

# Plant Diversity with High Conservation Value in Oil Palm Plantation in Pohuwato Regency, Gorontalo, Indonesia

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**Abstract** Ecological transformations resulting from forest-to-plantation conversion remain a critical challenge in balancing oil palm production with biodiversity conservation. This study assessed plant diversity in the plasma oil palm plantations of PT. Loka Indah Lestari in Pohuwato Regency, Gorontalo, Indonesia, from June to September 2024. Using belt transects and purposive sampling across forest and plantation sites, researchers identified 47 families, 85 genera, and 111 species. Forest plots supported 79 species, while plantations supported only 56, reflecting a significant reduction in richness and vegetation complexity. Forest sites exhibited diverse growth forms—trees, lianas, ferns, epiphytes—while plantations were dominated by herbs and shrubs, with limited tree regeneration. Eight Sulawesi endemics, including *Diospyros celebica* and *Dysoxylum quadrangulatum*, were categorized as Vulnerable and *Syzygium balgooyi* as Near Threatened under IUCN criteria. In addition, 64 species had medicinal uses and 59 species provided multipurpose values, ranging from food and fodder to construction and crafts. These findings reveal that even within monoculture landscapes, remnant habitats retain high conservation value and provide essential cultural and livelihood functions. The results highlight the ecological and social trade-offs of land conversion and

underscore the necessity of embedding High Conservation Value assessments into plantation management. The persistence of endemic and culturally important plants demonstrates opportunities for conservation-oriented certification schemes such as ISPO. This study provides insights into the planning of sustainable oil palm plantation landscapes that integrate economic interests of palm oil production, the ecological functions of the landscape, and conservation of endemic species, as well as the role of ethnobotany in strengthening the socio-economic and cultural dimensions of local communities.

**Keywords** Biodiversity Conservation, Endemic Species, Ethnobotany, Gorontalo, High Conservation Value, Oil Palm Plantations, Sustainable Land Use

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## 1. Introduction

The global palm oil industry, dominated by cultivation of *Elaeis guineensis* Jacq., has developed into one of the most significant agribusiness sectors, supplying the largest share of vegetable oil consumed worldwide and substantially shaping the socio-economic trajectory of

producing countries. Indonesia, as the world's leading producer, had cultivated approximately 22.3 million hectares of oil palm by 2020 across Sumatra, Kalimantan, Java, Sulawesi, Maluku, and Papua [1,2]. Beyond its contribution to foreign exchange earnings, palm oil has created vast employment opportunities, enhanced rural livelihoods, and supported poverty alleviation, particularly among smallholders. Nevertheless, the rapid expansion of oil palm plantations has precipitated severe ecological consequences, including large-scale deforestation, loss of endemic habitats, and declines in biodiversity across multiple taxa [3,4]. The replacement of diverse tropical forests with monoculture plantations reduces ecological heterogeneity. This transformation also weakens ecosystem resilience, creating major challenges for sustainable land management in tropical regions.

Studies across Southeast Asia have demonstrated that the biodiversity impacts of oil palm extend beyond initial deforestation to include ongoing ecological degradation during plantation replanting and intensification cycles [5]. The conversion of secondary forests into oil palm monocultures has resulted in the documented disappearance of 157 species of plants that were previously recorded in forested areas [6]. Faunal declines are equally significant, with populations of orangutans, tigers, deer, and bears becoming increasingly threatened as their habitats shrink and fragment [1].

The decline in biodiversity has led to the loss of ethnobotanical resources, which in turn threatens cultural identity, weakens social cohesion, and increases dependence on the modern market economy. Indonesia's tropical forests are globally recognized as biodiversity hotspots and serve as invaluable reservoirs of ethnobotanical knowledge, supporting the use of local plants for food, medicine, construction, rituals, and household economies [7]. However, the large-scale expansion of oil palm plantations over the past two decades has placed significant pressure on the sustainability of local plant diversity and the ethnobotanical knowledge systems associated with it. The conversion of forests into monoculture plantations in Sumatra, Kalimantan, and Papua has resulted in habitat degradation, the loss of high-value plant species, and a reduction in biological resources traditionally utilized by local communities [8]. Moreover, changes in land ownership status—particularly through the granting of *Hak Guna Usaha* (HGU, or cultivation rights) to plantation companies—have restricted the access of Indigenous peoples and rural communities to forests that once formed part of their living space. This restriction has directly disrupted the intergenerational transmission of traditional knowledge, as younger generations lose opportunities to learn firsthand from elders about the identification, use, and management of forest plants [9].

To address these challenges, Indonesia has implemented regulatory frameworks aimed at embedding environmental and social safeguards into palm oil governance. Central

among these is the Indonesian Sustainable Palm Oil (ISPO) certification scheme, mandated by Ministerial Regulation No. 11/2015 and reinforced by Presidential Regulation No. 44/2020, which requires all oil palm producers to comply with sustainability standards by 2025 [10]. ISPO compels companies to demonstrate environmental responsibility, socio-cultural sensitivity, and economic feasibility. A critical requirement of the certification process is the identification and management of High Conservation Value (HCV) areas, which encompass habitats for rare, threatened, and endemic species (HCV-1) and areas critical to the livelihoods of local and indigenous communities (HCV-5) [11]. These measures are designed to ensure that palm oil production is consistent with long-term sustainability objectives while maintaining its economic contributions.

HCV assessments enable the designation of set-aside areas to conserve biodiversity and ecosystem services. Recent studies have highlighted the capacity of HCV frameworks to reconcile conservation with production, allowing plantation managers to integrate ecological objectives into operational practices. By safeguarding essential ecological functions while enabling agricultural development, the HCV framework represents a promising approach to mitigating biodiversity loss and ecosystem degradation in monoculture landscapes [3,12]. However, challenges remain, including limited institutional capacity, uneven enforcement, and a lag between plantation expansion and HCV identification [13]. These limitations necessitate empirical studies to evaluate the effectiveness of HCV application in diverse ecological and social contexts.

More specific research has underscored the role of remnant forest patches within agricultural mosaics as refuges for biodiversity and as resources for local communities. Forest remnants act as reservoirs of genetic diversity and dispersal hubs, supporting connectivity across fragmented ecosystems. Sustaining microhabitat conditions is essential for the persistence of native flora, thereby mitigating the ecological impacts of intensive land use [14]. From a socio-economic perspective, these remnants provide local communities with medicinal plants, food, and construction materials, directly linking conservation with human well-being [15]. Such dual ecological and social functions reinforce the relevance of forest remnants to both HCV-1 and HCV-5 criteria, underscoring their centrality to certification schemes.

Previous scholarship suggests that integrating ethnobotanical knowledge into HCV assessments enhances their effectiveness by ensuring that conservation priorities align with community needs and expectations [10]. In Southeast Asia, plantation managers who incorporate local ecological criteria into conservation strategies have reported stronger community participation and improved biodiversity outcomes [12]. Nevertheless, empirical evidence remains limited regarding the composition, conservation status, and livelihood value of plant species in

oil palm plantation landscapes, particularly in frontier regions where palm oil expansion is relatively new. Without such evidence, efforts to implement certification standards may lack the scientific and social legitimacy required to achieve meaningful conservation outcomes.

Gorontalo Province in Sulawesi exemplifies a rapidly expanding frontier of palm oil development. By 2021, oil palm plantations in the province covered approximately 158,000 hectares, representing a 16.91% expansion over the previous year, with about 15,000 hectares planted and 13,000 hectares in production [16]. The establishment of PT. Loka Indah Lestari's 20,000-ha concession, including both core and plasma plantations, reflects the increasing scale of development in the region. Such rapid expansion raises urgent questions about the conservation of biodiversity within plantation landscapes and the capacity of certification frameworks to safeguard High Conservation Value areas.

This study aims to address these concerns by systematically identifying plant species with High Conservation Value in oil palm plantations operated by PT. Loka Indah Lestari in Gorontalo Province, Indonesia. Specifically, the research documents species richness, conservation status, and ethnobotanical importance, with the dual goals of informing company-level management practices and contributing to policy discussions on sustainable plantation governance. The novelty of this research lies in its integration of ecological and ethnobotanical dimensions within the HCV framework, offering a comprehensive evaluation of biodiversity and community needs in an emerging plantation frontier. By bridging ecological assessment with community-oriented values, the study seeks to generate actionable insights that support ISPO certification, strengthen biodiversity conservation, and enhance the sustainability of oil palm development in Gorontalo and beyond.

## 2. Materials and Methods

### 2.1. Place and Time of Research

This study was conducted between June and September 2024 at the oil palm plantation of PT. Loka Indah Lestari, located in Pohuwato Regency, Gorontalo Province, Indonesia. Geographically, PT. Loka Indah Lestari Palm Oil Plantation is located at 121°10'00" - 121°25'00" East Longitude and 00°37'30" - 00°47'30" with elevations ranging from 450 to 750 meters above sea level. The company covers an area of 20,000 ha, with a planted area of 6,219 ha, including 4,241 ha of core oil palm plantations and 1,978 ha of plasma oil palm plantations [17]. The research focused on sampling areas within plasma oil palm plantations. Sampling sites were deliberately selected to represent two distinct land-use types: (1) secondary forest areas that have not yet been converted and (2) areas

converted into oil palm farms. Site I was located in Bukit Harapan Village, Wanggarasi District, while Site II was located in Mekarti Jaya Village, Taluditi District (Figure 1). The purposive sampling design aimed to provide insights into plant composition and conservation values across different land uses. The methodological framework adopted in this research combines field-based plant inventories with digital biodiversity resources and conservation assessment tools. This integration ensures accuracy in plant identification, ecological assessment, and conservation status evaluation while aligning with standard protocols in tropical biodiversity studies.

### 2.2. Data Collection Procedures

The study employed belt transect methods, a standard approach in tropical forest and plantation research, to capture plant diversity systematically [18]. Researchers traversed this transect to record all plant species encountered. This method enabled efficient coverage of the heterogeneous plantation landscape and facilitated the detection of species distribution patterns and edge effects [19]. Each plant specimen observed was documented in situ through digital photography, and additional contextual data were recorded, including the collector's name, collection number, date, precise location, and habitus type. Unidentified or ambiguous species were preserved as herbarium specimens, following standard botanical practices to facilitate subsequent expert identification.

Identification of higher plants was performed using morphological observation, focusing on diagnostic features across families, genera, and species levels. Comparative references included regional and national floras, specifically *Flora Sulawesi* [20], *Plant Identification Terminology* [21], and *Flora for Indonesia* [22]. For pteridophytes, identification followed the keys of Hovenkamp & Joncheere [23]. When morphological characters were insufficient for conclusive identification, specimens were prepared for herbarium deposition to allow further taxonomic verification. This combination of field and herbarium methods is standard in tropical botany, ensuring reliable species-level identifications.

### 2.3. Taxonomic Validation

All plant names were validated using the Plants of the World Online (POWO) [24], which provides accepted nomenclature and distributional ranges based on standardized taxonomic backbones. Habitat and occurrence records were cross-referenced with the Global Biodiversity Information Facility (GBIF) [25]. GBIF data were filtered for geographic precision and taxonomic accuracy, minimizing risks of misidentification or erroneous spatial records. By combining in situ data with global biodiversity platforms, the study ensured methodological rigor, interoperability, and long-term value for conservation datasets.

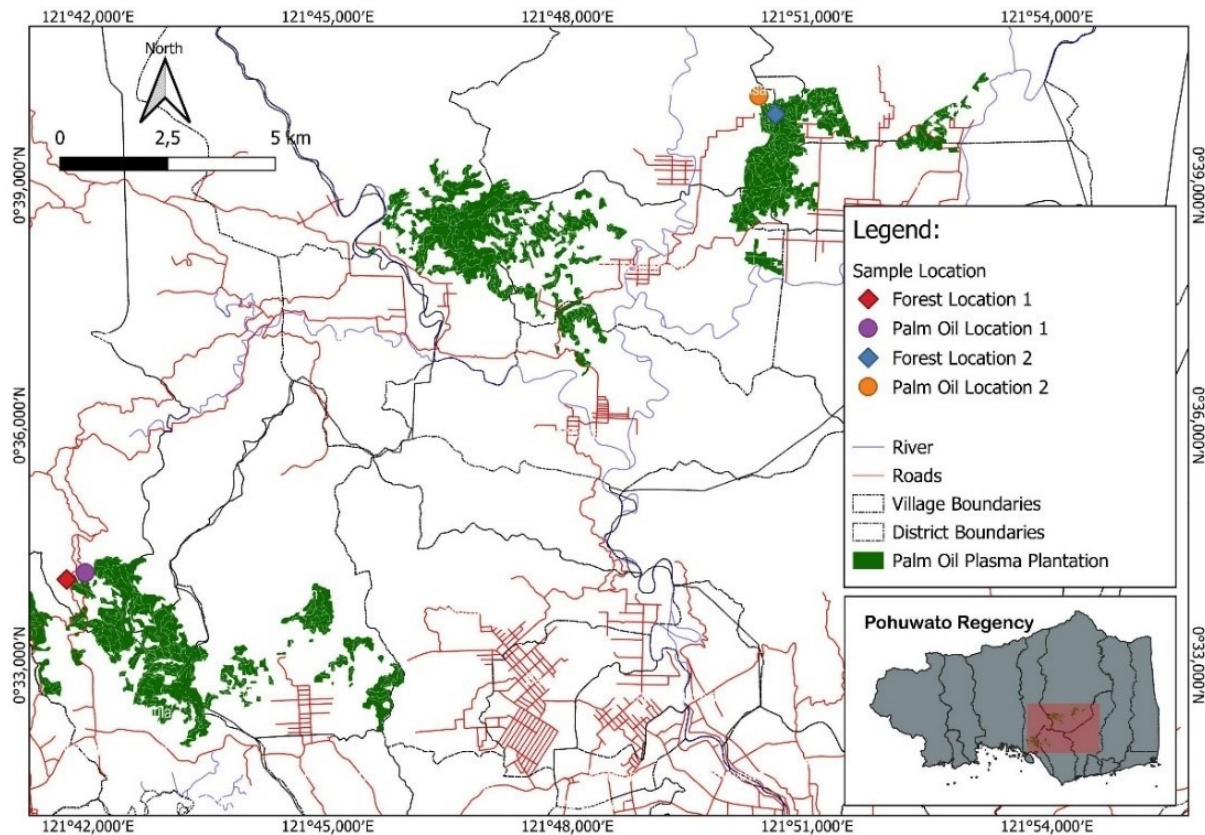


Figure 1. Location of PT. Loka Indah Lestari Oil Palm Plantation License

#### 2.4. Conservation Assessment

Conservation status for each species was determined through cross-referencing with the IUCN Red List [26]. This step allowed for a systematic evaluation of the presence of threatened, endangered, or endemic taxa within the plantation landscape. Such use of standardized conservation frameworks aligns with global biodiversity monitoring practices and supports comparability across studies.

#### 2.5. Analysis of High Conservation Value (HCV) Areas

Following identification and validation, species lists were analyzed qualitatively to determine the presence of High Conservation Value (HCV) elements, focusing on biodiversity significance (HCV 1) and community utility (HCV 5). HCV 1 identifies areas with species of global, regional, or local conservation concern, such as rare, endemic, or threatened taxa. HCV 5 emphasizes plant species vital to local and indigenous communities, serving as food, medicine, or cultural resources.

#### 2.6. Data Analysis

This study employed a qualitative descriptive approach to identify and describe the plant species found in the research area without applying diversity indices such as Simpson, Shannon-Wiener, or evenness indices. This approach was chosen considering that the main objective of the research is to document the species composition and characteristics of plants found in secondary forests and oil palm plantation areas for conservation purposes and local community benefits. In addition, time constraints, limited resources, and the hilly field conditions within the forest area were also methodological considerations for employing a descriptive approach. The descriptive approach remains scientifically valid for exploratory studies, particularly at the preliminary stage of biodiversity assessments, as its results can serve as a foundation for subsequent, more quantitative research using diversity indices or advanced statistical analyses [27]. The analysis also includes the categorization of taxa into HCV 1 and HCV 5, facilitating the assessment of the plantation landscape against sustainability certification criteria.

### 3. Results

#### 3.1. Species Composition and Richness

Field exploration across the plasma plantation areas of PT. Loka Indah Lestari revealed a total of 47 plant families, 85 genera, and 111 species (Table 1). A greater number of species were recorded in the forest area, where the

dominant growth form was trees, accompanied by the presence of lianas, epiphytes, ferns, shrubs, and herbs. In contrast, the plantation area exhibited fewer species, dominated by herbs, shrubs, and ferns. Figure 2 illustrates that the forest area contained a higher number of plant families, predominantly Araceae, Arecaceae, Fabaceae, and Piperaceae, whereas the oil palm plantation was mainly dominated by the Poaceae family.

**Table 1.** Composition of plant species in PT. Loka Indah Lestari oil palm plantation landscape, showing total numbers of families, and species across surveyed plots

No	Family	Species	Station				Strata of Plant	IUCN*
			Bukit Harapan Village		Mekarti Jaya Village			
			Oil Palm Farm	Forest	Oil Palm Farm	Forest		
1	Achariaceae	<i>Pangium edule</i> Reinw	-	-	-	√	Tree	LC
2	Anacardiaceae	<i>Buchanania arborescens</i> (Blume) Blume	-	√	-	-	Tree	LC
3	Araceae	<i>Alocasia alba</i> Schott	-	-	√	-	Herbs	-
4	Araceae	<i>Alocasia longiloba</i> Miq.	-	√	-	-	Herbs	-
5	Araceae	<i>Alocasia macrorrhizos</i> (L.) G.Don	-	-	-	√	Herbs	-
6	Araceae	<i>Alocasia odora</i> (G.Lodd.) Spach	-	-	-	√	Herbs	LC
7	Araceae	<i>Homalomena imitator</i> P.C.Boyce & S.Y.Wong	-	-	-	√	Herbs	-
8	Araceae	<i>Homalomena vittifolia</i> Kurniawan & P.C.Boyce	-	-	√	-	Herbs	-
9	Araceae	<i>Philodendron erubescens</i> K.Koch & Augustin	-	-	√	-	Epiphyte	-
10	Araceae	<i>Pothos scandens</i> L.	-	-	-	√	Vines	-
11	Arecaceae	<i>Arenga pinnata</i> (Wurmb) Merr	-	-	-	√	Tree	LC
12	Arecaceae	<i>Calamus inops</i> Becc. ex K.Heyne	-	√	-	√	Tree	-
13	Arecaceae	<i>Calamus oblongus</i> subsp. mollis (Blanco) A.J.Hend	-	-	-	√	Vines	-
14	Arecaceae	<i>Elaeis guineensis</i> Jacq.	√	-	√	-	Tree	LC
15	Arecaceae	<i>Saribus rotundifolius</i> (Lam.) Blume	-	√	-	-	Tree	-
16	Aspleniaceae	<i>Asplenium nidus</i> L.	√	-	√	-	Vern	-
17	Aspleniaceae	<i>Asplenium adiantum-nigrum</i> L.	√	-	-	-	Vern	-
18	Aspleniaceae	<i>Diplazium esculentum</i> (Retz.) Sw.	-	√	-	-	Vern	LC
19	Aspleniaceae	<i>Thelypteris dentata</i> (Forssk.) E.P.St.John	-	-	√	-	Herbs	LC
20	Asteraceae	<i>Ageratum conyzoides</i> L.	√	-	√	-	Herbs	LC
21	Asteraceae	<i>Ayapana triplinervis</i> (Vahl) R.M.King & H.Rob.	√	-	-	-	Bush	-
22	Asteraceae	<i>Mikania micrantha</i> Kunth.	√	√	-	-	Vines	-
23	Begoniaceae	<i>Begonia ignita</i> C.W.Lin & C.I Peng	-	-	-	√	Herbs	-
24	Burseraceae	<i>Dacryodes rostrata</i> (Blume) H.J.Lam	-	√	-	-	Tree	LC
25	Cannabaceae	<i>Celtis tetrandra</i> Roxb.	-	√	-	-	Tree	LC
26	Convolvulaceae	<i>Ipomoea indica</i> (Burm.) Merr.	-	-	-	√	Bush	-
27	Costaceae	<i>Hellenia speciosa</i> (J.Koenig) S.R.Dutta	-	-	√	-	Herbs	LC
28	Cyperaceae	<i>Cyperus rotundus</i> L.	√	-	√	-	Bush	LC
29	Dilleniaceae	<i>Dillenia serrata</i> Thunb.	-	√	-	-	Tree	LC
30	Ebenaceae	<i>Diospyros celebica</i> Bakh.	-	√	-	-	Tree	VU

Table 1 continued

31	Euphorbiaceae	<i>Endospermum diadenum</i> (Miq.) Airy Shaw	-	√	-	-	Tree	LC
32	Euphorbiaceae	<i>Euphorbia hirta</i> L.	-	-	√	-	Herbs	-
33	Euphorbiaceae	<i>Euphorbia rothiana</i> Spreng.	-	-	√	-	Herbs	-
34	Euphorbiaceae	<i>Macaranga gigantea</i> (Rehb.f. & Zoll.) Müll.Arg.	-	√	-	√	Tree	LC
35	Euphorbiaceae	<i>Macaranga magna</i> Turrill	√	-	-	-	Tree	-
36	Euphorbiaceae	<i>Macaranga tanarius</i> (L.) Müll.Arg.	√	-	-	√	Tree	LC
37	Euphorbiaceae	<i>Mallotus mollissimus</i> (Geiseler) Airy Shaw	√	-	-	-	Tree	LC
38	Fabaceae	<i>Bauhinia tomentosa</i> L.	-	-	-	√	Tree	LC
39	Fabaceae	<i>Mimosa pudica</i> L.	√	√	-	-	Bush	LC
40	Fabaceae	<i>Mucuna bracteata</i> DC. ex Kurz	√	-	√	√	Vines	LC
41	Fabaceae	<i>Pueraria montana</i> (Lour.) Merr.	√	-	-	-	Vines	-
42	Fabaceae	<i>Senna tora</i> (L.) Roxb.	√	-	-	-	Tree	-
43	Fabaceae	<i>Spatholobus littoralis</i> Hassk.	-	-	-	√	Liana	-
44	Fabaceae	<i>Spatholobus parviflorus</i> (Roxb. ex G.Don) Kuntze	-	√	-	-	Liana	LC
45	Flagellariaceae	<i>Flagellaria indica</i> L.	-	√	-	√	Vines	-
46	Hypnaceae	<i>Hypnum cupressiforme</i> Hedw.	-	-	√	-	Moss	-
47	Hypoxidaceae	<i>Curculigo orchioides</i> Gaertn.	-	-	-	√	Herbs	-
48	Lamiaceae	<i>Premna odorata</i> Blanco	-	√	-	-	Tree	LC
49	Lauraceae	<i>Cassytha filiformis</i> L.	-	-	√	-	Vines	-
50	Lauraceae	<i>Cinnamomum</i> sp.	-	-	-	√	Bush	-
51	Lauraceae	<i>Litsea tomentosa</i> Blume.	-	-	-	√	Tree	LC
52	Lecythidaceae	<i>Planchonia valida</i> (Blume) Blume	-	√	-	-	Tree	LC
53	Malpighiaceae	<i>Hiptage benghalensis</i> (L.) Kurz	-	√	-	-	Tree	LC
54	Malvaceae	<i>Ceiba pentandra</i> (L.) Gaertn.	-	√	-	-	Tree	LC
55	Malvaceae	<i>Ochroma pyramidale</i> (Cav. ex Lam.) Urb.	-	√	-	-	Tree	-
56	Malvaceae	<i>Pterospermum diversifolium</i> Blume.	-	-	-	√	Tree	LC
57	Malvaceae	<i>Pterospermum javanicum</i> Jungh	-	√	-	-	Tree	LC
58	Malvaceae	<i>Sida acuta</i> Burm.f.	√	-	-	-	Bush	-
59	Marantaceae	<i>Donax canniformis</i> (G.Forst.) K.Schum	-	√	-	√	Herbs	-
60	Marantaceae	<i>Maranta arundinacea</i> L.	-	√	-	-	Herbs	-
61	Meliaceae	<i>Dysoxylum quadrangulatum</i> Culmsee	-	√	-	√	Tree	LC
62	Moraceae	<i>Ficus hispida</i> L.f.	√	-	-	-	Tree	LC
63	Moraceae	<i>Ficus maclellandii</i> King	-	-	-	√	Tree	-
64	Moraceae	<i>Ficus magnoliifolia</i> Blume	-	√	-	-	Tree	-
65	Moraceae	<i>Ficus pumila</i> var. <i>pumila</i>	-	-	-	√	Vines	-
66	Moraceae	<i>Ficus variegata</i> Blume.	√	-	-	-	Tree	LC
67	Musaceae	<i>Musa acuminata</i> Colla	-	-	-	√	Herbs	LC
68	Myristicaceae	<i>Myristica kjellbergii</i> W.J.de Wilde	-	√	-	-	Tree	LC
69	Myrtaceae	<i>Syzygium balgooyi</i> Brambach, Byng & Culmsee	-	-	-	√	Tree	NT
70	Myrtaceae	<i>Syzygium ecostulatum</i> (Elmer) Merr.	-	√	-	-	Tree	-
71	Orchidaceae	<i>Nervilia concolor</i> (Blume) Schltr.	-	-	-	√	Orchid	-

Table 1 continued

72	Phyllanthaceae	<i>Phyllanthus niruri</i> L.	-	-	√	-	Tree	-
73	Phyllanthaceae	<i>Phyllanthus urinaria</i> L.	√	-	-	-	Tree	-
74	Piperaceae	<i>Piper aduncum</i> L.	-	√	√	√	Tree	LC
75	Piperaceae	<i>Piper baccatum</i> Blume.	-	-	-	√	Liana	-
76	Piperaceae	<i>Piper kadsura</i> (Choisy) Ohwi	-	√	-	-	Vines	LC
77	Piperaceae	<i>Piper retrofractum</i> Vahl.	-	√	-	-	Vines	-
78	Poaceae	<i>Chloris barbata</i> Sw.	-	-	-	√	Herbs	-
79	Poaceae	<i>Dinochloa scandens</i> (Blume ex Nees) Kuntze	-	√	-	-	Vines	-
80	Poaceae	<i>Eleusine indica</i> (L.) Gaertn.	√	-	-	√	Herbs	LC
81	Poaceae	<i>Eragrostis viscosa</i> (Retz.) Trin.	-	-	√	-	Herbs	-
82	Poaceae	<i>Oplismenus burmanni</i> (Retz.) P.Beauv.	√	-	-	-	Herbs	-
83	Poaceae	<i>Oplismenus compositus</i> (L.) P.Beauv.	-	√	√	-	Herbs	LC
84	Poaceae	<i>Oplismenus undulatifolius</i> (Ard.) P.Beauv.	√	-	-	-	Herbs	-
85	Poaceae	<i>Panicum repens</i> L.	-	-	√	-	Herbs	LC
86	Poaceae	<i>Setaria barbata</i> (Lam.) Kunth	-	-	√	-	Herbs	-
87	Polygonaceae	<i>Persicaria chinensis</i> (L.) H.Gross	-	-	√	-	Herbs	-
88	Polypodiaceae	<i>Davallia solida</i> var. <i>fejeensis</i> (Hook.) Noot.	√	-	-	-	Vern	-
89	Polypodiaceae	<i>Dryopteris cycadina</i> (Franch. & Sav.) C.Chr.	-	√	-	-	Vern	-
90	Polypodiaceae	<i>Nerprolepis biserrata</i> (Sw.) Schott	√	-	-	-	Vern	-
91	Polypodiaceae	<i>Nerprolepis cordifolia</i> (L.) C.Presl	√	√	-	-	Vern	-
92	Polypodiaceae	<i>Phlebodium aureum</i> (L.) J.Sm.	-	-	√	-	Vern	-
93	Polypodiaceae	<i>Pyrrosia piloselloides</i> (L.) M.G.Price	-	-	-	√	Herbs	-
94	Primulaceae	<i>Ardisia javanica</i> A.DC.	-	√	-	-	Tree	-
95	Pteridaceae	<i>Adiantum capillus-veneris</i> L.	√	-	-	-	Vern	LC
96	Pteridaceae	<i>Pteris vittata</i> L.	√	-	√	-	Vern	LC
97	Pteridaceae	<i>Vittaria lineata</i> (L.) Sm.	-	-	√	-	Vern	-
98	Rubiaceae	<i>Mycetia acuminata</i> (Wight) Kuntze	-	-	√	-	Bush	-
99	Rubiaceae	<i>Spermacoce alata</i> Aubl.	√	-	-	-	Herbs	-
100	Sapindaceae	<i>Harpullia arborea</i> (Blanco) Radlk.	-	√	-	√	Tree	LC
101	Sapindaceae	<i>Pometia pinnata</i> J.R.Forst. & G.Forst.	-	-	-	√	Tree	LC
102	Sarcoscyphaceae	<i>Sarcoscypha coccinea</i> (Jacq.) Lambotte	-	-	-	√	Saprophyt	-
103	Schizaeaceae	<i>Lygodium circinnatum</i> (Burm.f.) Sw.	√	√	√	-	Vern	-
104	Schizaeaceae	<i>Lygodium japonicum</i> (Thunb.) Sw.	√	-	-	√	Vern	-
105	Smilacaceae	<i>Smilax glauca</i> Walter.	-	√	-	-	Vines	-
106	Smilacaceae	<i>Smilax zeylanica</i> L.	-	-	-	√	Vines	-
107	Tetramelaceae	<i>Octomeles sumatrana</i> Miq.	-	√	-	√	Tree	LC
108	Urticaceae	<i>Laportea aestuans</i> (L.) Chew	-	-	√	-	Herbs	-
109	Verbenaceae	<i>Lantana camara</i> L.	-	√	-	-	Bush	-
110	Verbenaceae	<i>Stachytarpheta jamaicensis</i> (L.) Vahl	√	-	-	√	Bush	LC
111	Vitaceae	<i>Leea indica</i> (Burm.f.) Merr.	-	-	-	√	Tree	LC
TOTAL			29	39	27	40		

Note: (√) found; (-) not found; \*IUCN [26]

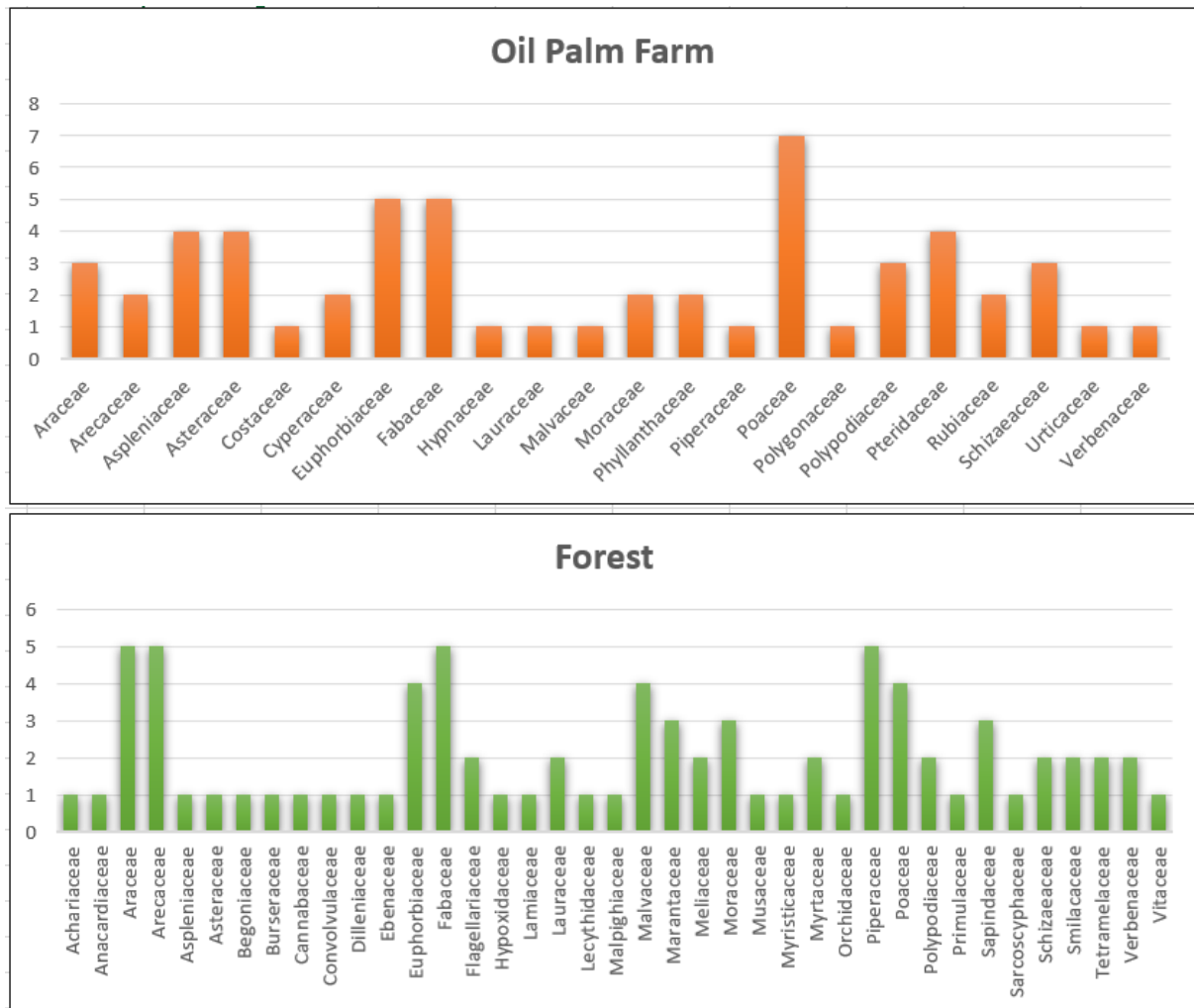


Figure 2. Composition of plant family in oil palm farms (above) and secondary forest landscape (below)

### 3.2. Endemic and Threatened Species

Analysis using POWO [24] identified eight species endemic to Sulawesi within the surveyed plots (Table 2). However, occurrence records from the GBIF [25] indicated that some of these species, such as *Begonia ignita*, *Calamus inops*, and *Diospyros celebica*, extend beyond Sulawesi, illustrating discrepancies between regional and global distribution datasets. Among the endemic species, there is *Diospyros celebica*, which is listed as a vulnerable species and *Syzygium balgooyi* as a near threatened species in the IUCN Red List [26]. Figure 3 illustrates the endemic species found in the forest and in the oil palm farm.

### 3.3. Medicinal Plants and Ethnobotanical Value

A significant portion of the recorded flora comprises species with ethnomedicinal properties (Table 3). These plants are widely used for treating ailments such as

respiratory infections, digestive disorders, skin diseases, and chronic illnesses like diabetes, and heart disease.

### 3.4. Other Utilization Values

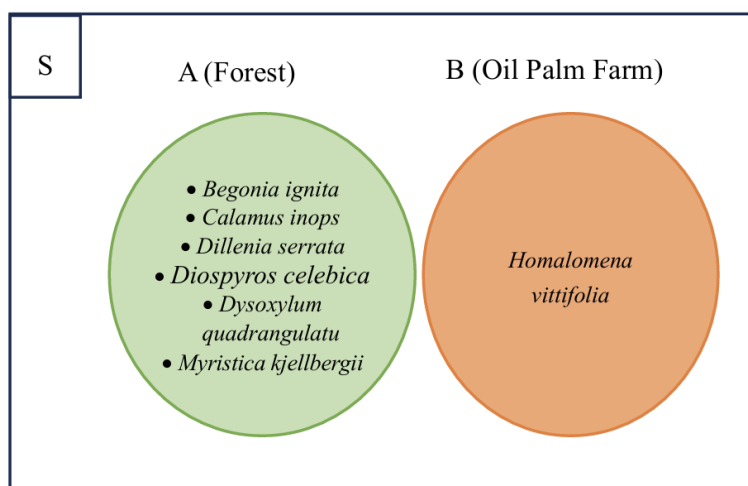
Beyond medicinal uses, several species serve other livelihood functions, such as ruminant animal food, building materials and furniture, and food and cosmetics (Table 4). A total of 25 species were recorded as being used as feed for ruminant livestock, 31 species for building materials and furniture, and 29 species for food and cosmetic purposes. From an ethnobotanical perspective, the number of species utilized as medicinal plants was higher than those used for other purposes (Figure 4).

Overall, this study has several methodological limitations, including limited resources and logistics, a relatively short sampling period, the absence of seasonal variation coverage, challenging terrain conditions and restricted site accessibility.

**Table 2.** Endemic plant species identified in PT. Loka Indah Lestari plantation landscape, based on POWO and GBIF

No.	Species	POWO#	GBIF##	Location	Habitus
1	<i>Begonia ignita</i> C.W.Lin & C.I Peng	Indonesia (Sulawesi)	Malaysia	Forest	Herbs
2	<i>Calamus inops</i> Becc. ex K.Heyne	Indonesia (Sulawesi)	Indonesia (Sulawesi, Maluku Utara)	Forest	Tree
3	<i>Dillenia serrata</i> Thunb	Indonesia (Sulawesi)	Indonesia (Sulawesi)	Forest	Tree
4	<i>Diospyros celebica</i> Bakh*	Indonesia (Sulawesi)	Indonesia, Malaysia, Brunei	Forest	Tree
5	<i>Dysoxylum quadrangulatum</i> Culmsee	Indonesia (Sulawesi)	Indonesia (Sulawesi)	Forest	Tree
6	<i>Homalomena vittifolia</i> Kurniawan & P.C.Boyce	Indonesia (Sulawesi)	Indonesia (Sulawesi)	Farm	Herbs
7	<i>Myristica kjellbergii</i> W.J.de Wilde	Indonesia (Sulawesi)	Indonesia (Sulawesi)	Forest	Tree
8	<i>Syzygium balgooyi</i> Brambach, Byng & Culmsee**	Indonesia (Sulawesi)	Indonesia (Sulawesi)	Forest	Tree

Note: #POWO [24]; ##GBIF [25]; \*vulnerable species [26]; \*\*near threatened species [26]



**Figure 3.** Endemic plant species in the forest and the oil palm farm

**Table 3.** Medical plant species including local uses in PT. Loka Indah Lestari plantation landscape

No.	Species	Types of Diseases
1	<i>Ageratum conyzoides</i> L.	Fever, cough, wound, headache
2	<i>Alocasia macrorrhizos</i> (L.) G.Don	Skin disease
3	<i>Ardisia Javanica</i> A.DC.	Fever, cough, indigestion
4	<i>Asplenium adiantum-nigrum</i> L.	Indigestion, fever, skin diseases
5	<i>Ayapana triplinervis</i> (Vahl) R.M.King & H.Rob.	Skin diseases, fever, inflammation, increased appetite
6	<i>Bauhinia tomentosa</i> L.	Diarrhea, reduce fever, tonic
7	<i>Cassytha filiformis</i> L.	Stiff waist, swelling from a blow, ulcers, scabs, chronic cough
8	<i>Celtis tetrandra</i> Roxb.	Fever, cough, skin diseases
9	<i>Chloris barbata</i> Sw.	Fever, diarrhea, diabetes
10	<i>Cinnamomum</i> sp.	Arthritis, blood sugar, diabetes, anti-microbial
11	<i>Curculigo orchioides</i> Gaertn.	Bone health, sexual health, heart disease, blood sugar, cholesterol, arthritis, diarrhea, hemorrhoids, asthma, colic, gonorrhea
12	<i>Cyperus rotundus</i> L.	Diarrhea, fever, indigestion
13	<i>Dacryodes rostrata</i> (Blume) H.J.Lam	Burns, rheumatism, skin diseases
14	<i>Dillenia serrata</i> Thunb.	Indigestion, inflammation
15	<i>Diospyros celebica</i> Bakh.	Fever, cough
16	<i>Diplazium esculentum</i> (Retz.) Sw.	Anemia, blood sugar

Table 3 continued

17	<i>Dryopteris cycadina</i> (Franch. & Sav.) C.Chr.	indigestion, inflammation
18	<i>Eleusine indica</i> (L.) Gaertn.	Worms, cough, lung infections, dysentery, heart attack, high blood pressure, spleen and liver problems, kidney stones, bone dislocations, back pain
19	<i>Euphorbia hirta</i> L.	respiratory disorders, skin diseases, indigestion
20	<i>Ficus hispida</i> L.f.	Diarrhea, fever, cough, inflammation
21	<i>Ficus maclellandii</i> King	Diarrhea, fever, cough, inflammation
22	<i>Ficus magnoliifolia</i> Blume	Inflammation, infection
23	<i>Flagellaria indica</i> L.	Indigestion
24	<i>Harpullia arborea</i> (Blanco) Radlk.	Fever, burns, indigestion
25	<i>Hellenia speciosa</i> (J.Koenig) S.R.Dutta	Abdominal pain
26	<i>Hiptage benghalensis</i> (L.) Kurz	Fever, indigestion, joint pain, external wound
27	<i>Ipomoea indica</i> (Burm.) Merr.	Fever, burns, skin diseases
28	<i>Lantana camara</i> L.	Fever, poisoning, pain, external wound, cough, eczema, indigestion, chickenpox, measles, asthma, gastric ulcer, high blood pressure,
29	<i>Laportea aestuans</i> (L.) Chew	Indigestion, urinary retention, bleeding, filariasis, rheumatism
30	<i>Leea indica</i> (Burm.f.) Merr.	Inflammation, muscle and joint pain, minor injuries
31	<i>Litsea tomentosa</i> Blume.	Skin diseases, diarrhea, indigestion
32	<i>Macaranga tanarius</i> (L.) Mill.Arg.	Diarrhea, fever, wound
33	<i>Mallotus mollissimus</i> (Geiseler) Airy Shaw	Skin diseases, diarrhea, fever
34	<i>Mikania micrantha</i> Kunth.	Fever, cough, abdominal pain
35	<i>Mimosa pudica</i> L.	Insomnia, fever, diarrhea, wound
36	<i>Mucuna bracteata</i> DC. ex Kurz	Fever, pain
37	<i>Musa acuminata</i> Colla	Heart disease, stroke, cancer
38	<i>Mycetia acuminata</i> (Wight) Kuntze	indigestion, skin diseases
39	<i>Oplismenus burmanni</i> (Retz.) P.Beauv.	Fever, cough, skin diseases
40	<i>Octomeles sumatrana</i> Miq.	Abdominal pain
41	<i>Pangium edule</i> Reinw.	Diarrhea, fever, wound
42	<i>Persicaria chinensis</i> (L.) H.Gross	Indigestion, inflammation, infections
43	<i>Phyllanthus niruri</i> L.	Dyspepsia, diarrhea, kidney stones, urinary tract infections
44	<i>Phyllanthus urinaria</i> L.	Kidney disease, urinary tract infections, inflammation, diabetes
45	<i>Planchonia valida</i> (Blume) Blume	Cough
46	<i>Piper aduncum</i> L.	Skin diseases, inflammation
47	<i>Piper baccatum</i> Blume.	Indigestion, inflammation, cough
48	<i>Piper kadsura</i> (Choisy) Ohwi	Pain, inflammation, indigestion
49	<i>Piper retrofractum</i> Vahl.	Indigestion, infections, inflammation
50	<i>Pometia pinnata</i> J.R.Forst. & G.Forst.	Heart disease, cancer
51	<i>Pothos scandens</i> L.	Skin blistering, seizures, chickenpox, asthma
52	<i>Premna odorata</i> Blanco	Fever, indigestion, inflammation
53	<i>Pterospermum diversifolium</i> Blume.	Toothache, fever, diarrhea, wound
54	<i>Pueraria montana</i> (Lour.) Merr.	Fever, cough, indigestion
55	<i>Pyrosia piloselloides</i> (L.) M.G.Price	Fever, cough, skin disease, wound, pain

Table 3 continued

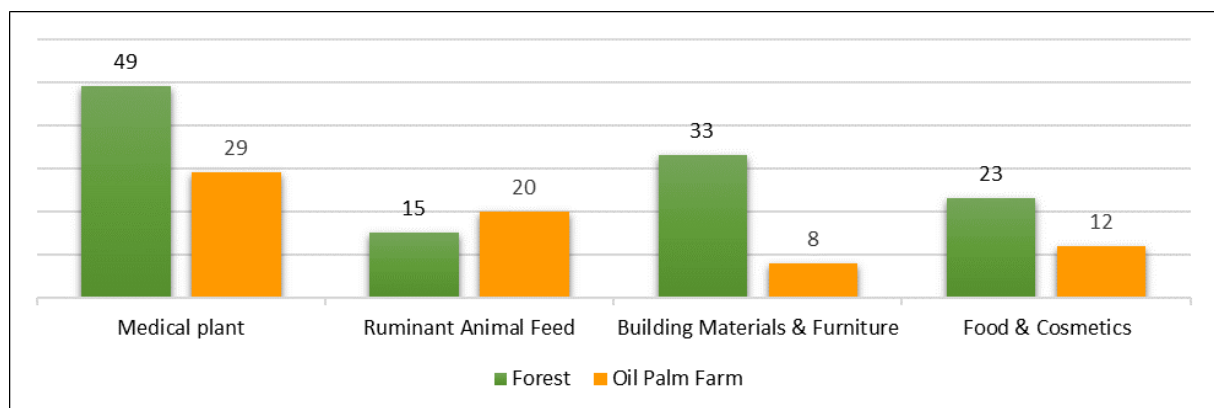
56	<i>Senna tora</i> (L.) Roxb.	Constipation, inflammation, acne
57	<i>Smilax glauca</i> Walter.	Skin diseases, joint pain, fever, indigestion
58	<i>Smilax zeylanica</i> L.	Indigestion, inflammation
59	<i>Spatholobus littoralis</i> Hassk.	Diarrhea, dysentery, sciatica, wounds, heart disease
60	<i>Spatholobus parviflorus</i> (Roxb. ex G.Don) Kuntze	Indigestion
61	<i>Spermacoce alata</i> Aubl.	Wound, inflammation, fever
62	<i>Stachytarpheta jamaicensis</i> (L.) Vahl	Urinary tract infections, respiratory disorders, skin diseases, fever, pain
63	<i>Syzygium ecostatum</i> (Elmer) Merr.	Fever, diarrhea, indigestion
64	<i>Thelypteris dentata</i> (Forssk.) E.P.St.John	Cough, diarrhea

**Table 4.** Plant species utilized for livestock feed, building and furniture materials, as well as food and cosmetic purposes

No	Species	Utilization		
		Ruminant Animal Feed	Building Materials & Furniture	Food & Cosmetics
1	<i>Ageratum conyzoides</i> L.	√	-	-
2	<i>Alocasia macrorrhizos</i> (L.) G.Don	-	-	√
3	<i>Arenga pinnata</i> (Wurmb) Merr.	-	-	√
4	<i>Bauhinia tomentosa</i> L.	√	√	-
5	<i>Buchanania arborescens</i> (Blume) Blume	-	√	√
6	<i>Calamus inops</i> Becc. ex K.Heyne	-	√	-
7	<i>Calamus oblongus</i> subsp. <i>mollis</i> (Blanco) A.J.Hend	-	√	-
8	<i>Ceiba pentandra</i> (L.) Gaertn.	-	√	√
9	<i>Celtis tetrandra</i> Roxb.	-	√	√
10	<i>Chloris barbata</i> Sw.	√	-	-
11	<i>Cinnamomum</i> sp.	-	-	√
12	<i>Cyperus rotundus</i> L.	√	-	√
13	<i>Dacryodes rostrata</i> (Blume) H.J.Lam	-	√	√
14	<i>Dillenia serrata</i> Thunb.	-	√	-
15	<i>Dinochloa scandens</i> (Blume ex Nees) Kuntze	√	√	-
16	<i>Diplazium esculentum</i> (Retz.) Sw.	-	-	√
17	<i>Donax caniniformis</i> (G.Forst.) K.Schum.	-	√	√
18	<i>Dysoxylum quadrangulatum</i> Culmsee	-	√	-
19	<i>Endospermum diadenum</i> (Miq.) Airy Shaw	-	√	-
20	<i>Elaeis guineensis</i> Jacq.	-	√	√
21	<i>Eragrostis viscosa</i> (Retz.) Trin.	√	-	-
22	<i>Euphorbia hirta</i> L.	√	-	-
23	<i>Ficus hispida</i> L.f.	-	√	-
24	<i>Ficus maclellandii</i> King	-	-	√
25	<i>Ficus variegata</i> Blume.	-	√	√
26	<i>Flagellaria indica</i> L.	√	√	-
27	<i>Harpullia arborea</i> (Blanco) Radlk.	-	√	√
28	<i>Lantana camara</i> L.	√	-	-
29	<i>Laportea aestuans</i> (L.) Chew	-	√	-
30	<i>Leea indica</i> (Burm.f.) Merr.	-	-	√

Table 4 continued

31	<i>Lygodium circinnatum</i> (Burm.f.) Sw.	√	√	-
32	<i>Macaranga gigantea</i> (Rchb.f. & Zoll.) Müll.Arg.	√	√	-
33	<i>Macaranga tanarius</i> (L.) Müll.Arg	√	√	-
34	<i>Mikania micrantha</i> Kunth.	√	-	√
35	<i>Mimosa pudica</i> L	√	-	-
36	<i>Mucuna bracteata</i> DC. ex Kurz	√	-	√
37	<i>Musa acuminata</i> Colla	-	-	√
38	<i>Myristica kjellbergii</i> W.J.de Wilde	-	√	√
39	<i>Ochroma pyramidale</i> (Cav. ex Lam.) Urb.	-	√	√
40	<i>Octomeles sumatrana</i> Miq.	-	√	-
41	<i>Oplismenus undulatifolius</i> (Ard.) P.Beauv.	√	-	-
42	<i>Pangium edule</i> Reinw.	-	-	√
43	<i>Panicum repens</i> L.	√	-	-
44	<i>Persicaria chinensis</i> (L.) H.Gross	√	-	-
45	<i>Piper baccatum</i> Blume.	-	-	√
46	<i>Planchonia valida</i> (Blume) Blume	-	√	-
47	<i>Pteris vittata</i> L.	-	-	√
48	<i>Pterospermum diversifolium</i> Blume.	-	√	√
49	<i>Pterospermum javanicum</i> Jungh.	-	√	√
50	<i>Pueraria montana</i> (Lour.) Merr.	√	-	√
51	<i>Saribus rotundifolius</i> (Lam.) Blume	-	√	√
52	<i>Setaria barbata</i> (Lam.) Kunth	√	-	-
53	<i>Sida acuta</i> Burm.f.	√	-	-
54	<i>Smilax glauca</i> Walter.	√	√	-
55	<i>Smilax zeylanica</i> L.	√	-	√
56	<i>Spatholobus parviflorus</i> (Roxb. ex G.Don) Kuntze	√	-	-
57	<i>Spermacoce alata</i> Aubl.	√	-	-
58	<i>Syzygium balgooyi</i> Brambach, Byng & Culmsee	-	√	-
59	<i>Syzygium ecostulatum</i> (Elmer) Merr.	-	√	√
TOTAL		25	31	29



**Figure 4.** Number of plant species utilized for different ethnobotanical purposes, including medicinal use, ruminant livestock feed, building and furniture materials, as well as food and cosmetic ingredients

## 4. Discussion

The results of this study at PT. Loka Indah Lestari (PT LIL) illustrate the profound ecological transformations that occur when secondary forests are converted into oil palm monocultures. The most striking finding was the decline in overall species richness, with 79 species recorded in forest sites compared to only 56 in oil palm plantations (Table 1). This difference underscores the homogenizing effects of monoculture systems, which eliminate the structural and compositional complexity that underpins biodiversity in natural forests. Such results align with broader evidence that natural forests maintain higher species richness and more complex vegetation structures than oil palm systems [28]. The dominance of herbaceous and shrub species in plantations, as opposed to the tree-dominated structure of secondary forests, reflects this simplification. This shift is ecologically significant, as it alters microhabitats, diminishes niche availability, and reduces ecosystem functions such as nutrient cycling and carbon storage [29].

The structural changes observed between forest and plantation sites also highlight the ecological consequences of losing lianas, epiphytes, and large-canopy trees. These groups are particularly sensitive to habitat simplification, and their absence in plantations reduces vertical complexity and canopy interactions [30]. In intact forests, epiphytes and lianas support a variety of faunal species, create unique microhabitats, and contribute to canopy nutrient cycling. Their decline in plantations signals the disruption of ecological interactions vital to forest resilience [31]. These findings corroborate global observations that monocultural land uses reduce both biodiversity and ecosystem stability [32]. The emergence of invasive, disturbance-tolerant species in plantation understories further highlights the fragility of homogenized ecosystems [33].

The study also sheds light on the conservation value of endemic species identified within PT LIL's landscape. The discovery of eight Sulawesi endemics, including *Diospyros celebica* and *Dysoxylum quadrangulatum*, emphasizes the irreplaceable ecological heritage embedded in remnant habitats [24,25]. The presence of these species in both forest and plantation contexts demonstrates that even modified landscapes retain elements of high conservation value (HCV-1), which must be prioritized in management strategies. However, the conservation statuses of these species—two vulnerable and one near threatened indicate their heightened susceptibility to extinction [26]. The economic importance of *Diospyros celebica* (ebony wood) has accelerated its overexploitation, mirroring findings across Sulawesi where endemic Ebenaceae taxa face severe pressures from logging and land-use change [34]. These observations highlight the dual challenge of conserving endemic taxa while addressing economic drivers that incentivize unsustainable exploitation [35].

Discrepancies between POWO and GBIF occurrence records, particularly regarding the distribution of *Begonia*

*ignita*, *Calamus inops*, and *Diospyros celebica*, illustrate the challenges of reconciling regional and global biodiversity datasets. Such inconsistencies may result from historical collection gaps or recent taxonomic updates, reinforcing the importance of integrating multiple data sources for accurate conservation assessments [36]. The vulnerability of endemic species to habitat loss and fragmentation is well documented [37], and the persistence of these taxa in plantation remnants underscores the urgent need for targeted conservation interventions.

The ethnobotanical dimension of the study further emphasizes the multifunctional role of local flora. A total of 64 species were recorded with medicinal uses, spanning a variety of plant forms from herbs to trees (Table 3). These species address a broad range of health conditions, reflecting the integration of biodiversity into cultural practices and healthcare systems of local communities [38]. The reliance on these plants for primary healthcare demonstrates their significance as both ecological and social assets. Ethnobotanical knowledge, passed down through generations, constitutes a vital part of cultural heritage, but risks being eroded as habitats are lost [39]. The loss of medicinal plant availability due to land conversion not only threatens biodiversity but also cultural resilience and healthcare sovereignty in rural communities. This aligns with global findings that ethnobotanical values must be embedded in conservation frameworks to ensure culturally grounded and socially relevant outcomes [40].

The multifunctionality of several plant species underscores the broader livelihood significance of biodiversity. These plants are used simultaneously for medicinal, nutritional, and material purposes, reflecting a synergy between ecological services and human needs [41]. Their integration into household economies illustrates the interconnectedness of biodiversity with local well-being. HCV-5 assessments, which explicitly account for community needs, are therefore indispensable in plantation landscapes [3,4]. Without recognition of these cultural and livelihood values, conservation efforts risk alienating communities or failing to safeguard their essential resources.

The ecological degradation observed in plantation sites, including habitat fragmentation and edge effects, highlights the systemic impacts of land conversion on ecosystem dynamics. Fragmentation reduces connectivity, limits species dispersal, and exacerbates extinction risks for both flora and fauna [42,43]. The observed edge effects—higher light intensity, temperature fluctuations, and reduced humidity—drive shifts in plant community composition, favoring disturbance-tolerant species over forest specialists [44]. These ecological processes were evident in PT LIL's plantations, where secondary growth consisted largely of fast-growing and invasive species, while sensitive forest-dependent taxa declined.

The persistence of endemic and medicinally significant species within PT LIL's landscape underscores the importance of adopting integrative management practices.

Embedding HCV-1 and HCV-5 frameworks into plantation management provides a pathway to reconcile oil palm production with biodiversity and community needs [45,46]. Studies have demonstrated that HCV patches within plantations can serve as ecotourism destinations, thereby generating alternative income streams while fostering conservation [46]. Such strategies exemplify the potential of integrated approaches to create synergies between conservation and socio-economic development.

The broader implications of these findings resonate with global case studies from tropical agricultural frontiers such as the Amazon and Congo Basin. Evidence shows that landscapes integrating forest patches, corridors, and agroforestry elements support higher biodiversity and ecosystem services than homogenous monocultures [47,48]. Agroforestry models demonstrate that tree diversity comparable to natural forests can be maintained when traditional practices are adapted to modern sustainability frameworks [49]. These insights reinforce the argument that oil palm production systems must incorporate landscape heterogeneity and multifunctional land uses to sustain ecological and social outcomes.

From a governance perspective, adaptive frameworks provide the institutional flexibility necessary to balance production objectives with ecological and community safeguards [50,51]. The findings at PT LIL affirm the need for participatory decision-making that integrates local knowledge and ensures equitable benefit sharing. Adaptive governance not only enhances ecological resilience but also fosters community trust and cooperation, which are critical for long-term sustainability [52]. The observed dependence of local communities on medicinal and multipurpose plants highlights the urgency of embedding livelihood considerations within ecological assessments. Certification schemes such as ISPO can provide institutional scaffolding for these integrative approaches, but their effectiveness depends on rigorous enforcement and genuine community engagement [53].

Finally, the study's findings contribute to the broader discourse on reconciling biodiversity conservation with oil palm expansion. While the decline in species richness and structural complexity in plantations is evident, the continued presence of endemic and culturally important species offers a foundation for targeted conservation within plantation matrices. By adopting biodiversity-friendly management practices such as reducing chemical inputs, conserving remnant patches, and integrating agroforestry models, oil palm landscapes can enhance ecological resilience while maintaining productivity [54]. These measures also mitigate vulnerabilities to environmental shocks and ensure that ecosystem services such as pollination and soil fertility remain intact. As demonstrated by smallholder initiatives in Jambi, sustainable practices aligned with certification schemes can deliver co-benefits of improved market access, income stability, and ecological sustainability [55]. Together, these insights underscore that ecological integrity and local livelihoods

are not mutually exclusive but can be mutually reinforcing when governance, management, and conservation are effectively integrated.

The results of this study should be viewed in light of several methodological limitations that may have influenced the scope and depth of the findings. These include time constraints, limited resources, and challenging field conditions such as uneven terrain and restricted accessibility, as well as a relatively short sampling period that covered only one season. Consequently, seasonal variations in vegetation dynamics and species occurrence may not have been fully captured. Furthermore, the limited number of direct interviews with local communities restricted the depth of ethnobotanical insights, particularly regarding traditional knowledge and long-term patterns of plant use. Despite these constraints, the study provides a valuable baseline for understanding plant composition, conservation value, and ethnobotanical relevance within plantation and secondary forest landscapes. Future studies with extended temporal coverage, broader spatial sampling, and more extensive community engagement are recommended to build a more comprehensive understanding of the ecological and socio-cultural dimensions of biodiversity in the region.

## 5. Conclusions

This study affirms that even within monoculture landscapes such as oil palm plantations, remaining habitat fragments and their associated species still possess significant conservation and socio-cultural value. The presence of endemic species, medicinal plants, and ethnobotanically important taxa indicates that plantation ecosystems have not entirely lost their ecological functions or social relevance to local communities. Therefore, integrated plantation management—combining conservation approaches that recognize endemic species for their biodiversity significance (HCV-1) and ethnobotanically important species for their livelihood relevance (HCV-5)—is essential to achieve a balance between economic productivity, environmental preservation, and socio-cultural sustainability in tropical regions. These findings not only inform the ISPO certification process but also contribute to broader discussions on reconciling oil palm expansion with biodiversity conservation and community well-being.

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