezeki* | Araceae | Herb | Herb | - | 0.2 | - | + | - | - | - |
| *Allamanda cathartica* L. | *Bunga alamanda* | Apocynaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Aloe vera* (L.) Burm.f. | *Lidah buaya* | Asphodelaceae | Herb | Herb | - | 0.2 | - | + | - | - | - |
| *Andrographis paniculata* (Burm.f.) Nees | *Sambiloto* | Acanthaceae | Climber | Climber | - | 0.2 | - | + | - | - | - |
| *Anredera cordifolia* (Ten.) Steenis | *Binahong* | Basellaceae | Climber | Climber | - | 0.2 | - | + | - | - | - |
| *Anthurium andraeanum* Linden ex André | *Kuping gajah* | Araceae | Herb | Herb | - | 0.2 | - | + | - | - | - |
| *Anthurium plowmanii* Croat | *Gelombang cinta* | Araceae | Herb | Herb | - | 0.2 | - | + | - | - | - |
| *Bambusa vulgaris* var. *striata* (Lodd. ex Lindl.) Gamble | *Bambu kuning* | Poaceae | Herb | Herb | - | 0.2 | - | + | - | - | - |
| *Bougainvillea spectabilis* Willd. | *Bunga kertas* | Nyctaginaceae | Climber | Climber | - | 0.2 | - | + | - | - | - |
| *Opuntia cochenillifera* (L.) Mill. | *Kaktus* | Cactaceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Calathea* sp. | *Calathea kuning* | Marantaceae | Herb | Herb | - | 0.2 | - | + | - | - | - |
| *Cananga odorata* (Lam.) Hook.f. & Thomson | *Kenanga* | Annonaceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Casuarina equisetifolia* L. | *Cemara* | Casuarinaceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Catharanthus roseus* (L.) G.Don | *Tapak dara* | Apocynaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Clerodendrum paniculatum* L. | *Bunga pagoda* | Lamiaceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Codiaeum variegatum* (L.) Rumph. ex A.Juss. | *Puring* | Euphorbiaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Coleus scutellarioides* (L.) R.Br. | *Miana* | Lamiaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cordyline fruticosa* (L.) A.Chev. | *Andong* | Asparagaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Epiphyllum anguliger* (Lem.) G.Don | *Bunga wijayakusuma* | Cactaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Euphorbia tirucalli* L. | *Patah tulang* | Euphorbiaceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Euphorbia trigona* Mill. | *Kaktus katedral* | Euphorbiaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Gliricidia sepium* (Jacq.) Walp. | *Gamal* | Fabaceae | Shrub | Shrub | - | 0.2 | - | + | - | + | - |
| *Hibiscus rosa-sinensis* L. | *Bunga sepatu* | Malvaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Indigofera tinctoria* L. | *Bunga tarum* | Fabaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Ixora coccinea* L. | *Bunga soka* | Rubiaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Jasminum sambac* (L.) Aiton | *Melati putih* | Oleaceae | Climber | Climber | - | 0.2 | - | + | - | - | - |
| *Kalanchoe pinnata* (Lam.) Pers. | *Cocor bebek* | Crassulaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Lavandula angustifolia* Mill. | *Lavender ungu* | Lamiaceae | Herb | Herb | - | 0.2 | - | + | - | - | - |
| *Monstera adansonii* Schott | *Janda bolong* | Araceae | Herb | Herb | - | 0.2 | - | + | - | - | - |
| *Murraya paniculata* (L.) Jack | *Kemuning* | Rutaceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Orthosiphon aristatus* (Blume) Miq. | *Kumis kucing* | Lamiaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Pandanus odorifer* (Forssk.) Kuntze | *Pandan laut* | Pandanaceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Pennisetum purpureum* Schumach. | *Rumput gajah* | Poaceae | Shrub | Shrub | - | 0.4 | - | + | - | + | - |
| *Phalaenopsis amabilis* (L.) Blume | *Anggrek bulan ungu* | Orchidaceae | Climber | Climber | - | 0.2 | - | + | - | - | - |
| *Pilea cadierei* Gagnep. & Guillaumin | *Tanaman perak* | Urticaceae | Herb | Herb | - | 0.2 | - | + | - | - | - |
| *Piper betle* L. | *Sirih* | Piperaceae | Climber | Climber | - | 0.4 | - | + | + | - | - |
| *Platycerium bifurcatum* (Cav.) C.Chr. | *Paku tanduk rusa* | Polypodiaceae | Climber | Climber | - | 0.2 | - | + | - | - | - |
| *Pluchea indica* (L.) Less. | *Beluntas* | Asteraceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Plumeria alba* L. | *Kamboja putih* | Apocynaceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Polyscias scutellaria* (Burm.f.) Fosberg | *Mangkokan* | Araliaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Rosa chinensis* Jacq. | *Mawar tiongkok* | Rosaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Rubia cordifolia* L. | *Pohon langitan* | Rubiaceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Ruellia tuberosa* L. | *Kencana ungu* | Acanthaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Saccharum officinarum* L. | *Tebu hitam* | Poaceae | Herb | Herb | - | 0.2 | - | + | - | - | - |
| *Sansevieria trifasciata* Prain | *Lidah mertua* | Asparagaceae | Herb | Herb | - | 0.2 | - | + | - | - | - |
| *Senna alata* (L.) Roxb. | *Ketepeng cina* | Fabaceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Spathiphyllum wallisii* Regel | *Lili perdamaian putih* | Araceae | Herb | Herb | - | 0.2 | - | + | - | - | - |
| *Stauntonia hexaphylla* (Thunb.) Decne. | *Stauntonia* | Lardizabalaceae | Shrub | Shrub | - | 0.2 | - | + | - | - | - |
| *Streblus asper* Lour. | *Serut* | Moraceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Syzygium myrtifolium* (Roxb.) Walp. | *Pucuk merah* | Myrtaceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Wrightia religiosa* (Teijsm. & Binn.) Hook.f. | *Anting putri* | Apocynaceae | Tree | Tree | - | 0.2 | - | + | - | - | - |
| *Alpinia galanga* (L.) Sw. | *Laos* | Zingiberaceae | Herb | Rhizome | Crushed, cut | 0.2 | - | - | + | - | - |
| *Capsicum annuum* L. | *Cabai* | Solanaceae | Herb | Fruit | Cooked, cut, mashed | 0.2 | - | - | + | - | - |
| *Capsicum frutescens* L. | *Cabai Rawit* | Solanaceae | Herb | Fruit | Cooked, cut, mashed | 0.2 | - | - | + | - | - |
| *Citrus latifolia* (Yu.Tanaka) Yu.Tanaka | *Jeruk Nipis* "Persia" | Rutaceae | Tree | Fruit, leaf | Cut, squeezed | 0.2 | - | - | + | - | - |
| *Curcuma longa* L. | *Kunyit* | Zingiberaceae | Herb | Rhizome | Mashed, crushed | 0.2 | - | - | + | - | - |
| *Curcuma xanthorrhiza* Roxb. | *Temulawak* | Zingiberaceae | Herb | Rhizome | Crushed | 0.2 | - | - | + | - | - |
| *Cymbopogon citratus* (DC.) Stapf | *Serai* | Poaceae | Herb | Stem | Crushed, cut | 0.2 | - | - | + | - | - |
| *Kaempferia galanga* L. | *Kencur* | Zingiberaceae | Herb | Rhizome | Mashed | 0.2 | - | - | + | - | - |
| *Pandanus amaryllifolius* Roxb. | *Pandan* | Pandanaceae | Herb | Leaf | Boiled | 0.2 | - | - | + | - | - |
| *Piper retrofractum* Vahl. | *Cabai Jawa* | Solanaceae | Herb | Fruit | Cooked, cut | 0.2 | - | - | + | - | - |
| *Syzygium aromaticum* (L.) Merr. & L. M. Perry | *Cengkih* | Myrtaceae | Tree | Flower | Dried | 0.2 | - | - | + | - | - |
| *Syzygium polyanthum* (Wight) Walp. | *Salam* | Myrtaceae | Tree | Leaf | Boiled | 0.2 | - | - | + | - | - |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Tamarindus indica* L. | *Asem* | Fabaceae | Tree | Fruit | Crushed | 0.2 | - | - | + | - | - |
| *Zingiber officinale* Rosc. | *Jahe* | Zingiberaceae | Herb | Rhizome | Crushed, cut | 0.2 | - | - | + | - | - |
| *Indigofera zollingeriana* Miq. | *Indigofera* | Fabaceae | Herb | Leaf | Fed directly | 0.2 | - | - | - | + | - |
| *Musa acuminata* Colla. var. pisang mas | *Pisang Mas* | Musaceae | Herb | Leaf, stem | Fed directly, dried | 0.2 | - | - | - | + | - |
| *Musa sapientum* L. | *Pisang Raja* | Musaceae | Herb | Leaf, stem | Fed directly, dried | 0.2 | - | - | - | + | - |
| *Acacia mangium* Willd. [2] | *Akasia* | Fabaceae | Tree | Wood | - | 0.2 | - | - | - | - | + |
| *Ficus benjamina* L. | *Beringin* | Moraceae | Tree | Wood | - | 0.2 | - | - | - | - | + |
| *Gigantochloa atter* (Hassk.) Kurz [1,2,3] | *Bambu Ater* | Poaceae | Tree | Wood | - | 0.2 | - | - | - | - | + |
| *Hevea brasiliensis* (Willd. ex A. Juss.) Mull. Arg. [1] | *Karet* | Euphorbiaceae | Tree | Wood | - | 0.2 | - | - | - | - | + |
| *Murraya paniculata* var. *paniculata* [4] | *Kemuning* | Rutaceae | Tree | Leaf | - | 0.2 | - | - | - | - | + |
| *Paraserianthes falcataria* (L.) I.C. Nielsen | *Sengon* | Fabaceae | Tree | Wood | - | 0.2 | - | - | - | - | + |
| *Swietenia macrophylla* King. [2] | *Mahoni* | Meliaceae | Tree | Wood | - | 0.2 | - | - | - | - | + |
| *Tectona grandis* L.f. [1,2] | *Jati* | Lamiaceae | Tree | Wood | - | 0.2 | - | - | - | - | + |

Note: F: Food plants, O: Ornamental plants, C: Cooking spices, A: Animal feed, Others uses: 1: House building, 2: Firewood, 3: House cleaner, 4: Insect repellent

Each recorded species was categorized into one of five primary utilization categories based on the dominant use reported by informants: food plants, ornamental plants, cooking spices, animal feed, and other uses (e.g., firewood, building material, repellents). The largest group was food plants, comprising 67 species (45.6%), followed by ornamental plants with 51 species (34.7%). Cooking spices accounted for 18 species (12.2%), animal feed included 13 species (8.8%), and the remaining 10 species (6.8%) were used for construction, tools, or household utilities. The number of species in each use category is shown in Figure 2, with food plants being the most represented group.

Several species were multifunctional, with different parts utilized in more than one context. For instance, *Gnetum gnemon* was used for its fruit (as a vegetable or snack), leaves (as edible greens), and seeds (as a cooking ingredient), demonstrating the breadth of use within a single species. Similarly, *Carica papaya* provided edible fruits and young leaves; *Musa acuminata* was valued for its fruit, leaves (used as wrappers), and pseudostem (used as fodder); while *Tectona grandis* served for both firewood and construction. However, for analytical consistency, each species was categorized under its primary function based on the most frequently cited use and perceived importance as reported by informants during interviews.

This diversity of plant functions highlights the adaptive strategies of rural households in managing plant resources for everyday needs. The reliance on diverse species types also supports household resilience in the face of limited market access, making homegardens not only a space of subsistence but also of cultural continuity and environmental adaptation. A summary of plant distribution by use category is presented in Table 4.

**Use value of key food plants**

Among the five primary utilization categories, food plants exhibited the highest species richness and use frequency. A total of 67 food plant species were recorded, including fruits, vegetables, tubers, and edible leaves commonly found in household gardens. Informants identified a wide range of preparation methods, such as raw consumption, boiling, steaming, frying, or use as complementary ingredients in traditional dishes. Cooking and boiling were the most prevalent methods, indicating their dominant role in daily food processing (Figure 3).

**Table 3.** Demographic profile of respondents in Paranggupito Sub-district, Wonogiri District, Central Java, Indonesia (n=100)

| Parameter | Category | Frequency | Percentage (%) |
|---|---|---|---|
| Gender | Male | 44 | 44.0 |
| | Female | 56 | 56.0 |
| Age group (years) | < 20 | 2 | 2.0 |
| | 21-30 | 7 | 7.0 |
| | 31-40 | 14 | 14.0 |
| | 41-50 | 24 | 24.0 |
| | 51-60 | 28 | 28.0 |
| | > 60 | 25 | 25.0 |
| Education level | No formal education | 2 | 2.0 |
| | Elementary school | 39 | 39.0 |
| | Junior high school | 18 | 18.0 |
| | Senior high school | 36 | 36.0 |
| | University | 5 | 5.0 |
| Main occupation | Farmer | 45 | 45.0 |
| | Housewife | 29 | 29.0 |
| | Trader | 11 | 11.0 |
| | Others (e.g., laborers) | 15 | 15.0 |

**Table 4.** Number of species, genera, and families used for non-medicinal purposes by communities of Paranggupito Sub-district, Wonogiri District, Central Java, Indonesia

| Utilization category | Number of species | Number of genera | Number of families | Percentage of total species (%) |
|---|---|---|---|---|
| Food plants | 67 | 47 | 34 | 42.1 |
| Ornamental plants | 51 | 49 | 32 | 32.1 |
| Cooking spices | 18 | 14 | 11 | 11.3 |
| Animal feed | 13 | 13 | 7 | 8.2 |
| Other uses | 10 | 10 | 10 | 6.3 |
| Total | 143 | 111 | 55 | 100.0 |

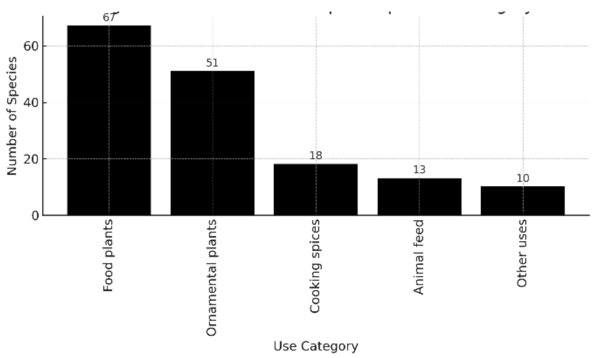


**Figure 2.** Number of plant species per use category

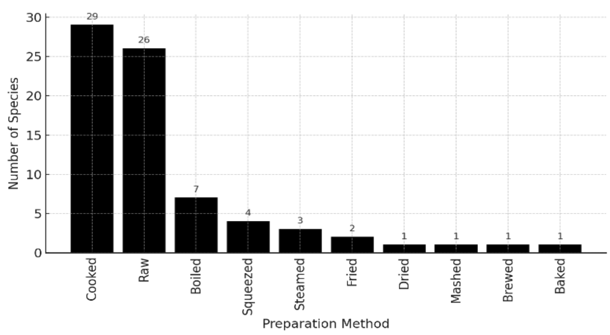


**Figure 3.** Distribution of preparation methods for useful plants of the food plants category

The Use Value (UV) index was calculated to assess each species' relative cultural and practical importance across all non-medicinal use categories. UV scores reflected how frequently a species was cited by respondents, regardless of whether it was used as food, spice, ornamental, fodder, or for other household purposes. Species with higher UV values typically possessed multiple functional roles, had year-round availability, or were considered essential to daily household practices. For instance, plants such as *Mangifera indica*, *C. papaya*, and *Zingiber officinale* achieved high UV scores due to their frequent citation across diverse usage contexts.

The top-ranked species, all with a UV score of 0.4, included *M. indica* (mango), *C. papaya* (papaya), *G. gnemon*, and *Z. officinale* (ginger), among others. These species were highly cited by respondents due to their frequent use in daily life, multiple edible parts, and year-round availability. For instance, *M. indica* was valued for its sweet fruit consumed fresh, while *C. papaya* was used for both its fruit and young leaves. *Z. officinale* and *Capsicum annuum* (chili) were widely used as essential kitchen spices. The 12 highest-ranked species with UV 0.4 are presented in Figure 4. Figure 4 presents the species with the highest UV scores, reflecting their multifunctional roles and prominence in household practices.

## Utilization by plant part used

Across all non-medicinal plant categories, respondents identified a total of 8 different plant parts that were regularly utilized in their daily activities. These included fruits, leaves, rhizomes, seeds, stems, tubers, wood, and flowers. The variation in part use reflects the multifunctionality of species in homegardens and the practical adaptation of households to karst environmental conditions.

Among these, fruits were the most commonly used plant part, cited in 55 species (37.4% of the total), particularly among food and spice plants. Most fruits, such as *M. indica*, *Syzygium aqueum*, and *Psidium guajava*, were consumed fresh or raw. Fruits were also processed into drinks, jams, or used as seasoning ingredients—for instance, *Citrus aurantifolia* and *Tamarindus indica* were frequently used for sour flavoring in traditional recipes.

Leaves were the second most commonly used plant part, found in 23 species (15.6%). These included edible leafy vegetables (*Sauropus androgynus*, *Ipomoea aquatica*), animal fodder plants (*Leucaena leucocephala*, *Manihot esculenta*), and aromatic species (*Ocimum basilicum*, *Syzygium polyanthum*). Leaf use was especially prominent in species adapted to continuous growth and year-round availability, making them a reliable source for both food and household applications.

Other parts with notable utilization included: (i) rhizomes (9 species), mostly from the Zingiberaceae family such as *Z. officinale*, *Curcuma longa*, and *Kaempferia galanga*, used as cooking spices and traditional condiments; (ii) tubers (e.g., *M. esculenta*, *Ipomoea batatas*) serving as carbohydrate staples; (iii) stems and wood, utilized as firewood, tools, and materials for house construction (*T. grandis*, *Gigantochloa atter*); and (iv) flowers (e.g., *Sesbania grandiflora*, *Bougainvillea spectabilis*) valued for aesthetics or as culinary garnishes. Figure 5 illustrates the distribution of plant parts used across all species reported in the study.

## Multipurpose and culturally important species

Among the 143 non-medicinal plant species recorded, a substantial number were found to serve multiple functions, highlighting their significance in both the subsistence economy and the cultural life of the community. A total of 39 species (26.5%) were categorized as multipurpose, being cited by respondents for at least two different primary uses. This functional overlap reinforces the value of homegardens as integrated agroecosystems that combine utility, tradition, and biodiversity.

Several food plants, for example, were also used for animal feed, shade, fencing, or ceremonial purposes. *Musa acuminata balbisiana* (banana) was used not only for its fruit but also for its leaves (as food wrappers), pseudostems (as animal fodder), and as decorative or ritual materials during community ceremonies. *Cocos nucifera* (coconut) has at least five distinct uses—including its fruit, shell, leaves, and trunk—making it one of the most versatile species reported.

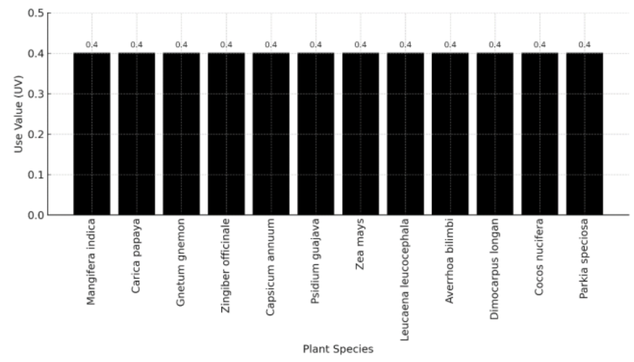


**Figure 4.** Top 12 plant species with the highest Use Value (UV)

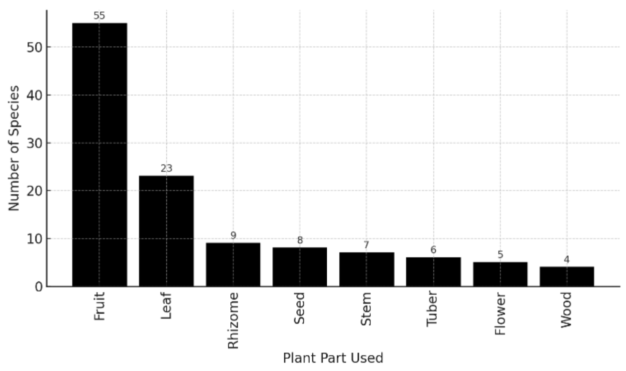


**Figure 5.** Frequency distribution of plant parts used by local communities in their homegardens in Paranggupito Sub-district, Wonogiri District, Central Java, Indonesia

Other culturally embedded species included *B. spectabilis*, used both as an ornamental and as a boundary marker; *T. grandis*, planted for its timber but also valued symbolically as a sign of prosperity; and *O. basilicum* and *S. polyanthum*, which are used in traditional cooking but also placed in ritual offerings and graveyard plantings.

These culturally important plants were often preserved even when no longer actively used, indicating their symbolic rather than utilitarian function. Older respondents, in particular, emphasized the role of such species in local identity and customary practices. Many of these species were inherited or propagated through familial exchange, reinforcing their social value across generations.

The combination of utility and cultural meaning contributes to the long-term resilience and continuity of homegarden management in the karst villages. It also suggests that conservation strategies must go beyond ecological parameters to include the preservation of biocultural relationships between people and plants. A list of key multipurpose and culturally significant species with their combined functions can be presented in Table 5. Several homegarden species were reported to serve multiple roles within the household, particularly as food, spices, and materials for other uses such as construction or ritual practices. The overlap of these uses is visualized in Figure 6.

**Plant growth forms and adaptation to karst conditions**

The analysis of growth forms among the 143 documented non-medicinal plant species revealed distinct patterns of vertical and functional stratification within homegardens. Species were classified into four major growth forms: trees, shrubs, herbs, and climbers. The distribution of plant life forms is illustrated in Figure 7, showing the dominance of trees and shrubs among homegarden species in Paranggupito Sub-district.

Trees represented the largest growth form category, accounting for 58 species (39.5%), including *M. indica*, *Artocarpus heterophyllus*, *C. nucifera*, and *T. grandis*. These species were favored not only for their fruit or timber but also for their shade-providing function, which regulates microclimate and supports the layered structure of the garden. Their deep-rooting systems also enhance resilience to drought and poor soil fertility—key characteristics of karst landscapes.

Shrubs comprised 34 species (23.1%), many of which were fruit-bearing or spice-producing taxa such as *C. annuum*, *Muntingia calabura*, and *B. spectabilis*. Shrubs were typically located at the mid-canopy level or used as living fences and hedgerows.

Herbs accounted for 37 species (25.2%), including vegetables and culinary spices such as *C. longa*, *O. basilicum*, *I. aquatica*, and *Z. officinale*. These species were mainly cultivated in the understory or near kitchen areas, benefiting from partial sunlight and routine watering.

Climbers were the least represented group, with 18 species (12.2%), including *Momordica charantia*. These plants are often grown on trellises or fences and valued for their edible fruits or shoots.

The coexistence of vertically layered species—trees, shrubs, herbs, and climbers—demonstrates the structural complexity and ecological adaptability of homegardens in karst environments. Respondents emphasized that species selection was influenced by tolerance to water scarcity, shallow soils, and heat stress. Species like *M. esculenta*, *L. leucocephala*, and *I. batatas* were noted for thriving in marginal spaces such as rock crevices or sloped plots.

These patterns reflect not only environmental filtering but also accumulated traditional ecological knowledge that informs plant selection and spatial arrangement. The dominance of hardy perennials and multi-strata vegetation in karst homegardens is a functional adaptation to environmental constraints, showcasing the resilience and ingenuity embedded in local agroecosystems.

**Table 5.** Multipurpose non-medicinal plant species and their combined functional roles

| Scientific name | Functional roles |
|---|---|
| *Musa acuminata balbisiana* Colla | Fruit, wrapper, fodder, ritual |
| *Cocos nucifera* L. | Fruit, oil, wood, ritual, roof material |
| *Tectona grandis* L.f. | Timber, symbolic planting, boundary |
| *Bougainvillea spectabilis* Willd. | Ornamental, boundary marker |
| *Ocimum basilicum* L. | Spice, ritual, ornamental |
| *Syzygium polyanthum* (Wight) Walp | Culinary, ritual, grave planting |
| *Zea mays* L. | Food, fodder, ornamental |
| *Leucaena leucocephala* (Lam.) de Wit | Fodder, shade, soil enrichment |
| *Cassia siamea* Lam. | Firewood, shade, ritual |
| *Cananga odorata* (Lam.) Hook.f. & Thomson | Ornamental, ritual, fragrance |

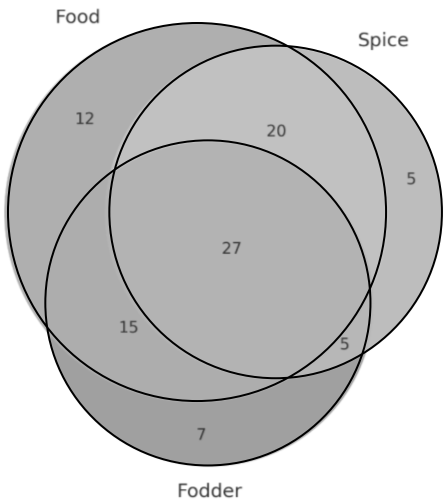


**Figure 6.** Venn diagram illustrating the overlapping uses of homegarden plants in Paranggupito Sub-district, Wonogiri District, Central Java, Indonesia

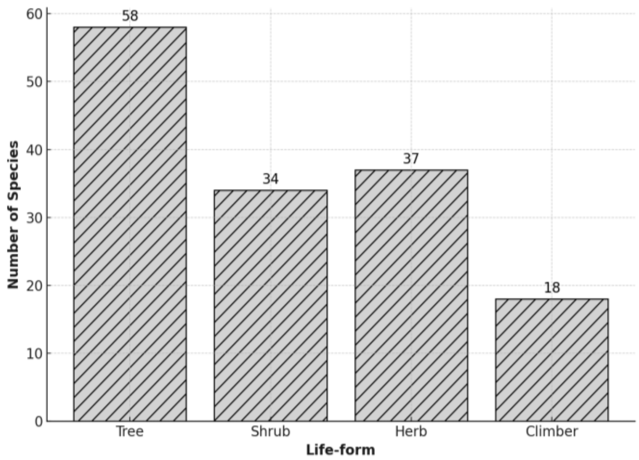


**Figure 7.** Distribution of life forms among useful homegarden plant species

**Inter-village comparison of species composition and UV patterns**

Comparative analysis among the three study villages—Johunut, Paranggupito, and Gudangharjo—revealed both shared and unique aspects in non-medicinal plant composition and use values. While many core species were present across all locations, notable differences emerged in species richness and UV distribution, shaped by ecological micro-conditions, household preferences, and sociocultural practices.

In terms of species richness, Johunut recorded the highest number of species (121), followed by Paranggupito (116) and Gudangharjo (108). The higher diversity in Johunut may be attributed to its relatively larger homegarden plots and higher population density, which enhances plant exchange and propagation networks among neighbors. Johunut also had the most varied ornamental species, while Gudangharjo showed greater dependence on food-producing perennials.

The Use Value (UV) analysis revealed several species with consistently higher UV scores (0.4) across villages, such as *M. indica*, *C. papaya*, and *Z. officinale*, indicating their widespread and frequent use. However, the distribution of UV values also reflected localized differences in species importance. For example, *C. annuum* had a UV of 0.4 in Paranggupito, where spicy foods are an everyday staple, while *S. polyanthum* also scored 0.4 in Gudangharjo, highlighting its significance in local rituals and culinary practices. Meanwhile, species with a UV of 0.2 were generally cited less frequently and often limited to specific households or uses.

Some plants were culturally or ecologically restricted to specific villages. For instance, *Hibiscus rosa-sinensis* was a prominent feature in Johunut due to its ornamental and boundary functions. At the same time, *L. leucocephala* was more common in Gudangharjo as a fodder plant on steep marginal land. These distinctions highlight the significant role of local traditions and household priorities in shaping species distribution alongside environmental conditions.

Despite such variations, the overall structure of homegarden plant use showed remarkable consistency in supporting household needs, underscoring the impressive adaptability and resilience and adaptability of this traditional land-use system across multiple karst settings.

**Species with highest cultural use and symbolism**

Beyond their practical functions, several non-medicinal plant species held distinct symbolic or ritual value within the communities of Paranggupito. Respondents frequently cited these species not only for their utility but also for their role in social events, ceremonies, and markers of local identity. In many cases, their continued cultivation was motivated more by cultural attachment than direct material use (Table 6).

One of the most consistently mentioned species was *M. a. balbisiana* (banana), whose leaves and pseudostems are essential components in local rituals such as *selamatan*, funerals, and wedding offerings. The banana plant was also valued as a boundary marker and a symbol of fertility.

*Cocos nucifera* (coconut) was another culturally significant species. In addition to its multi-use nature, it was associated with ancestral traditions, house-building rituals, and culinary symbolism. Its water and oil were believed to have purifying properties, and the plant was often present in ceremonial offerings.

*Tectona grandis* (teak) was respected not only for its high economic value but also as a status symbol. Planting teak near the house was often linked to aspirations of prosperity and intergenerational wealth. Its presence was particularly emphasized in Johunut and Paranggupito.

Other culturally loaded species included *O. basilicum* and *S. polyanthum*, which are used in food flavoring, religious offerings, and grave maintenance; *B. spectabilis*, which is valued not only as an ornamental but also as a privacy screen and informal property demarcator; and Cananga odorata, which older respondents cite for its role in traditional Javanese rituals and wedding decorations.

These species exemplify the biocultural interface of homegardens, where ecological choices are deeply interwoven with spiritual, symbolic, and social meanings. Their conservation, therefore, is not merely a matter of species survival but of cultural continuity and heritage preservation.

## Discussion

*Diversity and multifunctionality of non-medicinal plants*

The extensive diversity of non-medicinal plants recorded in the homegardens of Paranggupito—comprising 143 species across 55 families—demonstrates the critical role these systems play in rural livelihoods within karst landscapes. Such biodiversity surpasses that documented in similar tropical agroecosystems and reflects a dynamic interplay between ecological constraints and human management strategies (Wiersum 2004; Kefale 2020; Sholekha et al. 2023).

**Table 6.** Species richness and key culturally significant species (UV=0.4) across the three study villages

| Village | Species richness | Culturally significant species (UV = 0.4) |
|---|---|---|
| Johunut | 95 | *Pennisetum purpureum*, *Anacardium occidentale*, *Piper betle*, *Manihot esculenta*, *Citrus aurantifolia*, *Psidium guajava*, *Capsicum annuum* |
| Paranggupito | 102 | *Piper betle*, *Anacardium occidentale*, *Psidium guajava*, *Leucaena leucocephala*, *Mangifera indica*, *Cocos nucifera*, *Zea mays*, *Capsicum annuum*, *Syzygium polyanthum* |
| Gudangharjo | 83 | *Carica papaya*, *Psidium guajava*, *Zea mays*, *Mangifera indica*, *Gnetum gnemon*, *Capsicum annuum* |

This richness can be attributed to the multifunctional nature of homegardens, which integrate food production, aesthetic values, cultural practices, and ecological services within a limited spatial framework (Nair 2001; Yinebeb et al. 2022; Suwartapradja et al. 2023). In karst regions, where soil fertility and water availability are limited, the deliberate selection of drought-tolerant, multipurpose species ensures resilience and continuity of resource availability (Mane et al. 2019; Jiang et al. 2023).

The dominance of food and ornamental plants highlights the intertwined goals of sustenance and cultural identity preservation. Food plants provide essential nutrition and supplement household diets, while ornamental species fulfill aesthetic, symbolic, and social functions, enhancing community well-being (Cahyaningsih et al. 2022; Hanun et al. 2023). This multifunctionality confirms homegardens as socio-ecological hotspots where biodiversity conservation and cultural heritage coalesce (Garibaldi and Turner 2004; Sharma et al. 2024).

Furthermore, the presence of spices, fodder, and construction materials within the non-medicinal category underscores the diverse livelihood needs met by homegardens. This diversity buffers households against external shocks, such as market fluctuations or climatic variability, by providing readily accessible resources (Adhikari 2021; Korpelainen 2023).

Overall, the findings emphasize the value of non-medicinal plant diversity not merely as a reflection of species richness but as a manifestation of complex human-environment interactions, where traditional knowledge guides sustainable resource use and ecosystem stewardship in fragile karst environments.

*Cultural salience and Use Value (UV) patterns*

Use Value (UV) analysis serves as an effective quantitative tool to elucidate the relative cultural importance of plant species within local communities (Phillips and Gentry 1993). In this study, species such as *M. indica*, *C. papaya*, and *Z. officinale* emerged with the highest UV scores, reflecting their pervasive use and cultural embeddedness in Paranggupito's karst homegardens. These results align with previous ethnobotanical research in Indonesian rural settings, which consistently identifies fruit trees and spices as keystone species due to their versatile and multifunctional roles, showcasing the adaptability of local communities (Hanun et al. 2023; Wulandari et al. 2024; Afrianto et al. 2025).

The prominence of culinary spices with UVs comparable to staple food plants indicates the cultural centrality of flavor and traditional cuisine in local foodways. For example, *C. annuum*'s high UV underscores the importance of chili as both a dietary staple and an element in ritual preparations, a pattern also reported in Javanese ethnobotany (Wijaya et al. 2020). This reflects a broader understanding that plant importance is not solely driven by caloric contribution but also by symbols and the rich sensory values they bring to local foodways.

Variations in UV values further illuminate household preferences and adaptation strategies. Species with year-round availability, ease of propagation, and multipurpose functions tend to achieve higher UV scores, illustrating practical and cultural criteria in species selection. These findings underscore the integration of ecological suitability and cultural relevance in sustaining homegarden diversity.

Ultimately, UV patterns provide insights not only into which species are most valued but also into the resilience of traditional knowledge systems. Species with consistently high UVs across villages suggest stable cultural transmission, while those with variable UVs may point to shifts influenced by changing socio-economic or environmental factors.

*Plant part use and household adaptation*

The predominance of fruits and leaves as the most utilized plant parts within the homegardens reflects a pragmatic adaptation to both nutritional and ecological factors. Fruits, being rich in essential vitamins and sugars, serve as important direct food sources for households, while leaves offer micronutrients and are often used as vegetables or fodder, contributing to dietary diversity and livestock sustenance (Adhikari 2021).

This preference aligns with the seasonally limited growing conditions characteristic of karst landscapes, where shallow soils and irregular water availability restrict plant growth. Perennial fruit trees and leafy vegetables tend to be more resilient and provide more reliable yields than annual crops, making them valuable in buffering food security risks (Vico and Brunsell 2018; Mane et al. 2019).

The substantial use of rhizomes and tubers, particularly among Zingiberaceae and Euphorbiaceae families, further illustrates households' strategies to optimize energy storage and ensure availability during periods of scarcity. These below-ground storage organs also contribute to soil stabilization and carbon sequestration, supporting the ecological function of homegardens beyond direct consumption (Nair 2001; Wiersum 2004; Ottaviani et al. 2021).

Moreover, the use of multiple plant parts within a single species—such as fruit, leaf, and stem—indicates a high degree of plant resource efficiency and multifunctionality, a hallmark of traditional agroecosystems (Garibaldi and Turner 2004). This multifunctionality not only maximizes resource use but also enhances resilience to environmental stresses and socio-economic fluctuations. In sum, the patterns of plant part utilization documented in this study demonstrate intimate knowledge of species' ecological traits and a deliberate alignment of household needs with the constraints imposed by the karst environment.

*Growth forms and spatial structuring in karst systems*

The predominance of tree species (39.5%) in homegardens across the karst landscape of Paranggupito reflects a strategic ecological and cultural adaptation to the constraints of limestone geology. Trees provide essential resources such as fruits, timber, and shade, while also contributing to microclimate regulation, soil stability, and limited water retention capacity—functions that are vital in karst environments with shallow, porous soils and seasonal drought (Ellison et al. 2017)

Shrubs and herbs together account for nearly half of the recorded species, at 23.1% and 25.2% respectively, reinforcing the concept of vertical stratification in homegarden design. This stratification enhances productivity by optimizing light use and spatial efficiency (Nair 2001). Moreover, it buffers households from seasonal scarcity, as different growth forms yield resources at different times and microhabitats (Wiersum 2004).

Climbing plants, though comprising only 12.2% of total species, occupy vertical niches that would otherwise remain unused. Their integration exemplifies local ecological intelligence in intensifying land use on marginal terrain typical of karst regions.

The overall architectural complexity of these homegardens demonstrates a deep-rooted traditional knowledge system that integrates ecological function with household subsistence. Such spatial configurations embody sustainable land-use practices that support both biodiversity maintenance and ecological services in fragile karst ecosystems.

*Inter-village variations and cultural specificity*

The comparative analysis of plant species composition and Use Value (UV) across the villages of Johunut, Paranggupito, and Gudangharjo reveals both shared usage trends and distinctive local preferences. While several species appeared across multiple sites, their perceived importance varied. For instance, *M. indica* was identified as a culturally significant species only in Paranggupito based on its high UV, while *C. papaya* held similar status only in Gudangharjo. These differences reflect how microclimatic conditions, socio-economic contexts, and cultural practices shape plant selection and valuation at the village level (Arsyad 2018; Suwardi et al. 2024).

For instance, *C. annuum* displayed notably higher UV scores in Paranggupito, aligning with the village's culinary traditions that favor spicier flavors. Conversely, *S. polyanthum* was more culturally significant in Gudangharjo, often linked to specific ritual practices and culinary customs unique to that community. Johunut's greater species richness, particularly in ornamental plants, may be associated with its higher population density and more extensive social exchange networks fostering plant diversity.

These findings underscore the importance of recognizing local context and cultural specificity in ethnobotanical studies. Conservation and development initiatives should, therefore, be tailored to respect and incorporate community-level knowledge systems and plant preferences rather than applying uniform strategies across heterogeneous landscapes.

*Biocultural conservation and knowledge transmission*

The strong cultural significance attached to multipurpose species such as *M. a. balbisiana*, *C. nucifera*, and *T. grandis* highlights the intertwined nature of biological and cultural conservation within the homegarden systems of Paranggupito. These species serve not only practical functions but also embody social identities, spiritual values, and historical continuity, fitting the concept of cultural keystone species (Garibaldi and Turner 2004).

However, the demographic profile of respondents, skewed toward older adults, signals a potential erosion of traditional knowledge as younger generations become less engaged with local agroecological practices. This knowledge loss threatens the maintenance of species diversity and the sustainable management of homegardens, as the cultural transmission is essential for preserving both plant use and associated practices (Hanun et al. 2023; Suwardi et al. 2024).

To address these challenges, conservation strategies must integrate biocultural approaches. This approach supports community-led documentation, education, and revitalization of ethnobotanical knowledge, which are not just beneficial but necessary. Strengthening intergenerational learning, promoting cultural pride, and linking traditional plant management with contemporary sustainable development goals are critical to safeguarding both biodiversity and cultural heritage in karst landscapes.

The results from this study affirm the urgency of recognizing homegardens as living repositories of biocultural diversity. They also underline the crucial role of traditional knowledge in fostering resilient socio-ecological systems, emphasizing the importance of preserving and utilizing this knowledge.

In conclusion, this study provides a comprehensive insight into the diversity, use, and cultural significance of non-medicinal plants in homegardens of a tropical karst landscape in Central Java, Indonesia. The documented 143 species demonstrate the high biodiversity and multifunctionality of these agroecosystems, which fulfill diverse household needs ranging from food and ornamentation to fodder and ritual use. Use Value (UV) analysis highlighted key species such as *M. indica*, *C. papaya*, and *Z. officinale* as culturally and practically important. The structural predominance of trees and the utilization of fruits and leaves reflect adaptive strategies to the challenges of the karst environment, such as shallow soils and water scarcity. Comparisons across villages reveal both shared and distinct patterns of plant use shaped by local cultural practices and ecological conditions. Moreover, the presence of culturally significant multipurpose plants underscores the importance of integrating biocultural conservation with traditional knowledge transmission. Given high levels of concentration of plant knowledge among older community members, urgent efforts are needed to sustain intergenerational knowledge exchange and incorporate traditional practices into broader conservation and development frameworks. Ultimately, this research contributes valuable understanding of biodiversity conservation, cultural heritage preservation, and sustainable livelihoods in fragile karst ecosystems.

## REFERENCES


Adhikari J. 2021. Home garden, along with its functional category and key species reported in Nepal: A review. Revi Food Agric 2 (1): 16-19. DOI: 10.26480/rfna.01.2021.16.19.

Afrianto WF. 2025. Ethnobotanical documentation of home gardens in relation to Javanese basic life needs in Kediri District, East Java, Indonesia. Asian J Ethnobiol 8 (1): 79-91. DOI: 10.13057/asianjethnobiol/y080107.

Arsyad M. 2018. Studi etnobotani tumbuhan obat oleh masyarakat Tamban Kabupaten Barito Kuala. Insan Farmasi Indonesia 1 (1): 85-95. [Indonesian]

Ashari FN, Saptana FN, Purwantini TB. 2012. Potensi dan prospek pemanfaatan lahan pekarangan untuk mendukung ketahanan pangan. Forum Penelitian Agro Ekonomi 30 (1): 13-30. DOI: 10.21082/fae.v30n1.2012.13-30. [Indonesian]

Backer CA, Bakhuizen van den Brink JR. 1963. Flora of Java Vol. I. P Noordhoff, Groningen, Netherlands.

Badan Pusat Statistik (BPS). 2023. Kecamatan Paranggupito Dalam Angka 2023. BPS, Wonogiri. [Indonesian]

Borelli T, Hunter D, Powell B, Ulian T, Mattana E, Termote C, Pawea L, Beltrame D, Penafiel D, Tan A, Taylor M, Engels J. 2020. Born to eat wild: An integrated conservation approach to secure wild food plants for food security and nutrition. Plants 9 (10): 1299. DOI: 10.3390/plants9101299.

Cahyaningsih AP, Arifiani KN, Aprilia D, Nugroho ME, Setyawan AD. 2022. Ethnobotanical study of the non-medicinal plant by village communities in the karst area of Pacitan, East Java, Indonesia. Intl J Trop Drylands 6 (1): 1-10. DOI: 10.13057/tropdrylands/t060101.

Ellison D, Morris CE, Locatelli B et al. 2017. Trees, forests and water: Cool insights for a hot world. Glob Environ Chang 43: 51-61. DOI: 10.1016/j.gloenvcha.2017.01.002.

Farikha KN, Arlysia V, Raharjo YAA, Santika YE, Deristani A, Setyawan AD. 2025. Traditional knowledge of karst land management in Gunung Sewu, Java, Indonesia. Intl J Trop Drylands 9 (1): 1-9. DOI: 10.13057/tropdrylands/t090101.

Garibaldi A, Turner N 2004. Cultural keystone species: Implications for ecological conservation and restoration. Ecol Soc 9 (3): 1. DOI: 10.5751/ES-00669-090301.

Hanun Z, Athaya DN, Sholekha AM, Damayanti CE, Nazar IA, Cahyaningsih AP, Junaedi E, Buot JR IE Setyawan AD. 2023. The use of non-medicinal plants by the community of Ayah Village in South Gombong Karst Area, Kebumen, Central Java, Indonesia. Nusantara Biosci 15 (1): 68-78. DOI: 10.13057/nusbiosci/n150108.

Heyne K. 1987. Tumbuhan Berguna Indonesia, Volume II. Yayasan Sarana Wana. Jaya, Jakarta. [Indonesian]

Ivanova S, Delattre C, Karcheva-Bahchevanska D, Benbasat N, Nalbantova V, Ivanov K. 2021. Plant-based diet as a strategy for weight control. Foods 10 (12): 3052. DOI: 10.3390/foods10123052.

Jiang S, Xiong K, Xiao J, Yang Y, Huang Y, Wu Z. 2023. Agroforestry ecosystem structure and the stability improvement strategy in control of karst desertification. Forests 14 (4): 845. DOI: 10.3390/f14040845.

Kefale B. 2020. Homegarden agroforestry in Ethiopia-A review. Intl J Bio-resour Stress Manag 11 (4): 345-352. DOI: 10.23910/1.2020.2118d.

Korpelainen H. 2023. The role of home gardens in promoting biodiversity and food security. Plants 12 (13): 2473. DOI: 10.3390/plants12132473.

Malapane OL, Musakwa W, Chanza N. 2024. Indigenous agricultural practices employed by the Vhavenda community in the Musina local municipality to promote sustainable environmental management. Heliyon 10 (13): e33713. DOI: 10.1016/j.heliyon.2024.e33713.

Mane AM, Prabakaran N, Manchi SS. 2019. Floral diversity, composition, and recruitment on the karstland of Baratang Island, India. Ecol Complex 37: 47-54. DOI: 10.1016/j.ecocom.2018.11.002.

Mekonen T, Giday M, Kelbessa E. 2015. Ethnobotanical study of homegarden plants in Sebeta-Awas District of the Oromia Region of Ethiopia to assess use, species diversity and management practices. J Ethnobiol Ethnomed 11: 64. DOI: 10.1186/s13002-015-0049-8.

Nair PKR 2001. Do tropical homegardens elude science, or is it the other way around? Agrofor Syst 53 (3): 239-245. DOI: 10.1023/A:1013388806993.

Nofrianti N, Utaminingrum W, Hartanti D. 2021. Traditional use of medicinal plants in Baturraden, Central Java. Jurnal Jamu Indonesia 6 (2): 42-60. DOI: 10.29244/jji.v6i2.206.

Nurcahyo FD, Zen HM, Rahma HS, Triyanto A, Yasa A, Naim DM, Setyawan AD. 2024. Ethnobotanical study of medicinal plants used by local communities in the Upper Bengawan Solo River, Central Java, Indonesia. Intl J Bonorowo Wetlands 14 (1): 25-36. DOI: 10.13057/bonorowo/w140104.

Ottaviani G, Lubbe FC, Lepš J, Lisner A, Martínková J, Mudrák O, Klimešová J. 2021. Strong impact of management regimes on rhizome biomass across Central European temperate grasslands. Ecol Appl 31 (4): e02317. DOI: 10.1002/eap.2317.

Phillips OL, Gentry AH. 1993. The useful plants of Tambopata, Peru. II: Additional hypothesis testing in quantitative ethnobotany. Econ Bot 47: 33-43. DOI: 10.1007/BF02862204.

Rahman AA, Rubiyanti R, Kosasih ED. 2022. Increasing knowledge of medicinal plants usage for the prevention of digestive tract diseases in Tamansari Sub-district, Tasikmalaya City. Jurnal Pengabdian dan Pemberdayaan Masyarakat Indonesia 2 (2): 39-44. DOI: 10.59247/jppmi.v2i2.66.

Sharma R, Mina U, Devi A, Kumar BM. 2024. Do homegardens act as agent of agrobiodiversity conservation: a case study of homegardens of diverse socio-ecological zones in the Brahmaputra Valley, Assam. Front Sustain Food Syst 8: 1366499. DOI: 10.3389/fsufs.2024.1366499.

Sholekha AM, Yulia IT, Hanun Z, Perwitasari IG, Cahyaningsih AP, Sunarto, Sutarno, Sugiyarto, Buot Jr IE, Setyawan AD. 2023. Local knowledge and the utilization of non-medicinal plants in home garden by the people of Donorejo Village in the Menoreh Karst Area, Purworejo, Central Java, Indonesia. Biodiversitas 24 (1): 645-657. DOI: 10.13057/biodiv/d240173.

Suwardi AB, Navia ZI, Mubarak A, Rahmat R, Cristy P, Wibowo SG, Irawan H. 2024. The diversity and traditional use of home garden plants near Kerinci Seblat National Park, Indonesia. Biodiversitas 25 (7): 3284-3299. DOI: 10.13057/biodiv/d250750.

Suwartapradja OS, Iskandar J, Iskandar BS, Mulyanto D, Suroso, Nurjaman D, Nisyapuri FF. 2023. Plants diversity and socioecological functions of homegarden in Sundanese rural area: a case in Sumedang district, West Java, Indonesia. Biodiversitas 24 (1): 156-175.DOI: 10.13057/biodiv/d240120.

Tolentino PJS, Navidad JRL, Angeles MD, Fernandez AP, Villanueva ELC, Obena RDR, Buot Jr IE. 2020. Review: Biodiversity of forests over limestone in Southeast Asia with emphasis on the Philippines. Biodiversitas 21 (4): 1597-1613. DOI: 10.13057/biodiv/d210441.

Tynsong H, Dkhar M, Tiwari BK. 2020. Review: Traditional ecological knowledge of tribal communities of North East India. Biodiversitas 21: 3209-3224. DOI: 10.13057/biodiv/d210743.

Vico G, Brunsell NA. 2018. Tradeoffs between water requirements and yield stability in annual vs. perennial crops. Adv Water Resour 112: 189-202. DOI: 10.1016/j.advwatres.2017.12.014.

Whitten T, Soeriaatmadja RE, Afiff SA. 1996. Ecology of Java & Bali. Periplus Editions, HK.

Widyaningsih GA. 2017. Permasalahan hukum dalam perlindungan ekosistem karst di Indonesia (Studi Kasus: Ekosistem Karst Sangkulirang–MangkaliHat, Provinsi Kalimantan Timur). Jurnal

Hukum Lingkungan Indonesia 3 (2): 73-95. DOI: 10.38011/jhli.v3i2.44. [Indonesian]

Wiersum KF 2004. Forest gardens as an intermediate land-use system in the nature-culture continuum: Characteristics and future potential. Agrofor Syst 61: 123-134. DOI: 10.1023/B:AGFO.0000028994.54710.44

Wijaya CH, Harda M, Rana B. 2020. Diversity and potency of *Capsicum* spp. grown in Indonesia. In: Dekebo A (eds). *Capsicum*. IntechOpen, London. DOI: 10.5772/intechopen.92991.

Wulandari RS, Muflihati M, Aden LL, Wahdina W. 2024. Utilization of plants as traditional food by the Dayak Iban community of Mensiau Village, Batang Lupar District, Kapuas Hulu Regency. Jurnal Biologi Tropis 24 (1): 489-500. DOI: 10.29303/jbt.v24i1.6512.

Yinebeb M, Lulekal E, Bekele T, Lemessa D. 2022. Homegardens plant species richness and their use types have positive associations across agricultural landscapes of Northwest Ethiopia. Glob Ecol Conserv 40: e02342. DOI: 10.1016/j.gecco.2022.e02342.

Zenderland J, Hart R, Bussmann RW, Paniagua Zambrana NY, Sikharulidze S, Kikvidze Z, Kikodze D, Tchelidze D, Khutsishvili M, Batsatsashvili K. 2019. The use of “Use Value”: Quantifying importance in ethnobotany. Econ Bot 73: 293-303. DOI: 10.1007/s12231-019-09480-1.