Ethnobotanical knowledge of diversity and utilization of plants among Dayak Lundayeh in Malinau, North Kalimantan, Indonesia

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Ethnobotany Research and Applications 31:60 (2025) - http://dx.doi.org/10.32859/era.31.60.1-26
Manuscript received: 17/04/2025 – Revised manuscript received: 05/09/2025 - Published: 06/09/2025

Research

Abstract

Background: Indonesia's rapid economic expansion has led to biodiversity loss, causing issues for ethnic groups like the Dayak Lundayeh in Kalimantan. As one of Indonesia's oldest tribes, the Dayak Lundayeh are strongly committed to protecting natural resources and hold rich yet under-documented local knowledge. This study explores their expertise in spatial planning, plant species diversity, and plant uses while evaluating the economic value of non-timber forest products (NTFPs).

Methods: The study was performed using qualitative and quantitative methods, including the Index of Cultural Significance (ICS) and Local User's Value Index.

Results: The Dayak Lundayeh organize their property into residential, production, resource reserve, and natural sections, showing great environmental awareness. They recognize 486 plant species for health, food, technology, building, and energy. The LUVI and ICS identify community-valued species, reflecting their everyday reliance on them. Harvesting and processing NTFPs are important in their livelihoods, integrating traditional practices with sustainable resource management.

Conclusions: The findings emphasize the importance of integrating the Dayak Lundayeh's social, socioeconomic, and ecological knowledge into regional development initiatives. Their ethnobotanical knowledge of plant diversity and utilization helps protect biodiversity and enables people in the area to cope with economic changes by promoting the sustainable management of plant resources.

Keywords: Dayak Lundayeh, Ethnobotany, Ethnoecology, Local knowledge, Malinau

Background

Indonesia has undergone rapid changes in recent years, leading to rapid economic growth. However, biodiversity loss still occurs (Purwanto 2020, Wakhidah *et al.* 2020), and there has not been a significant reduction in the poverty rate (Firdausy 2020) and food insecurity among people experiencing poverty, especially those living near forest areas. As a result, many

ethnic groups face significant challenges in maintaining their way of life in a rapidly developing country. The Indonesian government's programs, which focus on rural development and poverty alleviation, have had a limited impact on sustainable community development, particularly for the Dayak Lundayeh ethnic group residing in the forest edge area. The local knowledge of the Dayak Lundayeh community in Malinau Regency needs to be documented and studied because it is the oldest tribe (Arifin *et al.* 2016, Arifin 2017) and a farming community that has a life that is close to the preservation of biological natural resources and the environment but is experiencing considerable pressure from the inclusion of intervention, foreign culture, new religion and intervention in regional development, especially the exploitation of the forestry sector and plantation development (Murhaini, Achmadi 2021).

Finding appropriate approaches to improve people's lives while conserving biodiversity, preserving, and respecting the cultural diversity of indigenous peoples' communities is an urgent task (Sheil *et al.*, 2004). Improving people's lives requires a clear understanding of biodiversity management, the needs of rural communities, especially indigenous peoples living around forest areas, and the community's original concept of managing their biodiversity resources. Therefore, solutions must be sought to solve the interrelated problems between local people's lives and biodiversity loss. Any proposed solution must make sense from the community's perspective, meet their immediate needs (Waylen *et al.* 2013), and be based on their needs and interests supported by scientific studies (Purwanto 1997, Boissiere & Purwanto 2007, Chapoose *et al.* 2012, Friedberg *et al.* 2004, Purwanto 2020b, Purwanto 2021). For this reason, this study is conducted to identify specifically the cumulative and collective pool of knowledge, experience, and values that local communities hold.

Ethnobotany studies aim to understand how community groups interact with plant resources and their environment to benefit from these resources, thereby meeting their cultural and socioeconomic needs. The contribution of ethnobotany begins with a descriptive text listing plants and their uses from the first half of the nineteenth century (Albuquerque 2013, Gaoue 2017). Subsequently, this field of study developed through a lengthy debate about rapidly changing environmental conditions, intervening human activities, and descriptive contributions. The knowledge gained has a fragile theoretical basis and a limited quantity of methodological rigor (Phillip 1996, Phillips & Gentry 1999a, Purwanto & Munawaroh 2001, Gaoue 2017). In addition, the intervention of human activities and external cultural influences has led to rapid changes in how people interact with natural resources and their environment, thereby making the relationship between humans and plants even more complex. As a result, ethnobotanists are increasingly being encouraged to move beyond descriptive studies and develop theoretical frameworks that explain human behavior regarding the use of plant resources (Gaoue *et al.* 2017) and environmental impacts. In recent decades, ethnobotany and ethnoecology have incorporated theoretical insights from several disciplines, including ecology, botany, economics, and anthropology (Ritter *et al.* 2015) and multi-inter-transdisciplinary approaches.

Disclosure of local community knowledge about the management of biological natural resources has significant value. It is understood as the basis and supporting data for the area's sustainable development (Berkes 2018). The role of the local community is very important, especially its role as a component of the area. Local communities are the primary actors that influence environmental conditions, particularly through their daily activities. Although external influences have a major impact on environmental damage in certain areas, the resulting damage is directly felt by local communities (Brondizio *et al.* 2021).

Specifically, this study aims to reveal the local knowledge of the Dayak Lundayeh community regarding their ethnoecological and ethnobotanical knowledge related to the management of biodiversity and their ecosystems, particularly in terms of plant diversity and utilization. This study complements the previous studies that have been carried out in Malinau, North Kalimantan, such as studies conducted by Purwanto *et al.* (2010a), Ajiningrum *et al.* (2011), Saparita *et al.* (2011), and Hutauruk *et al.* (2018) concerning the economic valuation of non-timber forest products and Sheil *et al.* (2004), Purwanto *et al.* (2010b, 2011) and Njau *et al.* (2019) regarding the ethnoecological research of the Dayak Kenyah community. Furthermore, this study also attempts to fill the gap by offering alternative methodologies to promote local knowledge and the development possibilities that indigenous peoples can use to cope with outside influences. By identifying the role of indigenous people’s local knowledge in the use and conservation of plant species diversity and their ecological knowledge (Purwanto 2010, Yuniati *et al.* 2019, Sari *et al.* 2020), it is expected that it can help planning and development agendas that take into account the local knowledge of the community in this area, rather than a top-down approach that is influenced by external knowledge that is applied bureaucratically in this area.

Materials and Methods

Study area

This study was conducted in Malinau, North Kalimantan, from 2010 to 2014, with additional observations and data verification in 2018. This study focuses on the ethnoecological and ethnobotanical knowledge regarding the management of plant species diversity, benefits, and use values, as well as the economic value of important useful plant species (according to local communities), and their role in the Dayak Lundayeh community in Malinau, North Kalimantan (Figure 1).

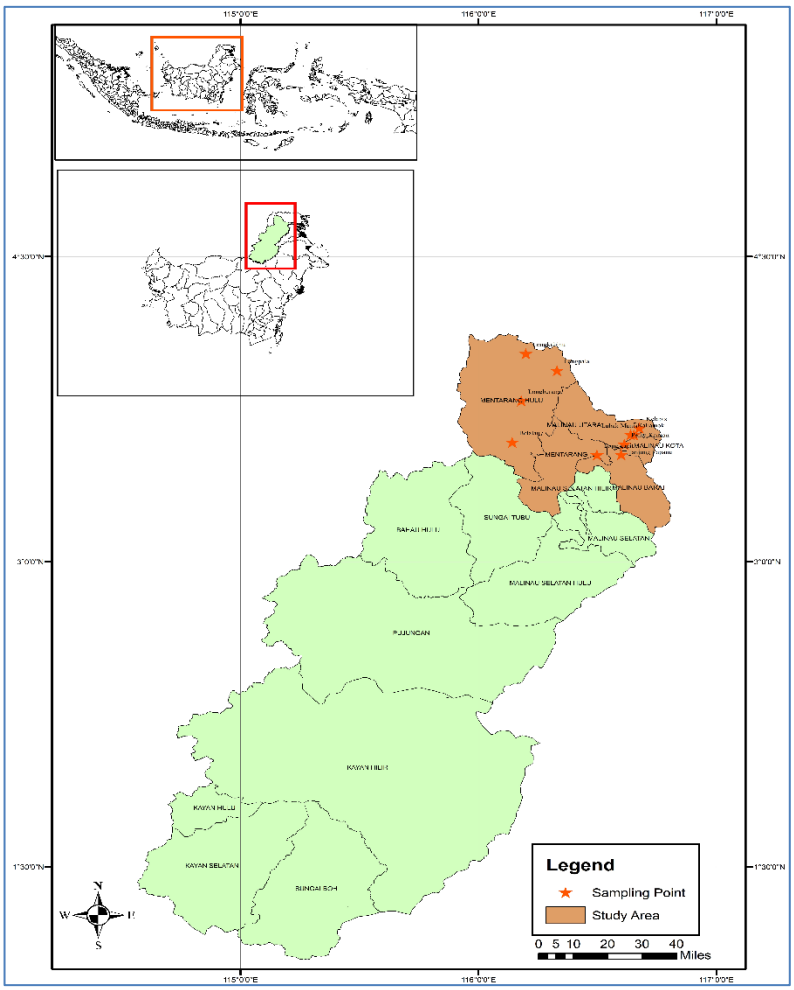

Figure 1. Research location and map of Malinau, North Kalimantan (Dinas Komunikasi dan Informasi Kabupaten Malinau, 2018)

Data collection

Data collection was conducted in several stages, following standard ethnobotanical methods. Prior to the interviews and documentation, oral informed consent was obtained from all informants (traditional elders, local experts, and local communities who have knowledge of the management of biological natural resources and their ecosystems) in compliance with research ethics. The first stage involved direct observation in the field, where data related to community knowledge about plant species diversity were collected through open-ended interviews and specimens of useful plant species with unknown scientific names were gathered. All those useful plants were recorded for their uses, how they were used, how they were taken, and their role in the lives of local people. On this occasion, those useful plant species were directly distributed by categorizing them into groups based on their characteristics. The second one was the selection of the products from those useful plant species that had the potential to be developed.

The collection of ethnoecological data of the Dayak Lundayeh community was carried out through four stages according to the principles of ethnoecological research (Turner 1988, Purwanto 2003, Purwanto 2004, Purwanto 2010, Ajiningrum *et al.* 2011b, Jumari *et al.* 2012, Dinas Komunikasi dan Informasi Kabupaten Malinau, 2018, Yuniati *et al.* 2019, Sari *et al.* 2020, Purwanto 2020b, Purwanto 2021). The first was describing the community corpus by conducting structured and casual interviews (open-ended interviews) with respondents consisting of the local community (59 people) and community leaders (10 people) (Figure 2). The selected respondents were community members considered most capable of representing their groups to share ethnobotanical and ethnoecological knowledge about their community. This selection was carried out using the purposive sampling technique to ensure that the study gained as much ethnobotanical and ethnoecological knowledge as possible from the community. All respondents were community members who possessed the best knowledge in their region. The second was observing community praxis, specifically the production activities carried out by the community, including farming and forest product extraction activities. The third step was to determine the effect of production activities by conducting a vegetation analysis and sampling plots on each environmental unit (ethnoecotope), such as forests, gardens, yards, and other areas. The determination of the sampling location was carried out using the purposive sampling technique. The sampling method used to select forests, gardens, and rice fields was the same as that employed by Purwanto (1997, 2010), Jumari *et al.* (2012), Yuniati *et al.* (2019), and Sari *et al.* (2020). The researchers recorded the species name, number

of individuals, tree diameter, and tree height for the tree level plot and the belt level subplot. Meanwhile, for the herb/seedling subplot, the researchers only recorded the species name and number of individuals. Identification of plant species was conducted at the Herbarium Bogoriense (BO). The fourth was conducting a scientific analysis of the aforementioned data collected from stages 1 to 3.

Figure 2. Interviews with informants (local expert) (left) and respondents (local community members) (right)

The selection of potentially useful plant species

The selection of useful, potential, and important plant species for the Dayak Lundayeh community was conducted by analyzing the value of cultural importance by calculating the Index of Cultural Significance (ICS), Value of Peddle Distribution Method (PDM), Local User's Value Index (LUVI) and determining the economic value of production activities and utilization of those useful plant species.

Index of Cultural Significance (ICS)

The Index of Cultural Significance (ICS) is calculated using the formula (Turner 1988, Ajiningrum *et al.* 2011b, Helida *et al.* 2015).

$$ICS = \sum_{i=1}^{n} (q + i \times e)_{ni}$$

If a plant species has more than one usage, the calculation formula develops as follows.

$$ICS = \sum_{i=1}^{n} (q_1 + i_1 \times e_1)_{n1} + (q_2 + i_2 \times e_2)_{n2} + \ldots + (q_n + i_n \times e_n)_{nn}$$

Note:

- ICS = Index of Cultural Significance, the equation for the total use-value of a plant species from uses 1 ton, where n indicates the last kind of use of a plant species and i indicates the value from 1 to n in the sequence.
- q = quality value; i = the intensity value of its use; and e = exclusivity value. The detailed categorization of ethnobotanical data quantification calculations can be seen in Purwanto (2002).

Value of Peddle Distribution Method (PDM)

The PDM value is needed to determine the types of potentially useful plants selected and most favored by the community. This data supports the data from the ICS calculation so that the obtained data can be more accurate about the selected potentially useful plant species to be developed as a source of the community economy.

The PDM value is calculated to assess each plant species' "value of importance" from each use category (Sheil *et al.*, 2004). The PDM values obtained from various main sources, as determined by the respondents, are then used to calculate the Local User's Value Index (LUVI) to assess the importance of plant value per utilization category.

Local User's Value Index (LUVI)

The LUVI value is calculated using the formula proposed by Arifin *et al.* (2016). This LUVI value is the sum of the Gij value of a species.

$$LUVI = G_{ij} = \sum category\ j\ G_{ij} = RW_j \times R_{wij}$$

Where:

i = species
j = usability
Gij = individual value
RWj = weight assigned to the class of usability to which the particular usability (j) belongs

Rwij = relative weight in category j in the utilization of species (i) that meet the requirements of member j

Economic valuation of potentially useful plant species

The study of the economic valuation of potentially useful plant species in Malinau, North Kalimantan, is carried out using several economic valuation methods based on the conditions of available data in Malinau, North Kalimantan. For non-timber forest products that have a market value, the applied approach is certainly much easier than for potentially useful plant species whose prices are unknown. The market price of the potentially useful plant species can be used as a benchmark or to estimate its value. The weakness is that the market value can provide an underestimated analysis because this market value does not take into account consumer surplus. For potentially useful plant species that do not have a market value, their value is measured using specific methods under field conditions.

This study assesses various types of potentially useful plant species and is carried out using several approaches, as mentioned in the following.

- The direct approach using market price: calculating the economic value of potentially useful plant species by multiplying forest product volume by the average market price.
- Relative value method: calculating the value of forest products whose market value is unknown but is exchanged or compared with the value of goods or services that already have a value. The value is calculated by multiplying the volume of certain forest products by their relative prices (relative prices of these goods to the prices of other goods whose market prices are known).
- Procurement cost method: determining non-timber forest products whose market value is not known and does not include an exchange system by calculating them using the following formula.

$$N_i = \frac{BP_i}{JV_i}$$

Where:

N = economic value of potentially useful plant species (IDR/volume unit), BP = cost of forest product procurement (IDR/collection), JV = total volume of non-timber forest products (volume unit/collection), and I = type of forest product taken.

This study began by conducting FGDs with local communities. Demographic data were collected directly from the village office, which provided the clearest general picture concerning the population of the local community groups represented in this survey. All local experts, community leaders, and local people came from each local community group who had good knowledge of the diversity of biological resources and their ecosystems. The selection of respondents followed the guidance of traditional elders and the advice of the community, who were considered to possess knowledge about the diversity of biological resources and their utilization.

In collecting ethnobotanical quantitative data, the interviews were conducted without restrictions concerning participants' conditions (Prance *et al.* 1987, Phillips and Gentry 1993, Phillips 1996, Kremen *et al.* 1998, Phillips & Gentry 1999a, Purwanto & Munawaroh, 2001, Phillips *et al.* 2003, Reyes-García *et al.* 2006, Purwanto 2010, 2022). Interviews were conducted in residential areas and environmental units located at the research site, including settlements, production areas (gardens, rice fields, or cultivation fields), and natural environments (forest areas, sacred forest areas, or others), through open-ended questionnaires and open discussions with the informants.

Results and Discussion

The Dayak Lundayeh community is a large Dayak community and a shifting cultivation farming community that has successfully developed adaptation strategies for sedentary farming, including the development of plantation and agroforestry crops.

Knowledge of the Dayak Lundayeh community about the division of spatial planning and environmental units

Community knowledge of spatial distribution is intrinsically a manifestation of the introduction of environmental units or forms of ecosystems that exist in the surrounding environment. Furthermore, spatial planning is partly shaped by human activities. Therefore, there are two groups of environmental units: natural environmental units and anthropic environmental units. The forms of natural environmental units are primary forests, valleys, mountains, rivers, caves, and others, while the forms of anthropic environmental units are rice fields, yards, gardens, secondary forests, sacred places, and villages.

Each form of the environmental unit is characterized not only by its ecological characteristics, but also by the conditions of its habitat (topography, soil type, or shape), and geological phenomena, as well as its inhabitants or plant species that inhabit it. In detail, the forms of environmental units known by the Dayak Lundayeh community in Malinau are as follows.

(1) ***Makadang***, or longhouse, is a house where the people of the Dayak Lundayeh community live communally. It has been abandoned for a very long time. At this time, they form a village in which each main family builds an individual house. This longhouse is preserved in the form of a traditional house or village hall, with several modifications, including embellishment with various carvings and changes in the house body height, which is built lower than previous ones.

Even though they live separately in individual houses, the value of togetherness still grows between them, although the level is decreasing daily.

(2) ***Kapul*** or yard. The Dayak Lundayeh community recognizes the concept of a yard (kapul) as a piece of leftover land from a house. This kapul has clear boundaries with other kapul. For the diversity of plant species in this kapul, the researchers record as many as 51-56 plant species, including cultivated plants, ornamental plants, medicinal plants, trees for building materials, and others.

(3) ***Leppu'*** or village. The village of the Dayak Lundayeh community in Kalimantan is typically built close to the river, providing transportation infrastructure that connects one area to another. The biodiversity in the village area is not much different from the diversity of plant species found in the yard.

(4) ***Balayat Buat***, or the former village. Former villages can be easily recognized by the presence of various species of local fruit trees, former buildings, and the remains of household appliances. Those fruit trees are rambutan (Nephelium *lappaceum* L.), langsat (*Lansium domesticum* Corrêa), mango (*Mangifera indica* L.), durian (*Durio zibethinus* Moon.), durian pulu (*Durio kutejensis* (Hassk) Beec), mangosteen (*Garcinia mangostana* L., *Garcinia* sp.), terap (*Artocarpus elasticus* Reinw. Ex Blume), jackfruit (*Artocarpus heterophyllus* Lam.), cempedak (*Artocarpus integra* (Thunb.) Merr.), wild banana (*Musa* spp.), bu' payang (*Pangium edule* Reinw.), and others. In addition, several forest tree species that are usually allowed to grow in the former village include ulin (*Eusideroxylon zwageri* Teijsm. & Binn.), tengkawang (*Shorea macrophylla* (de Vriese).P.S.Aston, *S. beccariana* Burck, *S. pinanga* Scheff.), jelutong (*Dyera costulata* (Miq.) Hook.f.), and others. The former villages hold a significant meaning for the Dayak community, as they also serve as a symbol of land tenure in the area.

(5) ***Bekkain*** – small gardens made in former fields and located close to villages. Bekkain has an area of around 1,000 - 2,000 m^2 which is planted with various species of food crops, such as vegetables, fruits, and other food ingredients whose utilization is as a complement to the provision of food or also as a reserve of food ingredients needed in daily life., such as cassava (*Manihot esculenta* Crantz), taro (*Colocasia esculenta* (L.) Schot), a kind of onion (*Allium sp.*), katuk (*Saurapus androgynus* (L.) Merr.), mustard (*Brassica sinensis* L.), cucumber (*Cucumis sativum* L.), chili (*Capsicum frustescens* (Willd.) Besser), tomato (*Lycopersicon esculentum* (Voss) C.O.Lehm), eggplant (*Solanum melongena* L.), lemongrass (*Cymbopogon nardus* (L.) Rendle), peanuts (*Arachis hypogaea* L.), black-eyed pea (*Vigna unguiculata* (L.) Walp.), and others. Variations in the diversity of the grown cultivated crops depend on the owner and the season.

(6) ***Umo***, or the dry field, is an environmental unit cultivated to produce the main food source, such as rice, various species of secondary crops, and vegetables. For instances rice (*Oryza sativa* L.) as a staple food, several types of additional food crops, such as corn (*Zea mays* L.), cassava (*Manihot esculenta* Crantz), sweet potato (*Ipomoea batatas* (L.) Lam.), taro (*Colocasia esculenta* (L.) Schott), and banana (*Musa* spp.), and several types of vegetable crops needed every day, such as eggplant (*Solanum melongena* L.), pumpkin (*Cucurbita moschata* Duchesne), black-eyed pea (*Vigna unguiculata* (L.) Walp.), tomato (*Lycopersicon esculentum* (Voss) C.O.Lehm), chili (*Capsicum annum* L., *C. frustescens* (Willd.) Besser), and others.

(7) ***Talun***, or former fields, refers to an area that has been reforested or has a secondary forest. Talun is an environmental unit in a fertility recovery phase after being used as a field (umo). In general, this environmental unit has quite important benefits for the lives of local people in this area, namely as a place for gathering various plant species useful for their daily life and as a source of additional food ingredients, medicinal plant materials, firewood, and other non-timber products. In addition, this former field (secondary forest) also has farmland reserves for cultivation purposes in the following years.

(8) ***Giman*** or jungle (primary forest). This is the initial form of a unit whose designation has not been converted. According to the Dayak Lundayeh community, this environmental unit is an area overgrown with large trees and inhabited by wild animals. Besides, trees in this area have never been cut down. However, in reality, it is a place to get wood for building materials, a place to gather or extract non-timber forest products, and a place to hunt. The results of the vegetation analysis showed that the "gima" units in the Dayak Lundayeh community area had, as recorded 71 species of seedlings, 72 species of saplings, 64 species of poles and 86 species of trees for every 0.5 ha. From the results of sampling the diversity of tree species with a diameter of more than 10 cm on a 0.5 ha transect, it is recorded that 41 species are used as building materials, 18 species are used as materials for making boats, 9 species are used as materials for making the roof, 26 species are used as materials for making huts, 18 species produce fruit, 11 species produce fruit and seeds for animal food, 5 species are rattan species, and 12 species produce other non-timber forest products. The usefulness of forest plant species will increase if the analysis has been completed, such as poisons, medicinal ingredients, refreshments, stimulants, and others. Non-timber forest products used by the community gained from this area are rattan (*Calamus* spp., *Daemonorops* spp., *Korsthalsia* spp.), sang leaves (*Licuala* sp.), tengkawang (*Shorea* spp.), resin (*Agathis* sp.), ketipai sap (*Palaquium gutta* (Hook.) Baill.), honey, bark, hunted animals (recorded 20 hunted animal species), various foodstuffs (seeds, fruit, leaves, or grass), and others.

(9) ***Méang*** – a term for an area that has a hilly topography with a relatively steep slope of more than 30°. This area should be protected and conserved, but local people still use it for swidden cultivation. The reason they use the méang area for cultivation is due to the limited land they have and several factors, including (a) the granting of forest concession rights to HPH companies, (b) the implementation of the village administration system which causes restrictions on land tenure for local communities, (c) the granting of forest concession rights to plantation and mining companies, causing land limitations for local communities, (d) the development of plantation plant species and introduced cultivation plant species in a monoculture, and (e) population growth, population migration, and economic pressures.

(10) ***Telihing*** is an area with a sloping or wavy topography of less than 30° and is usually found in hilly areas or mountains. Local people usually use this area as a shifting cultivation area. Some local communities utilize these areas for coffee plantations, cocoa plantations, and mixed plantations (traditional agroforestry) that integrate forest and cultivated plant species (Figure 3).

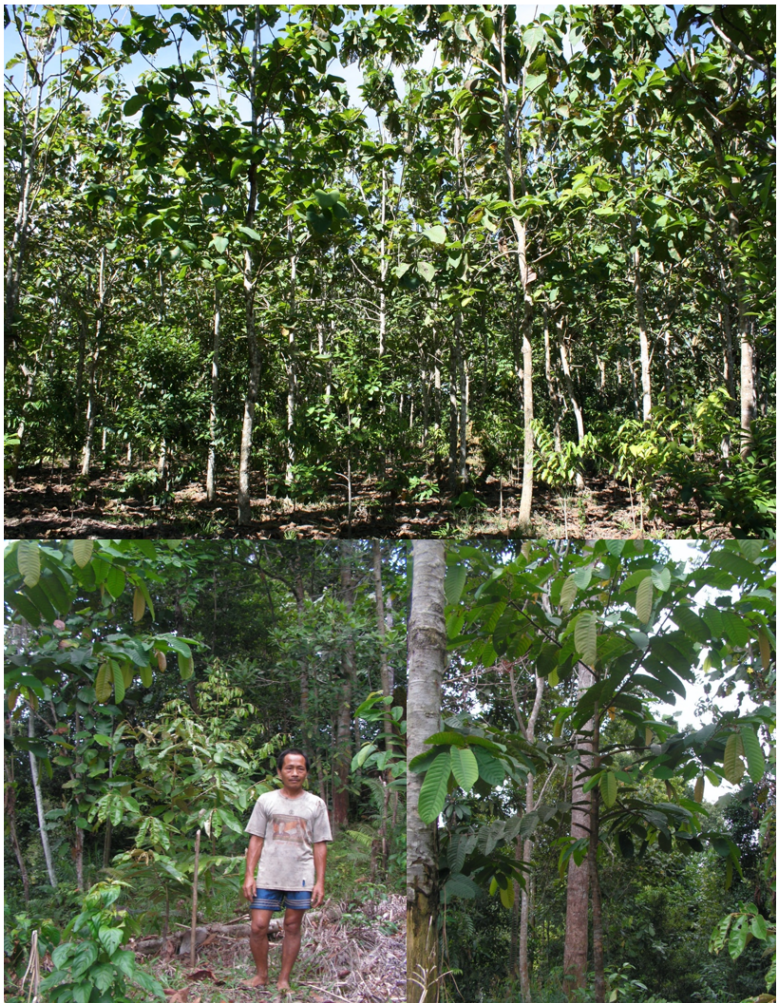

Figure 3. Traditional agroforestry system of the Dayak Lundayeh community in Malinau, Indonesia; Diverse agroforestry of teak (*Tectona grandis*) mixed with agarwood (*Aquilaria* spp.), coffee (*Coffea* spp.), and other species under mixed cultivation (above); A Dayak Lundayeh farmer within the agroforestry system (below)

As mentioned above, the community's knowledge of environmental unit division and spatial planning is integral to the development of the Lundayeh community's adaptation strategy for utilizing its environment and natural resources. This knowledge is manifested in daily activities related to managing natural resources and the environment, which customary institutions regulate and have passed down through their ancestors. The life activities of the Lundayeh are based on trust and occur in an order that connects the lives of the Lundayeh people with their natural environment in a holistic manner, forming an ecosystem landscape that continues to change and develop. Thus, in general, a belief system, in the form of customary institutions that regulate land tenure, can encourage the development of ecological knowledge and shape values in the management and utilization of plant resources and their environment. It demonstrates that the knowledge, utilization, and management of the Lundayeh community's ecosystem landscape involve a complex process mediated by intellectual functions, namely knowledge and cosmology, organized by their social institutions, based on the fundamental assumptions of a complex approach that integrates beliefs, knowledge, and activities in ethnoecological studies. The knowledge of the Lundayeh community about the main culturally recognized landscape units (ethnoecotopes) is generally the same, consisting of residential areas, production activity areas (gardens, fields, and mixed gardens), customary areas, primary forests, rivers, and other forms of environmental units. Introducing their natural landscape units is an effective and adaptive recognition of the environment that has supported their existence for hundreds or even thousands of years.

Environmental factors and the diversity of ecosystem landscapes influence the development of strategies for dealing with natural environmental conditions. The Lundayeh community, residing in Mentarang Regency, which features a hilly topography, has a significant amount of potential land for gardening. Meanwhile, the Dayak Lundayeh people living around the Malinau River developed a sedentary farming system, fruit orchards, mixed gardens, and rice fields.

The number of useful plant species found in each of the environmental units mentioned above can be seen in detail in Figure 4. The table indicates that secondary and primary forests play a crucial role in the lives of the Lundayeh community. The number of useful plant species shows it is more than in other environmental units.

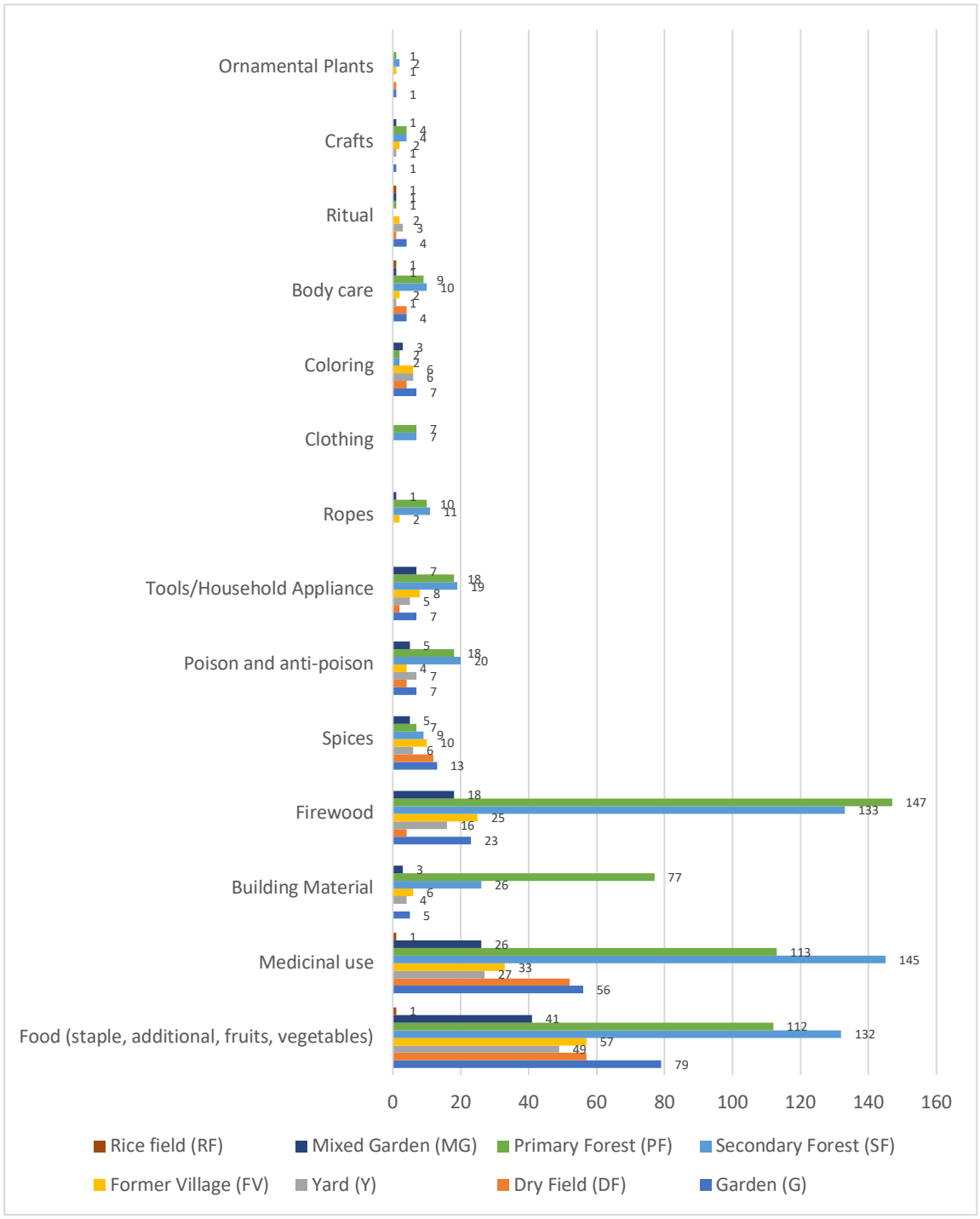

Figure 4. The number of useful plant species in each habitat of the Dayak Lundayeh community

The Dayak Lundayeh community has vast knowledge of its natural resources and environment. They principally divide spatial planning into five environmental units (ethnoecotone), namely Residential area (Former Village (FV), Yard (Y): Makadang, Kapul, Leppu, Balayar buat), Production area (Garden (G), Ricefield (RF), Dry Field (DF), Mixed Garden (MG): Bekkain, Umo, Telihing), Resources reserve area (Secondary Forest (SF): Talun), Natural ecological area (Primary Forest (PF): Giman) and Prohibited area: Meang (Purwanto 2022); we use a Venn diagram to discuss and enhance interpretation (Figure 5).

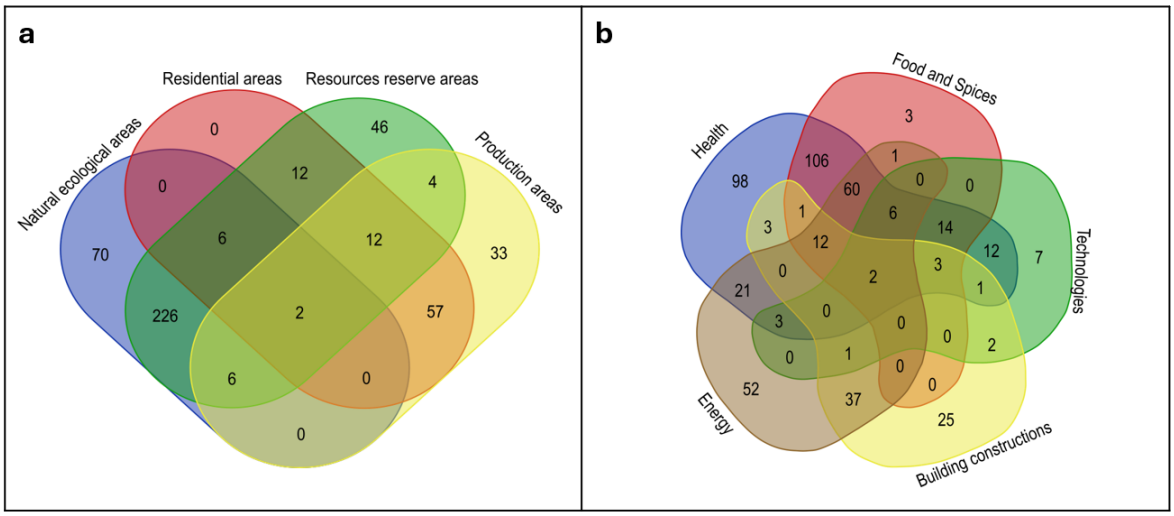

Figure 5. Venn diagrams illustrating diverse ecological units (ethnoecotone) (a) and important plant categories within the Dayak Lundayeh community (b)

Each environmental unit plays a distinct role and function in the life of the Dayak Lundayeh community, encompassing ecological, economic, and sociocultural aspects. The Lundayeh community's knowledge of spatial division is also a community strategy in managing natural resources and the environment in order to fulfill their subsistence needs: food (rice fields, gardens, fields, yards, and forest areas) as evidence of tenure and boundaries of land (sacred forest areas or customary forests), the need for building materials and hunting (forest areas), the need for medicinal materials (yards, forests, gardens), and as an effort to develop strategies in dealing with changes in the management of biodiversity (cultivation areas, residential areas, and conservation areas). This condition was also identified from the results of ethnoecological and ethnobotanical studies conducted in several local communities in Indonesia, such as the Dani community in the Baliem Valley, West Papua (Purwanto 1997, 1998, 2002a, 2002b, 2004); the Samin people, in Central Java (Jumari *et al.* 2012); the Toro community (Golar 2007, Munawaroh *et al.* 2013); and indigenous peoples in Indonesia (Purwanto 2022). The Bada people in Lore Lindu, Central Sulawesi (Yuniati, 2020); the Tanimbar-Kei community (Purwanto, 2022); and other local communities in Indonesia. Spatial division carried out by local communities in their own areas is also an adaptation strategy for dealing with changes and managing biodiversity (Purwanto 2022). Spatial divisions are also part of the proof of land tenure for the Dani people in the Baliem Valley, the Toro people in Central Sulawesi, and other indigenous peoples (Purwanto, 2022); and the people of Timor in the Province of East Nusa Tenggara (Soedjito & Purwanto, 2003).

Knowledge system about the utilization of plant species diversity

The knowledge system about natural resources, especially concerning the diversity of plant species, is fundamental knowledge that is crucial for the survival of the Dayak Lundayeh community, whose lives depend on the wealth of biological natural resources and their environment. The level of knowledge and methods for managing the diversity of plant species and their environment are influenced by sociocultural aspects and the environmental conditions in which they exist. The Dayak Lundayeh community groups that live around the forest area carry out their farming activities through shifting cultivation, gathering activities, and extracting forest products. Their activities are primarily aimed at meeting their own needs (subsystems) and only a small part is dedicated to fulfilling other supporting economic needs. They manage it based on customary provisions and social institutions, which they believe are very useful in managing natural resources and the environment. In contrast to the Dayak Lundayeh community groups, which reside far from forest areas around Malinau City, they engage in permanent farming activities, including rice fields, plantations, and mixed gardens. They manage and use their environment for the benefit of their lives, not only for subsistence interests but also for commercial purposes. However, they still maintain a farming culture whose arrangements are regulated by Lundayeh customary institutions, such as determining planting times and land tenure.

The results of the study of the diversity of useful plant species and their uses are presented in Table 1 and the habitus presented in Table 2, respectively. The Dayak Lundayeh community in Malinau Regency utilizes various types of plants to meet their needs for food, building materials, medicinal substances, dyes, spices, firewood, tools, poisons, antidotes, and ritual materials.

The utilization of plant species in the daily life of the Dayak Lundayeh community can be categorized as sufficiently high. This can be seen in almost all aspects of their life in which the Dayak Lundayeh people take advantage of the diversity of plant species. The analysis results show that between 15 and 30% of useful plant species are used in their daily lives, based on the total number of species they know. For example, they know more than 89 wood species for building materials but only use

about 10 – 25 species to build houses. Likewise, when making boats, they recognize 18 species of wood that can be used as materials, but they typically use only about 6 species. It can also be found in the utilization of other plant species.

Table 1. Categories of the utilization of plant species diversity by the Dayak Lundayeh community

No	Categories of the utilization of plant species	Total Species
A	**Domesticated plants**	**48**
1	Main food crops	1
2	Additional food crops	
	Vegetables and nuts	25
	Oil-producing plants	1
	Tubers	8
	Herbs and spices	7
	Beverage ingredients	4
	Fruits and seeds	20
3	Animal food	2
4	Latex, rubber, and resin-producing plants	1
5	Fiber-producing plants	1
6	Stimulants	1
7	Firewood	2
8	Decorative plants	4
9	Plants for making aromatic products and cosmetic products	2
10	Coloring agent	3
11	Plants for traditional events and rituals	15
12	Green fertilizers	1
13	Materials for making tools	1
14	Materials for making poison	3
B	**Wild Plant**	
1	Non-medicinal plant foodstuffs	128
	a. Leaves, stems, and shoots	43
	b. Flowers, fruits, and seeds	85
	c. Tubers, rhizomes, and roots	10
	d. Herbs or spices	15
	e. Beverage ingredients	3
2	Latex and resin-producing plants	4
3	Rope materials	
	a. Canes	12
	b. Binding/weaving	5
4	Coloring materials	8
5	Decorative plants	15
6	Fiber materials (clothing and containers)	6
7	Tool materials (household, agriculture, and war)	15
8	Materials for making musical instruments	2
9	Aromatics and cosmetics	> 2
10	Stimulants	4
11	House building materials	89
	a. Frames	60
	b. Poles	41
	c. Roofs	10
	d. Wall	60
	e. Boats	18
12	Fire woods	198
13	Commercial wood	> 20
14	Ecological indicators	1
15	Ritual materials	1
16	Mushroom	12
17	Poison	25
	a. For fish	9
	b. For other purposes	16
C	**Medicinal plants**	**198**
1	Domesticated plants	41
2	Wild plants	157
D	**Plants with special characters**	**-**
E	**Semi-domesticated plants**	**> 4**

Table 2. Uses of plant species and their habitus

No	Use Categories	Species Number	Habitus								
			T	S	Cl	H	PH	Aq.H	Fn	Sc	Clp
1	Food (Staple, additional, fruits, vegetables, tubers)	209	120	20	27	14	24		4		
2	Medicinal	198	79	31	25	25	33	1	3	1	
3	Building Material	89	88		1						
4	Firewood	198	196	2							
5	Spices	22	7	3	3	5	4				
6	Poison and antidotes	28	13	5	4	3	2		1		
7	Tools/Household Appliance	27	9	4	10		1				3
8	Ropes	17	7	1	8		1				
9	Clothing	7	7								
10	Coloring	11	3	4	1	2	1				
11	Body care	15	4	1	2	3	3		2		
12	Ritual	16	12	1	2	1					
13	Craft	15	4		8						3
14	Decorative Plant and Ornamental Plants	19	4	1	8	1	1		2		2

Notes: T = Tree; S = Schrub; Cl = Climber; H = Herb; PH = Perennial Herb; Aq.H = Aquatic Herb; Fn = Fern; Sc = Scandent/Succulent; Clp = Clump

Diversity of food ingredients

In meeting their food needs, the people of the Dayak community in Malinau conduct farming (rice fields) and forest product-gathering activities (extractive actions and hunting). It is recorded that 128 plant species are used as food ingredients, including 44 cultivated plant species and 128 non-cultivated plant species. These foodstuffs include one plant species for main food ingredient and 127 plant species for additional food ingredients (consisting of 85-108 species for being taken their fruits, seeds, or flowers), 43-49 plant species for vegetable ingredients (shoots, leaves, roots, or fruit), 6 – 10 plant species for being taken their tubers, roots, and rhizomes, 7 plant species for beverage ingredients, and 4 – 7 plant species for seasonings.

Diversity of medicinal plants

The Dayak Lundayeh community in Malinau, North Kalimantan, has good knowledge about using plant species diversity as medicinal ingredients. It is noted that 198 species are categorized as medicinal plants for 20 kinds of diseases, including skin diseases, diseases related to digestion, diseases due to wounds, diseases related to the respiratory tract, pregnancy, body fatigue, and others (Table 3).

The categorization results, based on the type of disease and the number of plant species used for medical treatment, indicate that digestive disorders (stomach pain, dysentery, and diarrhea) are the diseases with the most plant species available, totaling 79. It is followed by skin diseases with 49 plant species, diseases related to the nervous system (joint disorders, aches, and fever) with 27 plant species, wounds with 21 plant species, and respiratory tract disorders with 20 plant species. Medicinal plants in the form of trees had the highest number of 72 species, followed by perennial herbaceous 59 species, wood climbers (51 species), shrubs (48 species), and herbs (40 species) (Table 2).

Diversity of plant species for building materials

It is recorded that more than 89 plant species are used as building materials, including 60 species used as frame materials, 41 species as poles and beams, 10 species as roofing materials, about 60 as wall materials, and around 18 species as boat-making materials. Species are important building materials for the Dayak Lundayeh community, as seen in Tables 1 and 3.

Diversity of plant species for poison and antidotes

In the life of local people, toxic compounds contained in plants are used as ingredients to make poison placed in arrowheads and to poison fish. The results of observations indicate that 23 plant species can be used. 8 plant species are used to poison fish. Besides, 9 plant species are used to be placed in the arrowheads. Furthermore, 7 plant species are used as antidotes.

In the Dayak Lundayeh community in Malinau, poisonous plants are very important for hunting and fishing. One example is the tradition of preparing poison for blowguns (locally known as chopstick weapons). The poison in this blowgun is generally made from the sap of Antiaris toxicaria mixed with various species of plants that contain other toxic compounds. The toxic content is mostly the alkaloid d-tubocurarine. The activity of this toxic alkaloid is to bind to nerve cell receptors (neurons), which inhibits the activity of the acetylcholine neurotransmitter.

The activity of catching fish using poisons (ichthyotoxins) in the Dayak Lundayeh community is governed by specific rules, including restrictions on their use. This is carried out because it is feared that the use of fish poison can kill livestock or possibly poison humans. The fish poison contains chemicals in the form of isoflavonoids, saponins, cardiac glycosides, alkaloids, tannins, cyanogenic, and polyacetylene alcohol. Its poison power can cause respiratory distress, nerve paralysis, liver damage, and respiratory failure.

Table 3. Categorization based on the type of disease and the number of plant species used for medical treatment

No	Categories of utilization	Total Species	Habitus						
			T	S	W.Cl	H	PH	Aq.H	Fn
1	Gastrointestinal disorders: stomach pain, diarrhea, and digestive problems	79	39	17	9	2	12		
2	Orthopedics: rheumatism, fractures, and sprains	15	6	1	3	2	2	1	
3	Dental care, toothache, and canker sores	15	9		2	1	2	1	
4	Helping the process of childbirth and post-partum	13	3	3	3	2			1
5	Skin diseases: boils, wounds, and infections	49	14	5	10	8	11		
6	Nervous system disorders: fever, aches, and pains	27	16	4	2	2	2		1
7	Reproduction: fertility and pregnancy prevention	5	1				4		
8	Malaria	6	1	2	1		2		
9	Herbal tonic	10	3		2	3	2		
10	Cough, asthma, tuberculosis, and respiratory problems	20	5	2	5	2	5		1
11	Reproductive and urinary tract infections	12	3	1	2	2	3		1
12	Tumors and internal medicine	17	3	1		6	6		1
13	Menstrual disorders	4	2		1	1			
14	Ear, nose, and throat (ENT) infection	4	2		1	1			
15	Sore eyes	6	1	2	1	1	1		
16	Appetite enhancer	3	2	1					
17	Wound medicine	21	5	3	4	4	4		1
18	Anti-toxic and toxic ingredients	17	7	5	2	2	2		1
19	Cosmetics and body care	12	6	1	2	1			2
20	Headache	5	1		1	2	1		
Total		**334**	**72**	**48**	**51**	**40**	**59**	**2**	**9**

Notes: T = Tree; S = Shrub; W.Cl = Wood climber; H = Herb; PH = Perennial Herb; Aq.H = Aquatic Herb; and Fn = Fern

Diversity of plant species for coloring agents

It is recorded that the Dayak Lundayeh community uses 11 plant species for coloring plants, comprising 3 cultivated vegetables and 8 wild plants. In addition, based on their functions, 3 plant species are used as food coloring agents, 2 are used as body dyes, and 10 are used as dyes for equipment and handicrafts (Table 3). Natural dyes derived from plants are obtained through the process of fermentation, boiling, or chemical treatment of several chemical substances that exist in plant tissues. Each plant species contains pigments with chemical structures that differ from one another. Generally, the pigments contained in plants are in the form of chlorophyll, which gives a green color, carotenoids, which give a red color, and flavonoids and quinones, which give yellow and red colors.

Diversity of plant species for local equipment and technology

It is noted that 23 plant species are used as materials for local equipment and technology. Suppose we classify the equipment used by traditional communities, such as the Dayak Lundayeh community. In that case, at least six types of equipment systems and elements of physical culture are used in the community and in their daily lives, including those in rural areas. Those types of equipment and elements of physical culture are: (1) Production tools: including equipment for farming, gardening, hunting, raising livestock, and fishing; (2) War equipment: including (a) blowgun (afut), made of belian tree (Eusideroxylon zwageri Teijsm. & Binn. (Lauraceae)) and other hardwoods, having darts (laiyan), with sharp tip made of bamboo, tail made of roots, and holder made of bamboo or bark, (b) spears (busu) with spearheads made of iron and spear handles made of belian wood, and (c) swords (ayau) – a kind of machete made of metal with the handle made of buffalo horn or of hard wood, such as belian wood and other strong wood; (3) Household appliances: including (a) container

equipment, such as water container, jars, or other containers made of pumpkins, (b) kitchen utensils, (c) eating and drinking utensils, (d) equipment for making and starting fires, and (e) household furniture; (4) Transportation equipment: including (a) baskets made of rattan with the ropes also made of rattan or bark, (b) baskets made of rattan with not close webbing, (c) containers made of rattan with one side made of wood, (d) hand baskets for women made of woven rattan or bamboo, (e) canoes (locally known as alud or ldy) made of various types species of wood, and (f) rafts (locally known as red) made of bamboo, banana trunks, or and several species of light wood; (5) Traditional art equipment: artistic instrumentation of the community in expressing the aesthetic value of sound art which is closely related to dance and religious aspects, including (a) a type of gong made of metal, (b) keratung/tubung (a kind of drum), (c) musical instruments made of bamboo, (d) sampe (a kind of harp) and (e) suling (a kind of flute) made of bamboo; and (6) Equipment for shelter: all equipment whose function is to provide protection to humans from natural conditions, such as hot sun, rain, etc., including) individual houses (sebulang), kadang or betang as a shared house, huts in the fields or the gardens, a large hat made of woven rattan or bamboo, a type of conical hat made from plaited palm leaves, coconut, and other plant species with broad leaves, (f) rain cover made of leaves, and other rain protection equipment.

Based on the natural conditions and potentials in Malinau, the equipment used by the Dayak Lundayeh community is made of one or a combination of the following raw materials: (a) various species of plants – most of the community equipment is made of parts of plant species, such as wood, bark, leaves, leaf midrib, and others, (b) metals (iron, silver, brass, copper, aluminum, and gold) – they are raw materials for making agricultural tools, weapons, and jewelry, (c) animal skins – people of the Dayak Lundayeh community are not using much raw material from animal skins, except only for musical instruments, (d) soil – kitchen utensils (for cooking), such as jars and cauldrons, are made of soil, however, it seems that this equipment is imported from outside because, in this village, no type of clay can be used as the raw material for making this kind of equipment and no ceramic or pottery craftsmen are found in the village, (e) stone – household utensils made of stone are mortar and chili grinder, and (f) synthetic materials – they are generally used to make fishing equipment, such as nets or fishing line, and to make clothes, for example as dyes, threads, and others.

Diversity of plant species for firewood

It is recorded that 198 species of plants are used as firewood by the Dayak Lundayeh community. According to them, almost all wood species can be used as firewood. However, only a few species of wood are preferred and often used as firewood, namely *Macaranga* spp. (Euphorbiaceae), *Alstonia spectabilis* (L.) R.Br. (Apocynaceae), *Timonius sp*. (Rubiaceae), *Haplolobus celebicus* H.J.Lam (Burseraceae), *Glochidion sp*. (Phyllanthaceae), *Calophyllum inophyllum* L. (Calophyllaceae), *Palaquium obtusifolium* Burck (Sapotaceae), *Diospyros* spp. (Ebenaceae), *Cryptocarya subvelutina* Elmer (Lauraceae), *Dysoxylum sp*. (Meliaceae), *Aglaia* sp. (Meliaceae), and others. These wood species have good flames, are flammable, long-lasting, and provide sufficient heat. It is recorded that 100 plant species are used as firewood by the Dayak Lundayeh community. Firewood is a vital source of energy for people who do not have other fuel sources like kerosene, natural gas, or electricity. The majority of people in this community use wood as fuel to cook. Meanwhile, they use oil lamps for lighting, and some use a personal generator. According to the people in the study area, almost all types of wood can be used as firewood. However, only a few types are often used. Wood's properties are generally good, including flame resistance, flammability, long-lasting, and sufficient heat. The species of trees that are often used as firewood and the most preferred are *Macaranga* spp., *Alstonia spectabilis* R.Br., *Timonius sp*., *Haplolobus celebicus* H.J.Lam, *Glochidion sp*., *Calophyllum inophyllum* L., *Palaquium obtusifolium* Burck, *Diospyros* spp., *Cryptocarya subvelutina* Elmer, *Dysoxylum sp*., *Aglaia* sp., and others.

Diversity of plant species for ritual materials

The Dayak Lundayeh community often carries out three kinds of rituals to date, namely (1) rituals related to the exploitation of natural resources, especially those related to agricultural activities that must be carried out by the community during the gardening cycle, including traditional ceremonies for opening new fields, planting, and harvesting, (2) rituals related to customary violations, and (3) rituals related to the life cycle including (a) birth rituals, (b) child initiation rituals, (c) marriage rituals, and (d) death rituals.

At this time, the use of offerings in traditional rituals is only an addition. For example, people use borax (an alcoholic beverage from fermented rice), *Piper betle* L. (Piperaceae), *Areca catechu* L. (Arecaceae), and *Nicotiana tabacum* L. (Solanaceae) with added calcium hydroxide (kapur sirih). The use of borax holds spiritual significance because it serves as an intermediary for communication between traditional elders and their ancestral spirits. Additionally, borax serves as a liaison between community members. Therefore, borax must be presented at the beginning of the customary deliberation to establish togetherness and prevent prolonged disputes.

Diversity of plant species for rope materials

Rope material made from plants once played a crucial role in the lives of the Dayak Lundayeh people before they became familiar with the technology of pegs, nails, and synthetic ropes. Various forms of connectors (ropes) used in residential houses and cottage houses are made of plants. It is noted that 17 plant species are used as rope materials.

Potentially useful plant species in each environmental unit

The results of the study showed that the number of useful plant species in each environmental unit is as follows: in the garden area 97 species; in the dry fields area 71 species; in the yard 51 species; in the former village 70 species; in the secondary forest area 317 species; and in the primary forest 328 species (Table 4).

Table 4. The number of useful plant species found in each environmental unit

No	Categories of Habitat	Species Number	Habitus								
			T	S	Cl	H	PH	Aq.H	Fn	Sc	Clp
1	Garden (G)	97	34	18	10	15	19	-	-	-	-
2	Dry Field (DF)	71	7	9	11	17	27	-	-	-	-
3	Yard (Y)	51	23	15	4	4	5	-	-	-	-
4	Former Village (FV)	70	33	13	3	7	13	-	-	1	-
5	Secondary Forest (SF)	317	193	17	39	24	31	1	8	1	3
6	Primary Forest (PF)	328	229	18	33	14	22	1	8	-	3
7	Mixed Garden (MG)	46	26	10	2	3	5	-	-	-	-
8	Ricefield (RF)	1					1				

Notes: T = Tree; S = Schrub; Cl = Climber; H = Herb; PH = Perennial Herb; Aq.H = Aquatic Herb; Fn = Fern; Sc = Scandent/Succulent; Clp = Clump

Furthermore, the results of the calculation of the index of cultural significance (ICS) indicate that plant species with a very high ICS value (>71) are those that serve as the main food crop, namely rice (Oryza sativa), with an ICS value of 114. Apart from being the main food crop, rice can also be processed into various types of meals and serves as ritual materials, materials for making palm wine, and animal feed. It is followed by the coconut plant (*Cocos nucifera* L. (Arecaceae)) which has many uses with an ICS value of 91 and several species of cultivated plants serving as additional food, such as fruits (*Dimocarpus longan* Lour (Sapindaceae), *Durio zibethinus* L. (Malvaceae), *Nephelium lappaceum* L. (Sapindaceae), *Mangifera indica* L. (Anacardiaceae), *Artocarpus integer* (Thunb.) Merr. (Moraceae), *Artocarpus heterophyllus* Lam (Moraceae), *Carica papaya* L. (Caricaceae), *Annona muricata* L. (Annonaceae), *Annona squamosa* L. (Annonaceae), *Garcinia mangostana* L. (Clusiaceae), and others), secondary crops (*Zea mays* L. (Poaceae), *Manihot esculenta* Crantz (Euphorbiaceae), *Arachis hypogaea* L. (Fabaceae), *Glycine max* (L.) Merr. (Fabaceae), *Phaseolus lunatus* L. (Fabaceae), and others), vegetable crops (*Solanum lycopersicum* L. (Solanaceae), *Solanum melongena* L. (Solanaceae), *Vigna unguiculata* (L.) Walp. (Fabaceae), *Momordica charantia* L. (Cucurbitaceae), *Ipomoea aquatica* Forssk. (Convolvulaceae), and plantation crops (*Coffea canephora* Pierre ex A. Froehner (Rubiaceae), *Theobroma cacao* L. (Malvaceae), and *Cinnamomum burmanni* (Nees & T.Nees) Blume (Lauraceae). They have ICS values between 49 and 71. Those plant species have high ICS values because they have more than 3 uses, as shown in Table 5.

Table 5. The high ICS values of medicinal plant species

No	Species names	Family	ICS Value
1	*Adenostemma lavenia* (L.) Kuntze	Asteraceae	49
2	*Ageratum conyzoides* L.	Asteraceae	49
3	*Alpinia galanga* (L.) Willd.	Zingiberaceae	56
4	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	58
5	*Areca catechu* L.	Arecaceae	51
6	*Blumea balsamifera* (L.) DC.	Asteraceae	63
7	*Carica papaya* L.	Caricaceae	60
8	*Citrus × aurantiifolia* (Christm.) Swingle.	Rutaceae	63
9	*Curcuma longa* L.	Zingiberaceae	54
10	*Curcuma zanthorrhiza* Roxb.	Zingiberaceae	64
11	*Cymbopogon citratus* (DC.) Stapf.	Poaceae	63
12	*Erechtites hieraciifolius* (L.) Raf. ex DC.	Asteraceae	63
13	*Eurycoma longifolia* Jack	Simaroubaceae	63
14	*Flacourtia rukam* Zoll. & Moritzi	Salicaceae	54
15	*Imperata cylindrica* (L.) Raeusch.	Poaceae	49
16	*Musa × paradisiaca* L.	Musaceae	66
17	*Pangium edule* Reinw.	Achariaceae	54
18	*Piper betle* L.	Piperaceae	58
19	*Tetrastigma trifoliolatum* Merr.	Vitaceae	69
20	*Uncaria gambir* (W.Hunter) Roxb.	Rubiaceae	66

Those medicinal plant species have high ICS values because they also have more than 3 uses as traditional medicinal ingredients. Apart from that, from the results of interviews, most of the Dayak Lundayeh people who have grown up know the diversity of medicinal plant species around them. Traditional medical practices have been carried out for generations, led by a shaman (Indonesian: dukun). Treatment is carried out using magical, religious elements and materials derived from plants or animal body parts. One of the reasons for the development of traditional medicine practices in the Dayak Lundayeh

community is the trust in the shaman, which leads many people to be less motivated to consult the modern medical system. However, at this time, a trend indicates that the traditional medicine practices of the Dayak Lundayeh community are starting to change, along with the progress of information, increased education, population growth, and shifting beliefs. It is feared that knowledge about traditional medicine will decrease and even disappear from the culture of the Dayak Lundayeh community, especially among the younger generation.

The species of wood for building materials that are most preferred by the people of the Dayak Lundayeh community consist of 103 plant species with ICS values of between 49 and 71 (see Table 6 below).

Table 6. The species of wood for building materials that have high ICS values

No	Species names	Family	ICS Value
1	*Anisoptera costata* Korth.	Dipterocarpaceae	54
2	*Anisoptera grossivenia* V.Sloot.	Dipterocarpaceae	49
3	*Anisoptera marginata* Korth.	Dipterocarpaceae	49
4	*Anthoshorea bracteolata* (Dyer) P.S.Ashton & J.Heck.	Dipterocarpaceae	51
5	*Anthoshorea javanica* (Koord. & Valeton) P.S.Ashton & J.Heck.	Dipterocarpaceae	60
6	*Anthoshorea lamellata* (Foxw.) P.S.Ashton & J.Heck.	Dipterocarpaceae	54
7	*Anthoshorea retinodes* (Slooten) P.S.Ashton & J.Heck.	Dipterocarpaceae	63
8	*Cyrtophyllum fragrans* (Roxb.) DC.	Gentianaceae	67
9	*Cyrtophyllum giganteum* (Ridl.) Ridl	Gentianaceae	54
10	*Dactylocladus stenostachys* Oliv.	Crypteroniaceae	58
11	*Dipterocarpus borneensis* Slooten	Dipterocarpaceae	66
12	*Dipterocarpus caudiferus* Merr.	Dipterocarpaceae	66
13	*Dipterocarpus confertus* Slooten	Dipterocarpaceae	68
14	*Dipterocarpus cornutus* Dyer	Dipterocarpaceae	68
15	*Dryobalanops aromatica* C.F.Gaertn.	Dipterocarpaceae	70
16	*Dryobalanops beccarii* Dyer	Dipterocarpaceae	54
17	*Dryobalanops fusca* Slooten	Dipterocarpaceae	50
18	*Dryobalanops lanceolata* Burck	Dipterocarpaceae	64
19	*Dryobalanops rappa* Becc.	Dipterocarpaceae	54
20	*Dyera costulata* (Miq.) Hook.f.	Apocynaceae	54
21	*Dyera polyphylla* (Miq.) Steenis	Apocynaceae	52
22	*Eusideroxylon zwageri* Teysm. Binnend.	Lauraceae	65
23	*Gonystylus macrophyllus* (Miq.) Airy Shaw	Thymelaeaceae	54
24	*Hopea dryobalanoides* Miq.	Dipterocarpaceae	64
25	*Hopea ferruginea* Parijs	Dipterocarpaceae	56
26	*Hopea gregaria* Slooten	Dipterocarpaceae	52
27	*Hopea mengarawan* Miq.	Dipterocarpaceae	62
28	*Hopea sangal* Korth.	Dipterocarpaceae	54
29	*Intsia bijuga* (Colebr.) Kuntze	Fabaceae	58
30	*Intsia palembanica* Miq.	Fabaceae	58
31	*Richetia faguetiana* (F.Heim) P.S.Ashton & J.Heck.	Dipterocarpaceae	50
32	*Richetia gibbosa* (Brandis) P.S.Ashton & J.Heck.	Dipterocarpaceae	50
33	*Richetia multiflora* (Burck) P.S.Ashton & J.Heck.	Dipterocarpaceae	50
34	*Rubroshorea balangeran* (Korth.) P.S.Ashton & J.Heck.	Dipterocarpaceae	49
35	*Rubroshorea elliptica* (Burck) P.S.Ashton & J.Heck.	Dipterocarpaceae	52
36	*Shorea acuminatissima* (Symington) P.S.Ashton & J.Heck.	Dipterocarpaceae	64
37	*Shorea atrinervosa* Symington	Dipterocarpaceae	52
38	*Shorea falcifera* Dyer ex Brandis	Dipterocarpaceae	52
39	*Shorea glauca* King.	Dipterocarpaceae	50
40	*Shorea laevis* Ridl.	Dipterocarpaceae	50
41	*Shorea maxwelliana* King	Dipterocarpaceae	50
42	*Shorea seminis* (de Vriese) Slooten	Dipterocarpaceae	50
43	*Vatica oblongifolia* Hook.f.	Dipterocarpaceae	51
44	*Vatica rassak* (Korth.) Blume	Dipterocarpaceae	50
45	*Vatica venulose* Blume	Dipterocarpaceae	49

These plant species that produce wood for building materials also have a high ICS value because the quality of the wood can be used as poles, blocks, walls, and house-building frame materials, and they are considered to have good-quality building wood.

Based on the categorization of the ICS value of non-cultivated plant species, there are 2 species whose quality, intensity, and exclusivity values of use are considered to be in the high category (an ICS value between 49 and 71), namely *Eusideroxylon*

zwageri with an ICS value of 65 and *Calamus caesius* Blume (Arecaceae) (English name: rattan; Indonesian name: rotan sega) with an ICS value of 50. Both species offer benefits as building materials, medicines, food sources, and local technologies. Moreover, based on the ICS values classified as moderate (ICS 26–48), they are occupied by *Caryota mitis* Lour. (Arecaceae) (48), *Caryota no* Becc. (Arecaceae) (48), *Calamus ornatus* Blume (Arecaceae) (42), *Aquilaria beccariana* Tiegh. (Thymelaeaceae) (40), *Aquilaria malaccensis* Lam. (Thymelaeaceae) (40), *Eugeissona utilis* Becc. (Arecaceae) (40), *Arenga brevipes* Becc. (Arecaceae) (40), and *A. undulatifolia* Becc. (Arecaceae) (40). Additionally, there are 362 species categorized in the low category, with ICS values ranging from 3 to 25. Representative species are shown below (Figure 6).

Figure 6. *Aquilaria malaccensis* (agarwood) and *Calamus caesius* (rattan). *Aquilaria malaccensis*: (A) Mature tree, (B) Fruit, and (C) Processed gaharu wood (agarwood) (above). *Calamus caesius* (D) Raw rattan undergoing sun-drying and (E) Dried rattan canes bundled for storage or transport (below).

Ironwood (*Eusideroxylon zwageri*) obtained the highest ICS value with a value of 65, which has several main uses, including additional food, medicines, building materials, local technology materials, and crafts. The fruit of the ironwood can be eaten, the leaves are used as a traditional ingredient to treat stomach aches, and the water from the leaf soak can be used to treat toothaches. According to Ajizah *et al.* (2007), Amaliyah *et al.* (2018), and Amaliyah *et al.* (2019), phytochemical tests on ironwood indicate that it contains chemical compounds, such as flavonoids, tripenoids, and saponins, that have the potential as antibacterial and antiviral agents. Ironwood is also termite-resistant and can be used for local technology, especially for household appliances and war equipment. In addition, ironwood is also economically profitable. The population of this plant species has declined sharply in its natural habitat because it is still a logging commodity. Therefore, ironwood needs to be cultivated and preserved.

The second highest ICS value is obtained by uwe sugoh or rotan sega (*Calamus caesius* Blume (Arecaceae). Its stem tip can be eaten as a side dish. The fruit can also be eaten as additional food. The roots and fruit can also be used as medicinal ingredients. The old stems of rotan sega are widely used for handicrafts and household furniture. Based on ICS calculations, both *Eusideroxylon zwageri* and *Calamus caesius* have the same three uses: additional food, traditional medicinal ingredients, and local handicraft materials.

Three plant species have the same ICS value, namely *Calamus ornatus* Blume (Arecaceae), *Aquilaria beccariana*, and *A. malaccensis* (English name: agarwood, Indonesian name: Gaharu) with a value of 42. The difference between the three species is that *Calamus ornatus* has a higher quality value than the other two species. However, *Aquilaria beccariana* and *A. malaccensis* have a higher intensity value than *Calamus ornatus*, although the exclusivity of the three species has the same value.

Based on the results of the ICS calculation, 10 plant species have the most uses. Among them are ironwood and rotan sega, gondang putih (*Ficus variegata* Blume (Moraceae)), sup (*Eryngium foetidum* L. (Apiaceae)), payang (*Pangium edule* Reinw. (Achariaceae)), bua gerawet (*Passiflora foetida* L. (Passifloraceae)) and *Pimpinella pruatjan* Molk. (Apiaceae) have more than one use, namely as additional food, medicinal ingredients, craft materials, and anti-toxic materials. For example, *Pimpinella pruatjan* has three uses at once: the leaves are boiled and then eaten as a side dish, the leaves are also used as an antidote to fish poisons, and the roots have analgesic and antibacterial properties.

Based on the ICS calculation, 6 plant species (*Calamus caesius*, *Pangium edule*, *Ficus variegata*, *Eryngium foetidum*, *Calamus ornatus*, and *Aquilaria beccariana*) are quite important plants in the sociocultural life of the Dayak Lundayeh community, especially for food and medicine. In addition, five plant species — *Eusideroxylon zwageri*, *Calamus caesius*, *Eryngium foetidum*, *Caryota mitis*, and *C. no* —are utilized in local technology, with four of them also serving as food ingredients. Although *Caryota mitis*, *C. no*, *Calamus ornatus*, and *Aquilaria beccariana* only have two uses each, these species have higher ICS values than other species (*Calamus caesius*, *Pangium edule*, *Passiflora foetida*, *Ficus variegata*, and *Eryngium foetidum*). This indicates that *Caryota mitis*, *C. no*, *Calamus ornatus*, and *Aquilaria beccariana* possess higher sociocultural values, particularly when considering the quality and intensity of their use.

The calculation of this ICS value can change at any time because the value of the utilization of a plant species also changes, except for plant species that are the main food crops. Additionally, the ICS calculation remains subjective because the researchers determine the weight of each score. To address this problem, the researchers also calculate the Local User's Value Index (LUVI) value, whose assessment is based on the respondents, namely the local community being studied.

The gained LUVI values regarding the utilization of important plant species diversity, as per the Dayak Lundayeh community, are explained below and seen in Table 7.

(a) Of the 154 plant species known for the food crop category by the Dayak Lundayeh community, rice (*Oryza sativa* L.) has the highest LUVI value, followed by additional food crops, such as corn (*Zea mays* L.), cassava (*Manihot esculenta* Crantz), coconut (*Cocos nucifera* L.), sweet potato (*Ipomoea batatas* (L)). Lam., and uwi (*Dioscorea* spp).
(b) For the non-cultivated additional food category, the plant species with the highest LUVI is *Arenga brevipes*, followed by *Calamus caesius*, *Calamus ornatus*, *Arenga undulatifolia* Becc., *Caryota mitis*, *C. no*, and *Eugeissona utilis*.
(c) The important plant species based on non-cultivated vegetables are *Calamus caesius*, *C. ornatus*, *Dendrocalamus asper* (Schult. & Schult.f.) Backer, *Parkia speciosa* Hassk, *Eryngium foetidum*, *Diplazium esculentum* (Retz.) Sw. *Ficus racemosa* L., *Setaria palmifolia* (J. Koenig) Stapf, *Oncosperma horridum* (Griff.) Scheff., and *Eugeissona utilis*. The plant parts used for side dishes are leaves (*Eryngium foetidum*, *Diplazium esculentum*, and *Setaria palmifolia*), stem tips (*Calamus caesius*, *C. ornatus*, *Oncosperma horridum*, and *Eugeissona utilis*), shoots (*Dendrocalamus asper* and *Ficus racemosa*), and seeds (*Parkia speciosa*).
(d) Almost all plant species that have fruit are considered important by the people of the Dayak Lundayeh community, namely *Durio zibethinus*, *Mangifera indica*, *Psidium guajava* L., *Lansium domesticum* Corrêa, *Pometia pinnata* J. R. Forst. & G. Forst., *Salacca affinis* Griff., *Nephelium lappaceum* L., *Xanthophyllum flavescens* Roxb., *Garcinia forbesii* King, and *Musa* sp.
(e) Of the 183 medical plant species recognized by the people of the Dayak Lundayeh, 10 plant species are designated by them as the most important medicinal plants. The plant species with the highest LUVI values are *Alpinia galanga* and *Basella alba*, *Eusideroxylon zwageri*, *Callicarpa longifolia*, *Curcuma aeruginosa* Roxb., *Blumea balsamifera*, *Piper betle*, *Phyllanthus subscandens* (Zoll. & Moritzi) Müll.Arg., *Eryngium foetidum*, and *Euphorbia prostrata* Aiton.
(f) Plant species considered important by the Dayak Lundayeh community as materials for local technology and production equipment are *Agathis borneensis* Warb., *Bambusa* sp., *Eusideroxylon zwageri*, *Calamus javensis*, *Artocarpus* sp., *Daemonorops sabut*, *Dendrocalamus asper*, *Korthalsia echinometra*, *Ficus racemosa*, and *Dyera costulata*. Local people use *Agathis borneensis* and *Eusideroxylon zwageri* as the main choices for making household appliances, while for woven materials, they use *Bambusa* sp. and *Dendrocalamus asper*. In addition, several species of rattan are also used as a handicraft material, for example, *Calamus javensis* Blume (Arecaceae), *C. crinitus* subsp. *sabut* (Becc.) A. J. Hend. (Arecaceae) and *Korthalsia echinometra* Becc. (Arecaceae). For rope materials, local people use *Ficus racemosa* and *Artocarpus* sp. Meanwhile, for adhesives, they use the sap from *Dyera costulata*.
(g) Toxic substances from plants are usually used for hunting purposes by the Dayak Lundayeh community. The plant species considered important by them is *Antiaris toxicaria* (J.F.Gmel.) Lesch., *Albizia chinensis* (Osbeck) Merr., *Kaempferia galanga* L., *Callicarpa longifolia*, *Croton tiglium* L., *Derris elliptica* (Wall.) Benth., *D. thyrsiflora* (Benth.) Polhill, *Garcinia lateriflora*, *Phyllanthus borneensis*, and *Lygodium circinnatum* (Burm.f.) Sw.. Toxic compounds contained in these plant species are used as ingredients to make poison which is placed in arrowheads and blowguns. Meanwhile, for toxic substances in hunting mammals and fish, local people use the sap of *Antiaris toxicaria* and *Albizzia chinensis*, and the sap, leaves, and roots of *Derris elliptica*, *D. thyrsiflora*, and *Garcinia lateriflora*. Furthermore, plant species used as an antidote are *Phyllanthus borneensis* to counter snake venom and *Lygodium circinnatum* to counter spider venom.
(h) The Dayak Lundayeh people use natural dyes to color their handicrafts, such as woven mats, hats, and other items. The most important plant species as a source of natural dyes, based on the perception of the Dayak Lundayeh people are *Bixa orellana* L., *Curcuma longa*, *Kaempferia galanga*, *Lawsonia inermis* L., *Basella alba* L., *Melastoma malabathricum* L., *Nephelium lappaceum*, *Artocarpus heterophyllus*, and *Psidium guajava*. *Bixa orellana* produces a bright red color that is

used for coloring food, craft materials, and various agricultural equipment. Meanwhile, *Curcuma longa*, *Kaempferia galanga*, and *Nephelium* lappaceum produce a yellow color that is used to color food. *Lawsonia inermis* produces a reddish-yellow color which is used as a body dye for traditional ceremonies. The plant parts used to produce dye are roots, rhizomes, leaves, fruits, and stems.

(i) The Dayak Lundayeh people use firewood for cooking and lighting purposes. However, there are only a few types of trees whose wood produces good fire qualities (flammable and long-lasting). The important tree species according to the Dayak Lundayeh community are *Hevea brasiliensis*, *Timonius flavescens*, *Haplolobus celebicus*, *Glochidium* sp., *Macaranga* spp., *Alstonia spectabilis*, *Calophyllum inophyllum*, *Palaquium obtusifolium*, *Diospyros* spp., and *Cryptocarya subvelutina*.

Table 7. Use categorization and LUVI Values of plant species considered important by the Dayak Lundayeh

No	Use Categorize / Species name	Family	PDM Score	LUVI Values
A	**Food crop**			
1	*Oryza sativa* L.	Poaceae	36	1.9684
2	*Zea mays* L.	Poaceae	15	0.7980
3	*Manihot esculenta* Crantz	Euphorbiaceae	14	0.7448
4	*Cocos nucifera* L.	Arecaceaea	14	0.7448
5	*Ipomoea batatas* (L.) Lam.	Convolvulaceae	10	0.5320
6	*Dioscorea spp.*	Dioscoreaceae	10	0.5320
B	**Non-cultivated additional food**			
1	*Arenga brevipes* Becc.	Arecaceae	13	0.6916
2	*Calamus caesius* Blume	Arecaceae	12	0.6384
3	*Calamus ornatus* Blume	Arecaceae	11	0.5852
4	*Arenga undulatifolia* Becc.	Arecaceae	10	0.5320
5	*Caryota mitis* Lour.	Arecaceae	10	0.5320
6	*Caryota no* Becc.	Arecaceae	10	0.5320
7	*Eugeissona utilis* Becc.	Arecaceae	9	0.4788
8	*Xanthosoma sp.*	Araceae	9	0.4788
9	*Dioscorea alata* L.	Dioscoreaceae	8	0.4256
10	*Dioscorea pentaphylla*	Dioscoreaceae	8	0.4256
C	**Non-cultivated vegetables**			
1	*Calamus caesius* Blume	Arecaceae	13	0.637
2	*Calamus ornatus* Blume	Arecaceae	12	0.588
3	*Dendrocalamus asper* (Schult. & Schult.f.) Backer	Poaceae	11	0.539
4	*Parkia speciosa* Hassk.	Fabaceae	10	0.49
5	*Eryngium foetidum* L.	Apiaceae	10	0.49
6	*Diplazium esculentum* (Retz.) Sw.	Aspleniaceae	10	0.49
7	*Ficus racemosa* L.	Moraceae	9	0.441
8	*Setaria palmifolia* (J.Koenig) Stapf.	Poaceae	9	0.441
9	*Oncosperma horridum* (Griff.) Scheff.	Arecaceae	8	0.392
10	*Eugeissona utilis* Becc.	Arecaceae	8	0.392
D	**Fruit plants**			
1	*Durio zibethinus* L.	Bombacaceae	14	0.5292
2	*Mangifera indica* L.	Anacardiaceae	12	0.4536
3	*Psidium guajava* L.	Myrtaceae	11	0.4158
4	*Lansium domesticum* Corrêa	Meliaceae	10	0.3780
5	*Pometia pinnata* J.R.Forst. & G.Forst.	Sapindaceae	10	0.3780
6	*Salacca affinis* Griff.	Arecaceae	10	0.3780
7	*Nephelium lappaceum* L.	Sapindaceae	9	0.3402
8	*Xanthophyllum flavescens* Roxb.	Polygalaceae	8	0.3024
9	*Garcinia forbesii* King	Clusiaceae	8	0.3024
10	*Musa sp.*	Musaceaee	8	0.3024
E	**Medicinal plants**			
1	*Alpinia galanga* (L.) Willd.	Zingiberaceae	13	0.01495
2	*Basella alba* L.	Basellaceae	13	0.01495
3	*Eusideroxylon zwageri* Teijsm. & Binn.	Lauraceae	12	0.01380
4	*Callicarpa longifolia* Lam.	Lamiaceae	10	0.01150
5	*Curcuma aeruginosa* Roxb.	Zingiberaceae	10	0.01150
6	*Blumea balsamifera* (L.) DC.	Asteraceae	9	0.01035
7	*Piper betle* L.	Piperaceae	9	0.01035
8	*Phyllanthus subscandens* (Zoll. & Moritzi) Müll.Arg.	Phyllanthaceae	8	0.92000
9	*Eryngium foetidum* L.	Apiaceae	8	0.92000

10	*Euphorbia prostrata* Aiton	Euphorbiaceae	8	0.92000
F	**Plant species for materials (local technology and production equipment)**			
1	*Agathis borneensis* Warb.	Araucariaceae	13	0.975
2	*Bambusa sp.*	Poaceae	13	0.975
3	*Eusideroxylon zwageri* Teijsm. & Binn.	Lauraceae	12	0.900
4	*Calamus javensis* Blume	Arecaceae	11	0.825
5	*Artocarpus sp.*	Moraceae	10	0.750
6	*Daemonorops sabut* Becc.	Arecaceae	9	0.675
7	*Dendrocalamus asper* (Schult. & Schult.f.) Backer	Arecaceae	8	0.600
8	*Korthalsia echinometra* Becc.	Arecaceae	8	0.600
9	*Ficus racemosa* L.	Moraceae	8	0.600
10	*Dyera costulata* Hook.f.	Apocynaceae	8	0.600
G	**Plant with toxic substances usually used for hunting purposes**			
1	*Antiaris toxicaria* (J.F.Gmel.)	Moraceae	13	0.975
2	*Albizia chinensis* (Osbeck) Mer.	Fabaceae	12	0.900
3	*Kaempferia galanga* L.	Zingiberaceae	12	0.900
4	*Callicarpa longifolia* Lam.	Lamiaceae	10	0.750
5	*Croton tiglium* L.	Euphorbiaceae	10	0.750
6	*Derris elliptica* (Wall.) Benth.	Fabaceae	9	0.675
7	*Derris thyrsiflora* (Benth.) Polhill	Fabaceae	9	0.675
8	*Garcinia lateriflora* Blume	Clusiacae	9	0.675
9	*Phyllanthus borneensis* Müll.Arg.	Phyllanthaceae	8	0.600
10	*Lygodium circinnatum* (Burm.f.) Sw.	Schizaeaceae	8	0.600
H	**Natural dyes to color handicrafts**			
1	*Bixa orellana* L.	Bixaceae	14	0.014
2	*Curcuma longa* L.	Zingiberaceae	13	0.013
3	*Kaempferia galanga* L.	Zingiberaceae	13	0.013
4	*Lawsonia inermis* L.	Lythraceae	11	0.011
5	*Basella alba* L.	Basellaceae	11	0.011
6	*Melastoma malabathricum* L.	Melastomataceae	10	0.010
7	*Nephelium lappaceum* L.	Sapindaceae	10	0.010
8	*Artocarpus heterophyllus* Lam.	Moraceaee	9	0.900
9	*Psidium guajava* L.	Myrtaceae	9	0.900
I	**Firewood for cooking and lighting purposes**			
1	*Hevea brasiliensis* (Willd. ex A.Juss.) Müll.Arg.	Euphorbiaceae	13	0.585
2	*Timonius flavescens* Baker	Rubiaceae	13	0.585
3	*Haplolobus celebicus* H.J.Lam	Burseraceae	12	0.54
4	*Glochidion* sp.	Phyllanthaceae	11	0.495
5	*Macaranga* spp	Euphorbiaceae	10	0.45
6	*Alstonia spectabilis* R.Br.	Apocynaceae	9	0.405
7	*Calophyllum inophyllum* L.	Calophyllaceae	8	0.36
8	*Palaquium obtusifolium* Burck	Sapotaceae	8	0.36
9	*Diospyros* spp.	Dioscoreaceae	8	0.36
10	*Cryptocarya subvelutina* Elmer	Lauraceae	8	0.36

From the results of the ICS and LUVI analyses, we can find out which plant species are important and potentially useful for the Dayak Lundayeh community as food crops (main and supplementary food), building materials, medicinal materials, craft materials, dyes, poisons, antidotes, and firewood. The knowledge of the Dayak Lundayeh people about these useful plant species indicates that the Dayak Lundayeh people are still very closely related to natural resources and their environment. This also shows that the life of the Dayak Lundayeh people still depends on the natural resources found in their environment. In addition, the disclosure of several useful plant species also provides information about important and potential useful plant species, as shown from the analysis of the Index of Cultural Significance (ICS) and the Local User's Value Index (LUVI) which succeeded in identifying the most important species for the Dayak Lundayeh community. The more plants are used, the greater their importance (Turner 1988, Purwanto 2010, Ajiningrum *et al.* 2011b, Helida *et al.* 2015, Yuniati *et al.* 2019, Sari *et al.* 2020). However, the definitions and uses of plant resources will differ from culture to culture.

Collecting and utilizing plant species diversity plays a crucial role in the life of the Dayak Lundayeh community, contributing 55.888% in 2010, 74.7% in 2014, and 96.428% in 2018. The diversity of plant species documented among the Lundayeh reflects a rich body of ethnobotanical knowledge and a deep-rooted ecological relationship with their environment. Concurrently, as an agrarian society, the Lundayeh continue to engage in extractive practices, and their subsistence strategies remain heavily reliant on the availability and ecological sustainability of local biological resources and surrounding ecosystems. The results of the ethnoecological study of the Lundayeh community can be used as a basis for the sustainable regional development of the Dayak Lundayeh community.

Economic value of potentially useful plant species

The Dayak Lundayeh community, as farmers, still relies on gathering forest products to fulfill their household needs, with economic value described in Table 8.

Table 8. The economic value of the production and processing activities of several non-timber forest products

No.	Production activities for each family	Economic Value (IDR/Year)		
		2010	2014	2018
1	The average value of garden yields (langsat, durian, cempedak, jackfruit, banana, rambutan, coconut)	7,005,500	10,140,000	14,200,000
2	The value of coffee and cocoa plantations	-	5,500,000	7,650,000
3	The value of the results of one-harvest farming activities	7,300,500	10,200,000	13,860,000
4	The economic value of hunting activities:			
	Hunting pigs = 18 (25 kg/pig @ 10,000 IDR (2009), @ 15,000 IDR (2011), and @ 30,000 IDR (2018))	4,680,000	6,750,000	4,680,000
	Hunting deer = 8 (30 kg @ 15,000 IDR (2009), 25,000 IDR (2011), and @ 50,000 IDR (2018))	2,500,000	6,000,000	12,600,000
5	The economic value of catching fish (390,000 IDR per 12 months (2011) and 600,000 IDR per 12 months (2018))	-	4,680,000	7,200,000
6	The economic value of the diversity of plant species as materials for household utensils, crafts, and traditional needs (generally combining various rattan species)	840,000	1,440,000	700,000
7	The economic value of firewood: The estimated amount of wood used by each family per day ranges from 0.2 – 0.4 m3 or about 6 – 12 m3 per month with an average of 175,000 IDR (in 2009), 295,000 IDR (in 2011), and 550,000 IDR (in 2018) (this has been net value after deducting the value of labor)	2,040,000	3,540,000	6,600,000
8	The direct use-value of total production activities (farming and gathering the diversity of useful plant species)	24,366,000	48,250,000	76,310,000
9	The direct use-value of the diversity of useful plant species	10,060,000	22,410,000	40,500,000
10	Life necessities	18,000,000	30,000,000	42,000,000
11	% Fulfillment of activities for the use of biological resources	135.366	160.833	181.690
12	% Fulfillment of the needs from utilizing the diversity of useful plant species	55.888	74.700	96.428
13	% Fulfillment of the needs from farming activities (garden and field products)	79.477	86.133	85.023

Notes: 1 USD = IDR 9.080 (2010); IDR 9.750; IDR 13.700 (2018); IDR. 14.360 (2021)

The role of useful plant species in the community's economic life

The direct use value calculation results, as illustrated in the diagram below (Figure 7), indicate that the livelihood and economic dependence of the Dayak community remain substantial on forest areas. The diagrams illustrate the changing contributions of four key sectors—useful plant species diversity, farming and gardening activities, hunting and fishing, and equipment, local technology, and firewood—to the economic life of the Dayak community from 2010 to 2018. Over this period, there was a clear and consistent increase in the contribution of the diversity of useful plant species, rising from 55.888% in 2010 to 96.428% in 2018, which indicates a growing reliance on forest plant resources. Similarly, farming and gardening activities remained a major contributor throughout, with values of 79.454% in 2010, peaking at 86.133% in 2014,

and slightly decreasing to 85.023% in 2018. Hunting and fishing, important sources of protein, also showed a strong upward trend, increasing from 39.888% in 2010 to 79.286% in 2018. In contrast, the contribution of equipment, local technology, and firewood remained very small but steady, with only a slight increase from 0.16% in 2010 to 0.174% in 2018. Overall, the data emphasize the community's increasing dependence on forest-based resources, especially plant diversity and traditional subsistence activities.

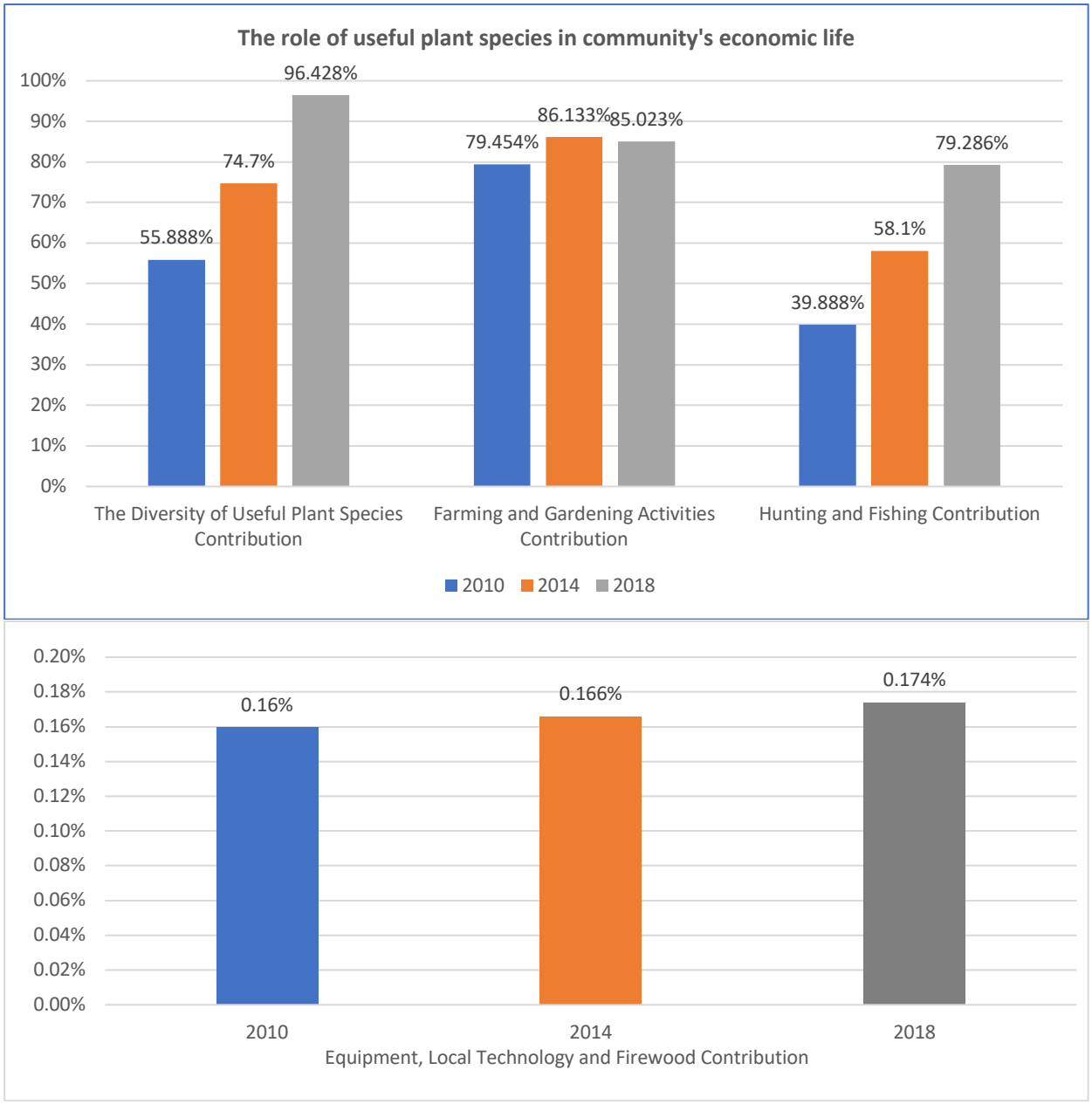

Figure 7. The contribution of useful plant species to the community's economic life

It should be noted that the location where local people live in this area is closely related to their dependence on forest products. The results of the observations show that those who live closer to the forest area (getting further from the center of Malinau City) will have a higher dependence on forest products. The area where the Dayak Lundayeh community lives is the "furthest" place from the center of Malinau with a distance of about 5 hours by water transportation (small boat or locally known as ketingting). Therefore, they highly depend on the diversity of useful plant species that are not cultivated. Moreover, their needs are fulfilled by relying on forest products or taking advantage of biodiversity from the surrounding forest area, which contributed 96.428% in 2018. This means that taking advantage of the diversity of useful plant species in the forest area around the settlement in 2018 can support the households of the Dayak Lundayeh community, which has a surplus of up to 50.9%. Actually, other factors cause dependence on forest products. One of them is the availability of transportation facilities and infrastructure, as well as access to residential locations.

The high dependence of the Dayak Lundayeh community on forest products indicates that they still need and rely on the forest's presence. For this reason, forest preservation in this area is very important to support their lives. In line with this, the rate of decline in forest areas in Malinau Regency must be addressed immediately, especially those located close to local community settlements. Some of the solutions that can be taken to overcome this problem are (a) implementing forest area management properly according to its function, (b) developing non-timber forest products into commodities that have higher economic value, (c) increasing the capacity of human resources, especially local communities through training on the introduction and utilization of forest product processing technology, (d) enforcing laws and strengthening local natural resource management institutions, (e) providing facilities and infrastructure for marketing forest products, (f) granting forest area management rights to local communities as a reserved area for meeting the needs of their daily life, and (g) developing sustainable forest product management innovation.

This study has several important notes on the direct use value of non-timber forest products, namely as follows. (a) Taking advantage of the biodiversity of potentially useful plant species continues to significantly contribute to the lives of local communities in Malinau, with an increase from year to year, ranging from 55.9% to 150.9% between 2010 and 2018. In addition, it is followed by hunting wild animals (pigs and deer) and catching fish. (b) Gathering useful non-timber forest products is one of the traditional activities of the Dayak Lundayeh community and is part of their livelihood. Therefore, the conservation of forest areas around the settlements of the Dayak Lundayeh people is very important and must be carried out. (c) The forest area is one of the environmental units that has a major influence on the lives of the Dayak Lundayeh community. Therefore, the government must give management rights to them through regional regulation as a place to fulfill their daily needs. (d) As the forest area decreases, it is necessary to carry out reform at the institutional level and increase the capacity of customary organizations to manage forest areas. (e) The government needs to increase the capacity of human resources, especially local communities, through training on the introduction and use of forest product processing technology for sustainable life support that is environmentally friendly.

Conclusion and Recommendation

The Dayak Lundayeh community possesses extensive ethnobotanical and ethnoecological knowledge, utilizing many plant species in their daily lives, which demonstrates a sustainable and multifunctional approach to conserving and utilizing biodiversity. The community can meet its daily needs through the traditional production and utilization of NTFPs. These results would help advance the study of sociocultural, socioeconomic, and management aspects of biological resources and their ecosystems, which are crucial to sustainably managing the diversity of valuable plant species in Malinau, North Kalimantan, particularly.

Their traditional knowledge offers valuable insights into sustainable biodiversity management, which can inform national conservation strategies. However, in connection with the very important role of the forest for the Lundayeh community, several measures must be taken, including preserving the forest area around the Dayak Lundayeh community's settlement and granting them management rights through local regulations, as a means to fulfill their daily needs. It is necessary to strengthen institutional capacity, enhance the ability of customary organizations to manage forest areas, and increase the capacity of local communities, particularly through training on forest product processing technology, to support environmentally friendly and sustainable living. Through disclosing the knowledge and wisdom of indigenous peoples in managing, dividing spatial planning, utilizing it and efforts to conserve the diversity of plant resources and their ecological knowledge, it is hoped that this will help planning and development agendas that pay attention to the conditions of the people and consider the local wisdom of the people in this area, not a top-notch approach down which is influenced by external knowledge applied bureaucratically in this area. This approach and the findings may be beneficial not only for Dayak Lundayeh but also for all ethnic groups in Indonesia and worldwide.

Declarations

List of abbreviations: ICS - Index of Cultural Significance; PDM - Peddle Distribution Method; NTFPs - Non-timber Forest Products; LUVI - Local User's Value Index; ENT – Ear, Nose and Throat

Ethics approval and consent to participate: The authors obtained permission from the local authorities and the participants to conduct the study.

Consent for publication: All people shown in images gave their prior informed consent to have their image published.

Availability of data and materials: All data, materials, and information are collected from the study sites. Data are available from the authors upon request. This paper contains the data consented by respondents to published.

Competing interests: The authors declare that they have no competing interests.

Funding: This research was funded by the Competitive Research Program LIPI and self-funded by the author.

Author contributions: P.S.A. acquired fund, fieldwork, formal analyses, data interpretation, writing-original draft, writing-review and editing; E.M. acquired fund, fieldwork, formal analyses, data interpretation, writing-original draft, writing-review and editing; D.O. formal analyses, writing-review and editing; R.S. acquired fund, fieldwork, formal analyses, data interpretation, writing-original draft, writing-review and editing; Y.T.H. acquired fund, formal analyses, and writing-original

draft; Y.P. acquired fund, fieldwork, formal analyses, data interpretation, writing-original draft, writing-review, and editing; R.C. formal analyses, data interpretation, writing-review and editing; all authors read and agreed on the final manuscript.

Acknowledgements

Author gratitude is presented to the Lundayeh community at Mentarang Hulu, Mentarang, Malinau Barat (Tanjung Lapang Village), Malinau Utara districts for their hospitality and willingness to help the author in collecting data at their villages; and to Research Center for Biology, LIPI and Coordinator Competitive Research Program, LIPI for the funding support and permission.

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