RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
58 (4) 1694-1705, 2026
http://doi.org/10.54910/sabrao2026.58.4.21
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

PLANT SPECIES DIVERSITY AND LIVELIHOOD SUPPORT IN TRADITIONAL PEATLAND AGROFORESTRY OF TAPUNG, KAMPAR, RIAU, INDONESIA

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SUMMARY

Traditional agroforestry on peatlands conserves biodiversity while supporting the livelihoods of rural communities. This study characterized species composition and community structure, compared plant diversity and dominance, and evaluated the livelihood functions of traditional peatland agroforestry in three villages in Tapung Subdistrict, Kampar, Riau, Indonesia. Vegetation data collection came from 12 20 m × 20 m plots, and the documentation of plant utilization continued through semi-structured interviews with agroforestry owners. These agroforestry systems contained 14–20 plant species, with different dominant species across the villages. Agricultural crops were dominant with oil palm, coconut, banana, and areca palm, while matoa, jackfruit, mango, rambutan, and water apple were the dominant tree species. All sites exhibited moderate species diversity (H' = 2.18–2.69), high evenness (J = 0.83–0.91), and low dominance (C = 0.08–0.16). Fruit species represent the largest utilization category, with 57%–65% of harvested produce consumed by households and the remainder sold as supplementary income. These findings indicate that traditional agroforestry on peatlands effectively integrates productive crops with various tree species, supports rural livelihoods and ecological diversity, and provides a scientific basis for the sustainable selection of species in tropical peatland agroforestry.

Keywords: Biodiversity, community livelihoods, traditional agroforestry, trees, tropical peatlands

Key findings: Traditional peatland agroforestry maintained moderate species diversity, high evenness, and low dominance despite differences in dominant agricultural crops and tree species among villages. Integrating productive crops with diverse multipurpose tree species supports household food security and supplementary income while maintaining ecological diversity, providing valuable guidance for species selection in sustainable peatland agroforestry.

Communicating Editor: Prof. Naqib Ullah Khan

Manuscript received: October 22, 2025; Accepted: August 06, 2026.

Citation: Fatonah S, Agustin HM, Yusfiati, Yulminarti, Fitmawati (2026). Plant species diversity and livelihood support in traditional peatland agroforestry of Tapung, Kampar, Riau, Indonesia. *SABRAO J. Breed. Genet. 58 (4) 1694-1705. http://doi.org/10.54910/sabrao2026.58.4.21*.

INTRODUCTION

Peatlands are the largest carbon stores, found vital for global climate stability. However, they remain highly vulnerable to degradation, drainage, and fires that convert them from sinks to major emission sources (Mishra *et al*., 2021). Mitigation through hydrological restoration, supportive policies, and sustainable land use, particularly traditional agroforestry, has become crucial (Applegate *et al*., 2022). Traditional agroforestry on peatlands integrates timber and non-timber crops and fruits and has a potential role in improving ecosystem services, biodiversity, and economic benefits. Agroforestry lands owned by local communities incur haphazard planting generally, lacking consistent planting spacing, with combinations of forestry and agricultural crops that vary according to needs (Juliarti *et al*., 2024). In adaptive local knowledge, the traditional agroforestry system sustains ecological functions and local livelihood, contributing to long-term peatland resilience (Erlangga *et al*., 2025).

In agroforestry systems, the tree diversity underpins ecosystem services, resilience, biodiversity conservation, and sustaining local livelihoods (Legesse and Negash, 2021). It reflects multifunctional values through food, medicines, and market commodities, while also supporting sustainable land management (Isda *et al*., 2025). Diverse forest tree species enhanced the carbon storage, soil fertility, and water regulation (Fahad *et al*., 2022), reduced vulnerability to pests and climate change (Altieri and Nicholls, 2008), and promoted wildlife, genetic diversity conservation, and local economy (Hendri *et al.,* 2024).

Previous studies on agroforestry in tropical peatlands have mainly focused on ecosystem restoration and climate change mitigation through sustainable land management practices (Applegate *et al*., 2022). Beyond restoration, agroforestry has also been effective in improving soil quality, nutrient cycling, and other ecosystem functions, thereby supporting the ecological sustainability of peatland landscapes (Fahad *et al.,* 2022). At the regional level, peatland degradation and restoration in Southeast Asia have reached wide examination, particularly concerning hydrological restoration, greenhouse gas emissions, and ecosystem resilience (Mishra *et al.,* 2021). Lately, studies in Indonesia have begun to document the flora composition and carbon sequestration potential of traditional agroforestry systems on peatlands, underscoring their ecological importance for biodiversity conservation and carbon storage (Isda *et al*., 2025). Agroforestry adapted to peatland conditions has likewise been proposed as a key strategy for restoring degraded peatlands while sustaining productive land use (Erlangga *et al*., 2025).

Traditional peatland agroforestry in Riau is highly heterogeneous, reflecting differences in dominant plant species, local management practices, and farmer preferences among villages. Despite this heterogeneity, previous studies have generally treated peatland agroforestry as a relatively homogeneous production system, providing limited comparative information among different agroforestry types. Although some studies have documented flora composition or carbon sequestration in peatland agroforestry, vegetation structure, species diversity, and patterns of plant utilization have rarely gained scrutiny together within the same system. Consequently, little empirical evidence is available on how differences in agroforestry composition affect plant diversity and livelihood-supporting functions in rural peatland communities in Riau, leaving the ecological and socioeconomic multifunctionality of traditional peatland agroforestry typologies poorly understood.

Addressing this knowledge gap enabled this study to aim to a) characterize the species composition and community structure of traditional peatland agroforestry systems in three villages in Tapung Subdistrict, Kampar, Riau; b) compare plant species diversity and dominance among representative traditional agroforestry typologies; and c) evaluate the livelihood-supporting functions of agroforestry vegetation based on patterns of plant utilization. A hypothesis of the study is that variation among traditional agroforestry typologies has an association with differences in species composition and dominance. Meanwhile, species diversity remains comparable across typologies and continues to support community livelihoods through diverse patterns of plant utilization. By integrating vegetation structure, species diversity, and patterns of plant use across agroforestry typologies, this study hopes to provide new insights into how traditional peatland agroforestry supports biodiversity conservation and community livelihoods.

MATERIALS AND METHODS

Study area and peatland status

This study began in 2025 in three villages within a peatland landscape of Tapung Subdistrict, Kampar Regency, Riau Province, Indonesia. The villages were Pagaruyung, Air Terbit, and Sungai Putih. Regency-level peatland distribution mapping indicates that the Tapung peat cluster covers approximately 75,953 ha, part of Kampar Regency's total peatland area of around 191,363 ha (Sudiana, 2018), consistent with the national peatland map series compiled for the region (Wahyunto *et al.,* 2014). Field measurements at each study site confirmed the peatland status of the sampled plots. Groundwater table depth, measured below the peat surface, was −30 cm in Pagaruyung, −31 cm in Air Terbit, and −38 cm in Sungai Putih. Peat depth, measured to the underlying mineral substratum, was 2.5 m in Pagaruyung, 1.94 m in Air Terbit, and 0.63 m in Sungai Putih. It corresponds to deep peat (200–400 cm) in Pagaruyung, moderate peat (100–200 cm) in Air Terbit, and shallow peat (50–100 cm) in Sungai Putih, following the peat-depth classification of Ritung and Sukarman (2016). The locations of the three study villages and the distribution of the vegetation sampling plots are available in Figure 1.

Plot selection and sampling design

Vegetation data collected came from 12 sample plots (400 m², 20 m × 20 m each), with four plots established in each village. Plot locations' selection used a purposive sampling approach based on the dominant traditional agroforestry pattern identified in each village through a preliminary field survey and interviews with local farmers. The adoption of this approach is suitable because agroforestry practices within the study area are highly heterogeneous even within a single village (Kindt and Coe, 2005). The selected plots represented the principal agroforestry typologies present at each site. In Pagaruyung Village, three plots represented fruit-tree-based agroforestry, and one plot represented areca nut (*Areca catechu*)-based agroforestry.

Figure 1. Location of the study area and distribution of vegetation sampling plots in the traditional peatland agroforestry systems in Tapung Subdistrict, Kampar Regency, Riau Province, Indonesia.

For Air Terbit Village, all four plots represented fruit-tree-based agroforestry, while in Sungai Putih Village, all four plots represented areca nut-based agroforestry. Within each plot, woody vegetation classification resulted from growth stage based on stem diameter at breast height (dbh), measured at 1.3 m above ground level; pole dbh is 10–19.9 cm, and tree dbh ≥ 20 cm (Soerianegara and Indrawan, 2016).

Species identification

All species encountered in the sampled plots were common cultivated plants that are readily recognizable based on well-known vegetative and reproductive morphological characters. Therefore, species identification occurred directly in the field by the research team without herbarium voucher preparation or comparison against reference specimens. Subsequent standardization of scientific names and taxonomic authorities followed the Plants of the World Online (POWO, Royal Botanic Gardens, Kew, https://powo.science.kew.org).

Vegetation and biodiversity data collection

Within each plot, data recorded for all trees and poles included species identity, the number of individuals per species, and stem circumference (converted to dbh). These data, upon use, derived density, frequency, and basal area for each species, which, in turn, served to compute the relative values and ecological indices described below.

Ecological indices

Tree biodiversity parameters, when calculated for each species, used the following:

Relative density (RD, %) = $(n_i/N) \times 100$, where n_i is the number of individuals of species i and N is the total number of individuals of all species recorded.

Relative frequency (RF, %) = $(f_i/\Sigma F) \times 100$, where f_i is the frequency of species i (the proportion of plots in which the species occurs) and ΣF is the sum of frequency values of all species.

Relative dominance (RDo, %) = $(BA_i/\Sigma BA) \times 100$, where BA_i is the total basal area of species i (derived from dbh) and ΣBA is the total basal area of all species.

Importance Value Index (IVI) = RD + RF + RDo (Mueller-Dombois and Ellenberg, 1974).

Shannon-Wiener Diversity Index: $H' = -\Sigma\, p_i \ln p_i$, where $p_i = n_i/N$ (Odum *et al*., 2005).

Pielou's Evenness Index: $J = H'/\ln S$, where S is the total number of species recorded (Krebs, 2014).

Species Dominance Index (Simpson's Index):

$$C = \Sigma(n_i/N)^2$$ (Odum *et al*., 2005).

Respondents and interview procedure

Each of the 12 sampled plots corresponded to a distinct home garden (500–700 m²) belonging to a different household. Data on the contribution of agroforestry vegetation to community livelihood entailed collection through semi-structured interviews with the owner of each sampled home garden. It yielded a total of 12 respondents, one per plot, following a total (census) sampling approach corresponding to the sampled locations (Etikan *et al.*, 2016). Interviews covered the plant products harvested, the purpose of utilization (household consumption, marketed, or both), and the plant parts used.

Utilization percentage calculation

The percentage utilization of each plant-product category employed the calculation as follows: Utilization (%) = (number of species recorded for a given utilization category / total number of species recorded) × 100.

Data analysis

All vegetation and utilization data underwent descriptive analysis, as the aim of the study was to characterize vegetation structure and compare representative agroforestry typologies among sites, rather than to test treatment effects. Vegetation parameters, when summarized, used descriptive statistics and the ecological indices described above (Importance Value Index, Shannon-Wiener Diversity Index, Pielou's Evenness Index, and Species Dominance Index).

RESULTS AND DISCUSSION

Species composition and community structure

In the three studied villages, plant species composition in the traditional peatland agroforestry systems showed considerable variation in richness and family diversity (Tables 1, 2, and 3). Pagaruyung Village recorded 20 species from 11 families, Air Terbit recorded 20 species from 12 families, and Sungai Putih recorded 14 species from 10 families. Combining individuals across all growth stages, the highest Importance Value Index (IVI) in Pagaruyung appeared with oil palm (IVI = 67.45%), followed by coconut (40.37%) and banana (26.45%); among tree species, matoa (22.26%), jackfruit (20.12%), and mango (17.88%) ranked highest (Table 1). In Air Terbit, coconut (24.13%), banana (14.07%), and areca nut (12.59%) were the leading agricultural crops, while rambutan reached an exceptionally high IVI (112.09%) among tree species, followed by matoa (23.93%) and water apple (20.96%) (Table 2). In Sungai Putih, areca nut (52.66%) and coconut (43.12%) were the leading agricultural crops, while matoa (38.61%), mango (31.29%), and rambutan (23.27%) ranked highest among tree species (Table 3).

The vegetation composition of the traditional peatland agroforestry systems reflected differences in both agroforestry management and farmers' species-selection strategies. Across the three villages, agricultural crops consistently dominated the vegetation structure, whereas tree species contributed most of the floristic richness and compositional diversity. Oil palm, coconut, banana, and areca nut recorded the highest importance values among agricultural crops, indicating their primary role in supporting household production. In contrast, tree species, such as matoa, mango, jackfruit, rambutan, and water apple, formed a more diverse vegetation layer that enhanced the structural complexity of agroforestry systems. Similar patterns have emerged in reports on traditional agroforestry, where farmers deliberately retain economically valuable crops while maintaining diverse tree species to provide multiple ecological and socioeconomic benefits (Legesse and Negash, 2021). The description of a similar vegetation structure has also resulted in traditional agroforestry on peatlands in Rimbo Panjang, Riau, where productive tree species coexist with supporting vegetation, resulting in a relatively high diversity of flora despite continuous agricultural management (Isda *et al*., 2025).

The clear distinction between structurally dominant agricultural crops and ecologically important tree species indicates complementary rather than competing functions within the agroforestry system. Agricultural crops primarily determine community dominance because of their greater abundance or basal area, whereas associated tree species contribute to biodiversity conservation, vertical vegetation stratification, and ecosystem complexity. This multifunctional vegetation structure has reached wide recognition as a characteristic of traditional tropical agroforestry systems that integrate production with ecological sustainability (Legesse and Negash, 2021). Nevertheless, the exceptionally high importance value of rambutan in Air Terbit should entail cautious interpretation because of relative dominance (basal area) mainly driving it rather than high abundance or frequency. As a composite metric, the Importance Value Index can gain a disproportionate influence from one or a few large-diameter trees, particularly in relatively small fixed-area plots (Peck and Zenner, 2021).

Diversity-dominance relationships and their ecological implications

Community-level diversity indices calculated from the combined tree and pole strata (Table 4) indicated the traditional agroforestry systems maintained moderate species diversity, with Shannon-Wiener diversity

Table 1. Importance Value Index (IVI) of tree species in the traditional agroforestry system at Pagaruyung Village, Tapung, Kampar, Riau, Indonesia.

No.	Local Name	Scientific Name	Family	RD (%)	RF (%)	RDo (%)	IVI (%)
Tree species							
1	Matoa	*Pometia pinnata*	Sapindaceae	8.57	9.68	4.01	22.26
2	Jackfruit	*Artocarpus heterophyllus*	Moraceae	7.14	9.68	3.30	20.12
3	Mango	*Mangifera indica*	Anacardiaceae	7.14	6.45	4.28	17.88
4	Cempedak	*Artocarpus integer*	Moraceae	7.14	6.45	2.46	16.05
5	Petai Cina	*Leucaena leucocephala*	Fabaceae	4.29	6.45	0.32	11.06
6	Breadfruit	*Artocarpus altilis*	Moraceae	2.86	6.45	1.05	10.36
7	Sweet Orange	*Citrus sinensis*	Rutaceae	4.29	3.23	0.15	7.66
8	Rambutan	*Nephelium lappaceum*	Sapindaceae	1.43	3.23	2.28	6.93
9	Longan	*Dimocarpus longan*	Sapindaceae	2.86	3.23	0.37	6.45
10	Bay Leaf	*Syzygium polyanthum*	Myrtaceae	1.43	3.23	1.65	6.30
11	Cashew Nut	*Anacardium occidentale*	Anacardiaceae	1.43	3.23	1.17	5.82
12	Durian	*Durio zibethinus*	Malvaceae	1.43	3.23	0.85	5.51
13	Papaya	*Carica papaya*	Caricaceae	1.43	3.23	0.57	5.22
14	Mangosteen	*Garcinia mangostana*	Clusiaceae	1.43	3.23	0.09	4.74
15	Sapodilla	*Manilkara zapota*	Sapotaceae	1.43	3.23	0.06	4.71
16	Lime	*Citrus aurantiifolia*	Rutaceae	1.43	3.23	0.00	4.65
Agricultural crops							
1	Oil Palm	*Elaeis guineensis*	Arecaceae	11.43	3.23	52.79	67.45
2	Coconut	*Cocos nucifera*	Arecaceae	14.29	6.45	19.63	40.37
3	Banana	*Musa × paradisiaca*	Musaceae	12.86	9.68	3.92	26.45
4	Areca Nut	*Areca catechu*	Arecaceae	5.71	3.23	1.06	10.00

RD = Relative Density; RF = Relative Frequency; RDo = Relative Dominance; and IVI = Importance Value Index (RD + RF + RDo).

Table 2. Importance Value Index (IVI) of tree species in the traditional agroforestry system at Air Terbit Village, Tapung, Kampar, Riau, Indonesia.

No.	Local Name	Scientific Name	Family	RD (%)	RF (%)	RDo (%)	IVI (%)
Tree species							
1	Rambutan	*Nephelium lappaceum*	Sapindaceae	5.71	8.11	98.26	112.09
2	Matoa	*Pometia pinnata*	Sapindaceae	12.86	10.81	0.26	23.93
3	Water Apple	*Syzygium aqueum*	Myrtaceae	10.00	10.81	0.15	20.96
4	Mango	*Mangifera indica*	Anacardiaceae	8.57	5.41	0.23	14.21
5	Jackfruit	*Artocarpus heterophyllus*	Moraceae	7.14	5.41	0.10	12.64
6	Starfruit	*Averrhoa carambola*	Oxalidaceae	4.29	5.41	0.08	9.77
7	Jengkol	*Archidendron pauciflorum*	Fabaceae	4.29	5.41	0.06	9.76
8	Durian	*Durio zibethinus*	Malvaceae	4.29	5.41	0.01	9.70
9	Sapodilla	*Manilkara zapota*	Sapotaceae	2.86	2.70	0.10	5.66
10	Petai Cina	*Leucaena leucocephala*	Fabaceae	2.86	2.70	0.02	5.58
11	Cempedak	*Artocarpus integer*	Moraceae	1.43	2.70	0.06	4.19
12	Ginger Apple	*Syzygium malaccense*	Myrtaceae	1.43	2.70	0.03	4.16
13	Mangosteen	*Garcinia mangostana*	Clusiaceae	1.43	2.70	0.01	4.15
14	Breadfruit	*Artocarpus altilis*	Moraceae	1.43	2.70	0.00	4.14
15	Ambarella Apple	*Spondias dulcis*	Anacardiaceae	1.43	2.70	0.00	4.13
16	Papaya	*Carica papaya*	Caricaceae	1.43	2.70	0.00	4.13
Agricultural crops							
1	Coconut	*Cocos nucifera*	Arecaceae	12.86	10.81	0.46	24.13
2	Banana	*Musa × paradisiaca*	Musaceae	8.57	5.41	0.10	14.07
3	Areca Nut	*Areca catechu*	Arecaceae	7.14	5.41	0.04	12.59

RD = Relative Density; RF = Relative Frequency; RDo = Relative Dominance; and IVI = Importance Value Index (RD + RF + RDo).

Table 3. Importance Value Index (IVI) of tree species in the traditional agroforestry system at Sungai Putih Village, Tapung, Kampar, Riau, Indonesia.

No.	Local Name	Scientific Name	Family	RD (%)	RF (%)	RDo (%)	IVI (%)
Tree species							
1	Matoa	*Pometia pinnata*	Sapindaceae	12.61	13.33	12.67	38.61
2	Mango	*Mangifera indica*	Anacardiaceae	7.21	10.00	14.09	31.29
3	Rambutan	*Nephelium lappaceum*	Sapindaceae	5.41	6.67	11.20	23.27
4	Sapodilla	*Manilkara zapota*	Sapotaceae	1.80	13.33	3.24	18.38
5	Jackfruit	*Artocarpus heterophyllus*	Moraceae	4.50	6.67	5.73	16.91
6	Chocolate	*Theobroma cacao*	Malvaceae	9.01	3.33	3.55	15.90
7	Jengkol	*Archidendron pauciflorum*	Fabaceae	1.80	3.33	5.10	10.23
8	Guava Ball	*Syzygium malaccense*	Myrtaceae	1.80	6.67	1.16	9.63
9	Guava	*Psidium guajava*	Myrtaceae	1.80	3.33	1.23	6.37
10	Petai Cina	*Leucaena leucocephala*	Fabaceae	0.90	3.33	0.06	4.29
Agricultural crops							
1	Areca Nut	*Areca catechu*	Arecaceae	32.43	6.67	13.56	52.66
2	Coconut	*Cocos nucifera*	Arecaceae	10.81	13.33	18.97	43.12
3	Banana	*Musa × paradisiaca*	Musaceae	8.11	6.67	7.55	22.32
4	Cotton*	*Gossypium hirsutum*	Malvaceae	1.80	3.33	1.89	7.02

RD = Relative Density; RF = Relative Frequency; RDo = Relative Dominance; and IVI = Importance Value Index (RD + RF + RDo).

Table 4. Diversity index, evenness index, and species dominance index in the traditional agroforestry system in Tapung, Kampar, Riau, Indonesia.

Village	Shannon-Weiner Diversity Index (H')	Pielou's Evenness Index (J)	Species Dominance Index (C)
Pagaruyung	2.688	0.897	0.083
Air Terbit	2.692	0.914	0.080
Sungai Putih	2.179	0.826	0.160

values ranging from 2.18 to 2.69. Air Terbit recorded the highest diversity (H' = 2.692), closely followed by Pagaruyung (H' = 2.688), whereas Sungai Putih exhibited the lowest diversity (H' = 2.179). Pielou's evenness index ranged from 0.826 to 0.914, indicating a relatively even distribution of individuals among species across all villages, with Air Terbit showing the highest evenness. Simpson's dominance index remained low (0.08–0.16) in all study sites, although Sungai Putih had the topmost dominance value. Overall, these results signify that the traditional peatland agroforestry systems were characteristically of relatively diverse and evenly distributed plant communities with low species dominance. Meanwhile, Sungai Putih exhibited a comparatively narrower species composition and stronger dominance than Pagaruyung and Air Terbit.

The diversity, evenness, and dominance indices indicate that the traditional peatland agroforestry systems maintained relatively stable and heterogeneous plant communities despite differences in species composition among villages. The moderate Shannon-Wiener diversity values, high evenness, and low Simpson dominance specify that no single species overwhelmingly dominated the vegetation community, even though agricultural crops accounted for the highest Importance Value Index. This pattern reflects the coexistence of structurally dominant commercial crops with a diverse assemblage of fruit and multipurpose tree species, resulting in a balanced community structure. However, the lower diversity, lower evenness, and higher dominance observed in Sungai Putih suggest that vegetation composition had stronger influences from fewer cultivated species than in Pagaruyung and Air Terbit. Similar vegetation patterns have had reports in traditional agroforestry systems, where farmers' species-selection practices largely determine community structure and diversity (Legesse and Negash, 2021).

Structurally diverse agroforestry systems generally provide a wider range of ecosystem functions than simplified production systems. Higher plant diversity has shown an association with greater carbon storage and ecosystem multi-functionality (Manaye *et al*., 2021), while diverse tree assemblages also enhance ecological resilience under changing environmental conditions (Chauhan *et al*., 2025). However, since this study did not measure carbon stocks, peat hydrology, and soil properties, these relationships should be regarded as potential ecological implications rather than direct evidence. Future studies integrating vegetation inventories with carbon and hydrological measurements are necessary to better evaluate the ecological performance of tropical peatland agroforestry systems (Nungula *et al.*, 2024).

Livelihood-supporting functions

Fruit species accounted for the largest share of vegetation utilization across the three villages, ranging from 57.14% in Sungai Putih to 70.00% in Air Terbit, with Pagaruyung at 65.00% (Table 5, Figure 2). Of the total number of species found in agroforestry systems, the report stated domestic consumption reached 57%–65%, while 35%–43% were sold, with durian, mango, and areca nut identified as the principal income-generating commodities.

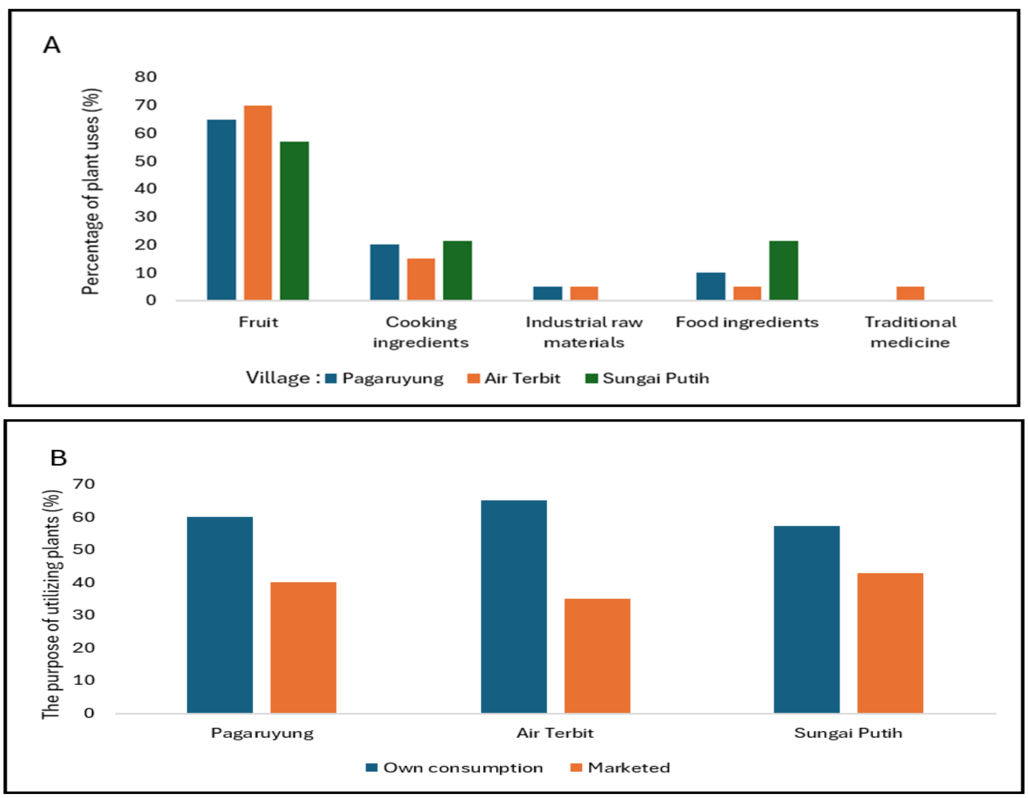

Figure 2. Percentage of uses and purposes of plant utilization in the traditional agroforestry system in the Tapung District, Kampar, Riau, Indonesia: A) Percentage of plant uses, and B) The purpose of plants' utilization.

Table 5. Utilization of the traditional agroforestry vegetation in the Tapung, Kampar, Riau, Indonesia.

No.	Local name	Scientific Name	Family	Village			Plant products	Purpose of Plant Utilization
				Paga-ruyung	Air Terbit	Sungai Putih		
1	Banana	*Musa × paradisiaca*	Musaceae	✓	✓	✓	Fruit	Household consumption
2	Coconut	*Cocos nucifera*	Arecaceae	✓	✓	✓	Cooking ingredients	Marketed
3	Jackfruit	*Artocarpus heterophyllus*	Moraceae	✓	✓	✓	Fruit	Marketed
4	Papaya	*Carica papaya*	Caricaceae	✓	✓		Fruit	Household consumption
5	Matoa	*Pometia pinnata*	Sapindaceae	✓	✓	✓	Fruit	Household consumption
6	Durian	*Durio zibethinus*	Malvaceae	✓	✓		Fruit	Marketed
7	Lime	*Citrus aurantiifolia*	Rutaceae	✓	-	-	Cooking ingredients	Household consumption
8	Rambutan	*Nephelium lappaceum*	Sapindaceae	✓	✓	✓	Fruit	Household consumption
9	Petai Cina	*Leucaena leucocephala*	Fabaceae	✓	✓	✓	Cooking ingredients	Household consumption
10	Breadfruit	*Artocarpus altilis*	Moraceae	✓	✓		Food ingredients	Household consumption
11	Areca Nut	*Areca catechu*	Arecaceae	✓	✓	✓	Industrial raw materials	Household consumption
12	Cashew Apple	*Anacardium occidentale*	Anacardiaceae	✓	-	-	Fruit	Marketed
13	Cempedak	*Artocarpus integer*	Moraceae	✓	✓		Fruit	Household consumption
14	Mango	*Mangifera indica*	Anacardiaceae	✓	✓	✓	Fruit	Marketed
15	Bay Leaf	*Syzygium polyanthum*	Myrtaceae	✓	-	-	Cooking ingredients	Household consumption
16	Sweet Orange	*Citrus sinensis*	Rutaceae	✓	-	-	Fruit	Household consumption
17	Longan	*Dimocarpus longan*	Sapindaceae	✓	-	-	Fruit	Household consumption
18	Mangosteen	*Garcinia mangostana*	Clusiaceae	✓	✓		Fruit	Marketed
19	Sapodilla	*Manilkara zapota*	Sapotaceae	✓	✓	✓	Fruit	Household consumption
20	Oil Palm	*Elaeis guineensis*	Arecaceae	✓	-	-	Industrial raw materials	Marketed
21	Water Apple	*Syzygium aqueum*	Myrtaceae		✓	-	Fruit	Household consumption
22	Jengkol	*Archidendron pauciflorum*	Fabaceae		✓	✓	Cooking ingredients	Household consumption
23	Starfruit	*Averrhoa carambola*	Oxalidaceae		✓		Fruit	Household consumption
24	Guava	*Psidium guajava*	Myrtaceae		✓	✓	Fruit	Household consumption
25	Ambarella	*Spondias dulcis*	Anacardiaceae		✓	-	Fruit	Household consumption
26	Morrino noni	*Morinda citrifolia*	Rubiaceae		✓	-	Traditional medicines	Household consumption
27	Chocolate	*Theobroma cacao*	Malvaceae		-	✓	Industrial raw materials	Marketed
28	Cotton	*Gossypium hirsutum*	Malvaceae		-	✓	Industrial raw materials	Marketed
29	Malay Apple	*Syzygium malaccense*	Myrtaceae		-	✓	Fruit	Household consumption

Note: ✓= present at the location; **-** = not present at the location.

The traditional peatland agroforestry systems fulfilled multiple livelihood functions by combining agricultural crops with diverse fruit and multipurpose tree species. Agricultural crops, particularly oil palm, coconut, banana, and areca nut, represented the principal source of household cash income, whereas most tree species primarily supported household consumption through fruit production. Across all agroforestry typologies, more than half of the harvested products reached consumption domestically, indicating these systems remain predominantly subsistence-oriented while providing supplementary income from a limited number of high-value commodities. Similar livelihood strategies have been widely reported in Indonesian smallholder agroforestry, where multifunctional tree systems simultaneously support food security and household income (Sudomo *et al.,* 2023). Farmers also commonly combine subsistence production with the selective commercialization of economically valuable tree crops (Achmad *et al.,* 2022).

Despite relatively high tree species richness, household income remained concentrated in only a few commercial crops. This finding suggests that floristic diversity does not necessarily correspond to income diversification because many associated tree species contribute primarily to household consumption rather than market production. Comparable economic dependence on a limited number of commodity crops has had many reports in peatland communities of Kampar (Yunus *et al.,* 2024). However, because this study assessed plant utilization rather than species-specific income, no quantification of the contribution of tree diversity to household economic resilience occurred, requiring investigation in future studies.

Implications for peatland agroforestry management

The promising study demonstrates that traditional peatland agroforestry represents a multifunctional land-use system capable of simultaneously supporting biodiversity conservation and rural livelihoods. Although agricultural crops—oil palm, coconut, banana, and areca nut—dominated the vegetation structure and provided principal sources of household income, the associated fruit and multipurpose tree species substantially increased plant diversity and maintained a balanced community structure. This combination indicates that farmers' species-selection practices contribute not only to production but also to the ecological stability of peatland agroforestry systems. Similar conclusions have emerged from reports for tropical agroforestry, where maintaining diverse tree assemblages enhances ecosystem resilience while sustaining agricultural production (Nungula *et al*., 2024).

From a management perspective, these findings suggest peatland agroforestry development should prioritize the retention of diverse fruit and multipurpose tree species alongside economically important crops rather than promoting simplified monoculture systems. Maintaining vegetation diversity can strengthen ecosystem resilience, improve long-term sustainability, and increase the capacity of agroforestry landscapes to provide multiple ecosystem services. These include biodiversity conservation, climate-change adaptation, and livelihood support (Mallesh *et al*., 2025). As this study evaluated vegetation composition and plant utilization without measuring carbon stocks, peat hydrology, or household income quantitatively, future research should integrate ecological, hydrological, and socioeconomic assessments. These will enable a higher understanding of the long-term sustainability of tropical peatland agroforestry and support evidence-based peatland management in Indonesia (Chauhan *et al*., 2025).

CONCLUSIONS

Traditional peatland agroforestry systems in Tapung differed in vegetation composition and dominant species but maintained similarly moderate species diversity, high evenness, and low dominance. Agricultural crops had the dominance of oil palm, coconut, and banana in Pagaruyung; coconut, banana, and areca nut in Air Terbit; and areca nut and coconut in Sungai Putih. The dominant tree species were matoa, jackfruit, and mango in Pagaruyung; rambutan, matoa, and water apple in Air Terbit; and matoa, mango, and rambutan in Sungai Putih. Despite differences in species composition and dominance, all agroforestry systems supported household food security and supplementary income through diverse patterns of plant utilization while maintaining ecological diversity, demonstrating their multifunctional role in sustaining biodiversity and rural livelihoods.

ACKNOWLEDGMENTS

The author would like to thank the Institute for Research and Community Service, University of Riau, Indonesia, for the funding provided through the Riau University Flagship Research program with contract number 28999/UN.19.5.1.3/AL.04/2025, which enabled this research to proceed efficiently.

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