Vol. 14(1): 31-47, January 2026

DOI: https://doi.org/10.23960/jsl.v14i1.1190

Jurnal Sylva Lestari

P-ISSN: 2339-0913
E-ISSN: 2549-5747

Journal homepage: https://sylvalestari.fp.unila.ac.id

Full Length Research Article

Biodiversity Patterns of Flora and Fauna in Mangrove Ecosystems under Anthropogenic Pressure in South Sumatra, Indonesia

Sarno[1,*], Muhammad Ikhsan[2], Desitarani[2], Yadi Oktariansyah[1], Guntur Pragustiandi[1]

[1] Department of Biology, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Indralaya, Indonesia
[2] PT Kiara Multi Lestari, Jakarta, Indonesia
[*] Corresponding author. E-mail address: sarno@mipa.unsri.ac.id

ARTICLE HISTORY:

Received: 13 May 2025
Peer review completed: 5 August 2025
Received in revised form: 1 October 2025
Accepted: 26 October 2025

KEYWORDS:

Biodiversity
Conservation
Mangrove
Rapid assessment
Vegetation analysis

ABSTRACT

Mangrove habitats serve vital functions; however, this habitat tends to face degradation affected by human activity. This study proposes to evaluate the diversity of flora and fauna in two mangrove habitats in South Sumatra, Indonesia: Banyuasin and Ogan Komering Ilir (OKI). Vegetation analysis was assessed using standard transect and plot-based methods, while fauna were recorded using a rapid assessment method. The results indicated that Banyuasin exhibited a superior flora diversity through a higher Shannon-Wiener Index (H' = 1.61) in contrast to OKI (H' = 1.04); however, the disparity was not statistically significant (p = 0.06). Banyuasin had a greater variety of mangrove trees, including *Avicennia alba*, *Nypa fruticans*, *Sonneratia caseolaris*, *Kandelia candel*, and *Bruguiera gymnorrhiza*, than OKI, which only had *A. alba* and *S. caseolaris*. In Banyuasin, fauna observations found three mammal species, 17 bird species, and 6 herpetofauna species, compared to one mammal, 16 birds, and 4 herpetofauna in OKI. Species such as *Trachypithecus cristatus*, *Prionailurus* sp., and *Elanus caeruleus* were only found in Banyuasin. These findings conclude that higher human activity in OKI may lead to biodiversity degradation. Therefore, there is an urgent need for robust conservation policies and community-based management to preserve ecosystem services in the mangrove habitats of these regions.

1. Introduction

Mangrove ecosystems play pivotal roles in the environment, the economy, and society in tropical and subtropical regions. Ecologically, mangrove ecosystems provide habitats for a diverse range of flora and fauna, facilitate carbon sequestration, recycle nutrients, and serve as natural barriers to erosion (Manoj et al. 2023; Moritsch et al. 2021). Mangroves enable local communities to maintain their traditional ways of life, support ecotourism, and sustain fisheries activities (Sarkar et al. 2024; Singgalen 2020). Mangroves are very important, but they are dying off worldwide. The current study has revealed that approximately 3.4% of the world's mangrove ecosystems were degraded between 1996 and 2020 (Bunting et al. 2020). As one of the largest owners of mangrove forests, Indonesia has lost approximately 182,091 ha of mangrove habitats between 2009 and 2019 (Arifanti et al. 2021). This was largely due to the combined effects of aquaculture, agriculture, pollution, and climate change (Sarkar et al. 2024; Utomo and Septinar

2022; Yudha et al. 2022). Such degradation jeopardizes biodiversity, diminishes ecosystem services, and heightens the susceptibility of coastal communities (Amelia et al. 2024; Carugati et al. 2018; Richards and Friess 2016).

The Banyuasin and Ogan Komering Ilir (OKI) regions encompass extensive mangrove ecosystems that are crucial for local livelihoods in South Sumatra. Banyuasin's mangrove ecosystems are relatively well-studied (Agustriani et al. 2023; Yuliana et al. 2019), but information from OKI remains scarce. Historical assessments by Eddy et al. (2003) indicate that Banyuasin has lost approximately 20,546.5 ha of mangroves between 1993 and 2003, while nearly 20% of the remaining area is now critically endangered (Septinar et al. 2023). In OKI, residents' activities, including the widespread conversion of mangroves into fish ponds and agricultural land, represent a significant threat to ecosystem stability. However, although land-cover change has been documented, little is known about the biodiversity status of flora and fauna in these two regions. This knowledge gap limits the ability to design comprehensive conservation and management strategies in these regions.

The goal of this research is to conduct a survey of species diversity within the mangrove ecosystems of Banyuasin and OKI. Previous studies have shown that mangrove ecosystems in South Sumatra are under pressure from local community activities, including aquaculture expansion, settlement development, and resource extraction (Septinar et al. 2023; Utomo and Septinar 2022; Utomo et al. 2025). In general, mangrove ecosystems are categorized into primary ecosystems, which have relatively undisturbed habitats, and secondary ecosystems, where degradation has occurred due to anthropogenic activities (Carugati et al. 2018). In this study, monitoring was conducted as a short-term field survey during September–October 2024, serving as a baseline assessment rather than a long-term monitoring program. Several sampling sites were selected to represent different mangrove ecosystem types, as categorized by PT Kiara Multi Lestari (unpublished data). The survey included vegetation analysis to document and analyze species composition, abundance, and distribution, along with a rapid assessment of fauna (Yustian et al. 2017). The findings are expected to provide a baseline for long-term monitoring and contribute to conservation planning and management practices, serving as a reference for policymakers in preserving these vital ecosystems.

2. Materials and Methods

2.1. Study Area

This research was conducted in September and October 2024 at two sites: Banyuasin (**Fig. 1**) and OKI (**Fig. 2**). In Banyuasin, three sites were assessed, each representing a different vegetation type. For OKI, one site was chosen (**Table 1**).

Table 1. Research survey area

No.	Sampling Area	Mangrove Site	Coordinate Point	Vegetation Type
1	Transect 1	Banyuasin	2°22'55.0"S 104°37'55.3"E	Secondary mangrove forest
2	Transect 2	Banyuasin	2°27'6.0"S 104°44'54.4"E	Secondary swamp forest
3	Transect 3	Banyuasin	2°22'0.3"S 104°55'24.2"E	Primary mangrove forest
4	Transect 4	OKI	3°32'33.9"S 105°50'39.3"E	Secondary mangrove forest

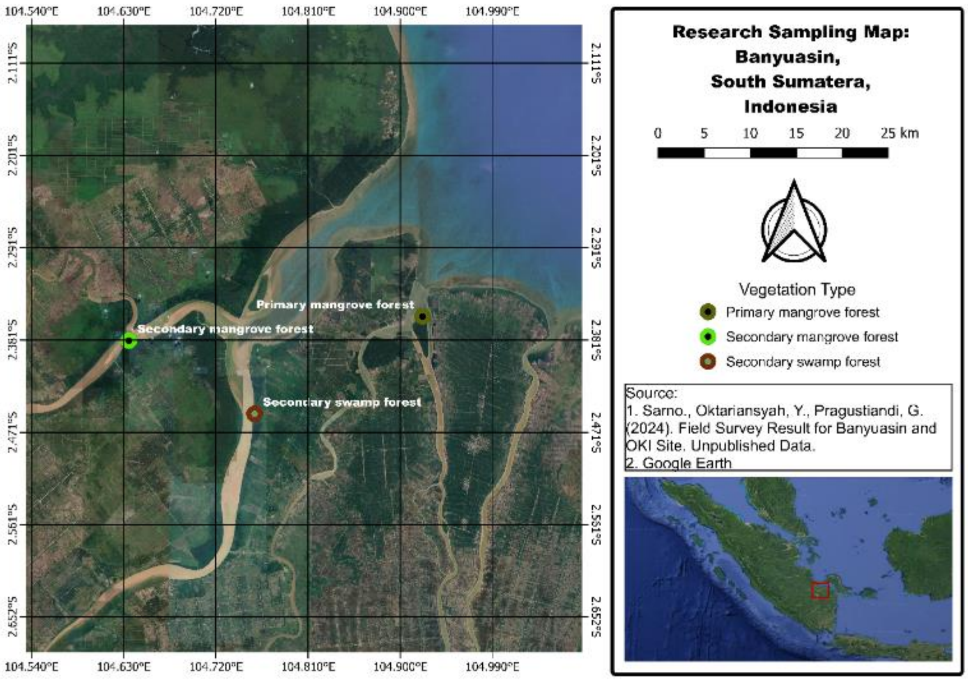

Fig. 1. Sampling map for Banyuasin site.

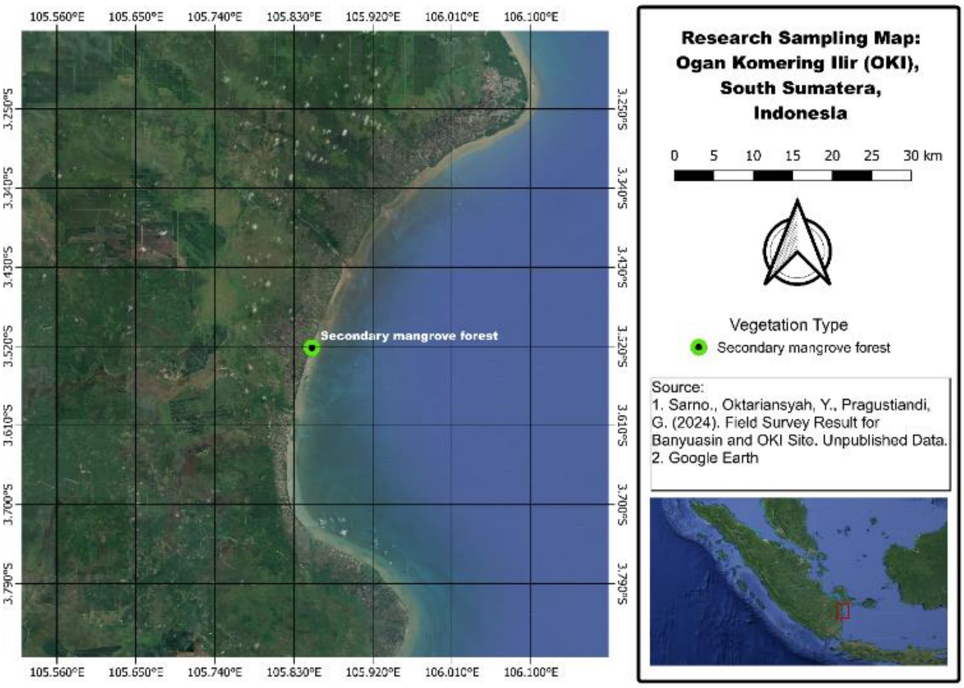

Fig. 2. Sampling map for OKI site.

2.2. Research Procedures

2.2.1. Flora Survey

A flora survey uses the vegetation analysis method to refer to vegetation types in several spots of natural habitat areas by creating main transects line about 100 m, five observation plots with 20 m distance for each plots with zig zag configuration (**Fig. 3**). Several characteristics for plot wide specification refer to Fachrul (2007) as follow: A (2 × 2 m) for the seedling level with plant height < 1.5 cm, B (5 × 5 m) for the tree diameter < 10, with plant height > 1.5 m, C (10 ×

10 m) for the tree diameter about 10–20 cm (pole level), and D (20 × 20 m) for the tree diameter > 20 cm (tree level) that are expected to represent each type of vegetation. A combination of path and gridded line methods is crucial for determining the composition of types and vegetation structures (Sapardi et al. 2024). However, since the effect of sea tides is significant, we focus only on assessing plant communities at the tree and pole levels.

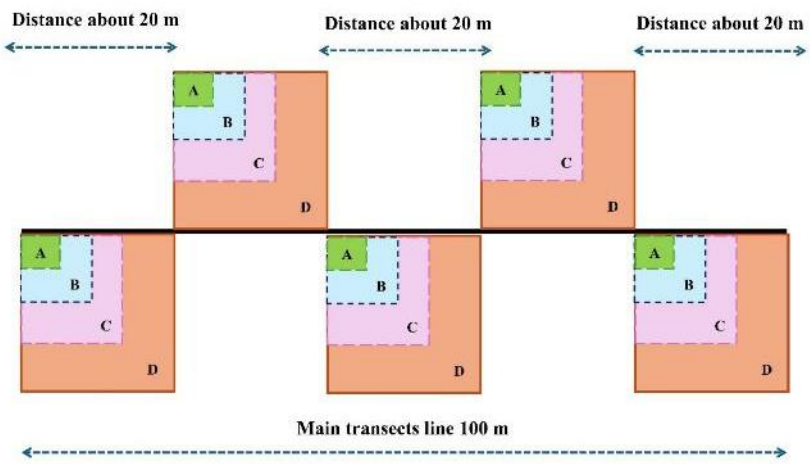

Fig 3. Transect scheme at study site: A (2 × 2 m) for the seedling level with plant height < 1.5 cm, B (5 × 5 m) for the tree diameter < 10, with plant height > 1.5 m, C (10 × 10 m) for the tree diameter about 10–20 cm (pole level), and D (20 × 20 m) for the tree diameter > 20 cm (tree level) that are expected to represent each type of vegetation).

The variables measured in this observation were relative density (RD), relative frequency (%), relative dominance (RDo), importance value index (IVI) and diversity index (H') using Equations 1–5 (Akram et al. 2019; Harbi et al. 2024).

$$RD\ (\%) = \frac{Density\ of\ a\ species}{Density\ of\ all\ species} \times 100\% \tag{1}$$

where *RD* is vital to measure the proportion of individuals of a species relative to the total number of individuals by identifying which species are most abundant.

$$RF\ (\%) = \frac{Frequency\ of\ a\ species}{Frequency\ of\ all\ species} \times 100\% \tag{2}$$

where *RF* is essential to measure the proportion of plots where a species occurs relative to all species, indicating how widely a species is distributed.

$$RDo\ (\%) = \frac{Dominancy\ of\ a\ species}{Dominancy\ in\ all\ species} \times 100\% \tag{3}$$

where *RDo* measures the proportion of total basal area (or cover) a species occupies and highlights the species that occupies the most space or biomass.

$$IVI = RD + RF + Rdo \tag{4}$$

The *IVI* measures the sum of relative density, frequency, and dominance, indicating overall importance and ranking species by ecological significance.

The Shannon–Wiener exponential index was used as follows for the diversity index.

$$H' = exp\ [-\sum_{i=1}^{n} pi\ ln(pi)] \tag{5}$$

The diversity index quantifies species diversity by assessing community richness and evenness. The Shannon–Wiener diversity index (H') quantifies species diversity within a community. In this context, *Pi* represents the relative abundance of a given species, calculated as the number of individuals of that species (*n*) divided by the total number of individuals across all species (*N*). The term *ln(Pi)* refers to the natural logarithm of this relative abundance. The index is computed by summing the product of each *Pi* and its corresponding *ln(Pi)* across all species, denoted by the summation symbol (Σ), and multiplying the final result by negative one (-1) to yield a positive diversity value.

2.2.2. Fauna Survey

For the fauna survey, a rapid assessment method by Yustian et al. (2017) was employed, with modifications made to suit the mangrove landscape. The survey was adjusted to the taxa level, including mammals, birds, amphibians, and reptiles (herpetofauna), using different approaches for each group to maximize detection. For birds, observations were conducted using point counts and line transects during peak activity periods (6:00–10:00 AM and 3:30–6:00 PM). At each site, observers stood quietly for 10 minutes at fixed points within a 50 m radius and recorded all individuals seen or heard. Additional records were obtained opportunistically along transects while moving slowly. For mammals, surveys combined direct sightings, auditory detections, and indirect signs (such as tracks, nests, or feces) along established transects. Surveys were conducted both in the morning and afternoon. Binoculars and digital cameras were used to aid identification and documentation. For herpetofauna (amphibians and reptiles), visual encounter surveys (VES) were carried out along transects and around water bodies during both daytime and nighttime (7:00–10:00 PM) using headlamps and flashlights. Observers systematically searched microhabitats, such as under logs, within root systems, and around tidal pools, to detect individuals that were hidden.

All fauna were identified in the field using regional field guides and species keys. Uncertain identifications were supported with photographs for later verification by experts. For each record, the following data were noted: species name, number of individuals, time of observation, GPS location, and habitat type. To ensure standardization, the survey effort (in terms of person-hours and transect length) was kept consistent across both the Banyuasin and OKI sites. The conservation status of recorded species was later verified using the IUCN Red List (2023), the CITES Appendices, and the Minister of Environment and Forestry Regulation P.106/MENLHK/SETJEN/KUM.1/12/2018 regarding protected species in Indonesia.

2.3. Data Analysis

Analyses were conducted using RStudio (statistical analysis software), version 4.4.2. R package vegan (Oksanen et al. 2025; https://github.com/vegandevs/vegan) was used in this study to analyze the flora diversity index and other related to ecological functions for community and vegetation analysis. For the statistical test, the normal distribution of the flora diversity index was assessed using the Shapiro–Wilk W test. Student's t–test or Mann–Whitney U test was used to assess the difference in flora diversity index. The significance level was set to $p < 0.05$. The package Biodiversity RGUI (Kindt and Coe 2005) was used for the statistical analysis.

3. Results and Discussion

3.1. Flora Survey

The presence of various plant types in an area indicates its ability to adapt to diverse habitats and exhibit a wide tolerance to environmental conditions (Pragustiandi et al. 2024). Based on the field observation, the Banyuasin site was dominated by *Avicennia alba*, *A. marina*, *Nypa fruticans*, *Sonneratia caseolaris*, *Kandelia candel*, and *Bruguiera gymnorrhiza*; however, the OKI site was only dominated by *A. alba* and *S. caseolaris* (**Table 2**). On the other hand, *A. alba*, *N. fruticans*, *A. marina*, *S. caseolaris*, and *B. gymnorrhiza* have been well–known as actual composers of mangrove ecosystems (Pohos et al. 2021; Win et al. 2019). In general, the diversity of mangroves at the Banyuasin site (H' = 1.61) was higher than in OKI (H' = 1.05), but the difference was not significant (**Table 3**).

Table 2. Diversity index (H') of flora at Banyuasin and OKI site

Location	Community level	H'	Category*
Banyuasin			
1	Tree	1.47	Moderate
2	Pole	1.75	Moderate
OKI			
3	Tree	1.05	Moderate
4	Pole	1.04	Moderate

Note: * = refer to Fachrul (2007).

Table 3. Statistical test for diversity index (H')

Community level	Mean H'		*p* – value
	Banyuasin	OKI	
Pole – Tree	1.61	1.05	0.06

Note: * = significantly lower than those in another site (student's t–test).

At both the Banyuasin and OKI sites, *A. alba* was easily observed. It appears that *A. alba* has adapted well to both sites. Under direct observation, both the Banyuasin and OKI sites have a similar soil type, characterized by a muddy sand substrate, which may facilitate a more even distribution of *A. alba* at these sites (Bimantara et al. 2021). Some studies have revealed that *A. alba* prefers soft, muddy substrates with high organic content, but can also grow in sandy or clayey soils (Alongi 2015). *A. alba* is often found in dense mangrove forests, contributing to coastal stabilization and providing a habitat for diverse marine and terrestrial organisms (Hongwiset et al. 2022).

A deeper investigation at the community level revealed that the diversity index for the Banyuasin and OKI sites showed slight differences at the tree and pole levels (**Table 3**). Both sites were categorized as moderate ecosystems (Fachrul 2007). The OKI site has a lower diversity index than Banyuasin, which may be due to higher local community activity at OKI (**Table 4**). Another study by Utomo et al. (2025) indicates that 544.17 ha of mangrove ecosystems have been used as production forests, resulting in a 28.54% decrease from 2013 to 2023, as protected areas have been converted into production forests (BPS OKI 2023). The local community at the OKI site, located in the coastal region, continually relies on the mangrove ecosystem to support their daily lives, using it as a habitat, agricultural land, and fishponds (Utomo et al. 2025). This use harms biodiversity, ultimately leading to its decline. Moreover, several factors may contribute to this condition, especially anthropogenic factors, which reduce vegetation diversity on these sites from high to moderate levels. On the other hand, robust regulation to maintain the biodiversity of flora on these sites needs to be a concern for policymakers.

Table 4. Plant community and ecological index for each transect

No.	Transect	Scientific names	Mangrove sites	Community level	RD (%)	RF (%)	RDo (%)	IVI
1	1	*A. alba*	Banyuasin	Tree	46.30	41.67	26.31	114.27
2		*N. fruticans*	Banyuasin	Tree	18.52	16.67	69.50	104.69
3		S. *caseolaris*	Banyuasin	Tree	35.19	41.67	4.19	81.04
4		*A. alba*	Banyuasin	Pole	35.71	42.86	37.78	116.35
5		*N. fruticans*	Banyuasin	Pole	35.71	28.57	33.00	97.28
6		*S. caseolaris*	Banyuasin	Pole	28.57	28.57	29.23	86.37
7	2	*A. alba*	Banyuasin	Tree	68.75	66.67	36.62	172.04
8		*N. fruticans*	Banyuasin	Tree	31.25	33.33	63.38	127.96
9		*A. alba*	Banyuasin	Pole	59.09	50.00	50.59	159.69
10		*N. fruticans*	Banyuasin	Pole	40.91	50.00	49.41	140.31
11	3	*A. alba*	Banyuasin	Tree	8.33	15.38	2.02	25.74
12		*A. marina*	Banyuasin	Tree	38.89	38.46	42.87	120.22
13		B. *gymnorrhiza*	Banyuasin	Tree	5.56	15.38	2.97	23.91
14		*K. candel*	Banyuasin	Tree	8.33	15.38	1.62	25.34
15		*N. fruticans*	Banyuasin	Tree	38.89	15.38	50.52	104.79
16		*A. alba*	Banyuasin	Pole	12.50	12.50	4.36	29.36
17		*A. marina*	Banyuasin	Pole	25.00	37.50	27.03	89.53
18		*K. candel*	Banyuasin	Pole	25.00	25.00	22.96	72.96
19		*N. fruticans*	Banyuasin	Pole	37.50	25.00	45.66	108.16
20	4	*A. alba*	OKI	Tree	46.30	41.67	26.31	114.27
21		*S. caseolaris*	OKI	Tree	35.19	41.67	4.19	81.04
22		*A. alba*	OKI	Pole	30.30	50.00	41.34	121.64
23		*S. caseolaris*	OKI	Pole	69.70	50.00	58.66	178.36

Based on the ecological index at both the Banyuasin and OKI sites, at both pole– and tree–levels, *A. alba* demonstrates a strong ecological presence across most transects, highlighting its significance in mangrove ecosystems. However, *N. fruticans* and *S. caseolaris* exhibit greater dominance, which may potentially influence interspecific competition (**Table 4**). The dominance of *N. fruticans* and *S. caseolaris* may lead to resource monopolization, particularly for light and belowground nutrients. Their extensive root systems and rapid vegetative growth could suppress *A. alba* regeneration, potentially altering community structure over time. Another study by Wu et al. (2024) revealed that *N. fruticans* has a low mutation rate and evolved slowly, contributing to its stability and tolerance to waterlogging, while also indicating its long-term adaptation to intertidal environments and ultimately supporting its wide distribution along the mangrove ecosystem.

Transect 3 at Banyuasin has a greater variety of mangrove species than other locations, including *A. alba*, *K. candel*, and *N. fruticans* (**Fig. 4**). *K. candel* stands as a mangrove community builder that plays an important role in conservation activities because it is a kind of rare mangrove (Sarno et al. 2020). On the other hand, *K. candel* exhibits unique physiological responses that confer greater tolerance to increasing salinity than those of other species (Nizam et al. 2024), potentially leading to its use in rehabilitation programs. This could suggest that this area has greater habitat complexity or less environmental stress, which supports the ability to enable coexistence between each species (Nauta et al. 2023). Under direct observation, Transect 3 is situated in an area with lower anthropogenic activity, which may provide a better habitat for these species. Anthropogenic activity can reduce mangrove ecosystems by altering land use, such as converting farmland to fish ponds (Utomo and Septinar 2022).

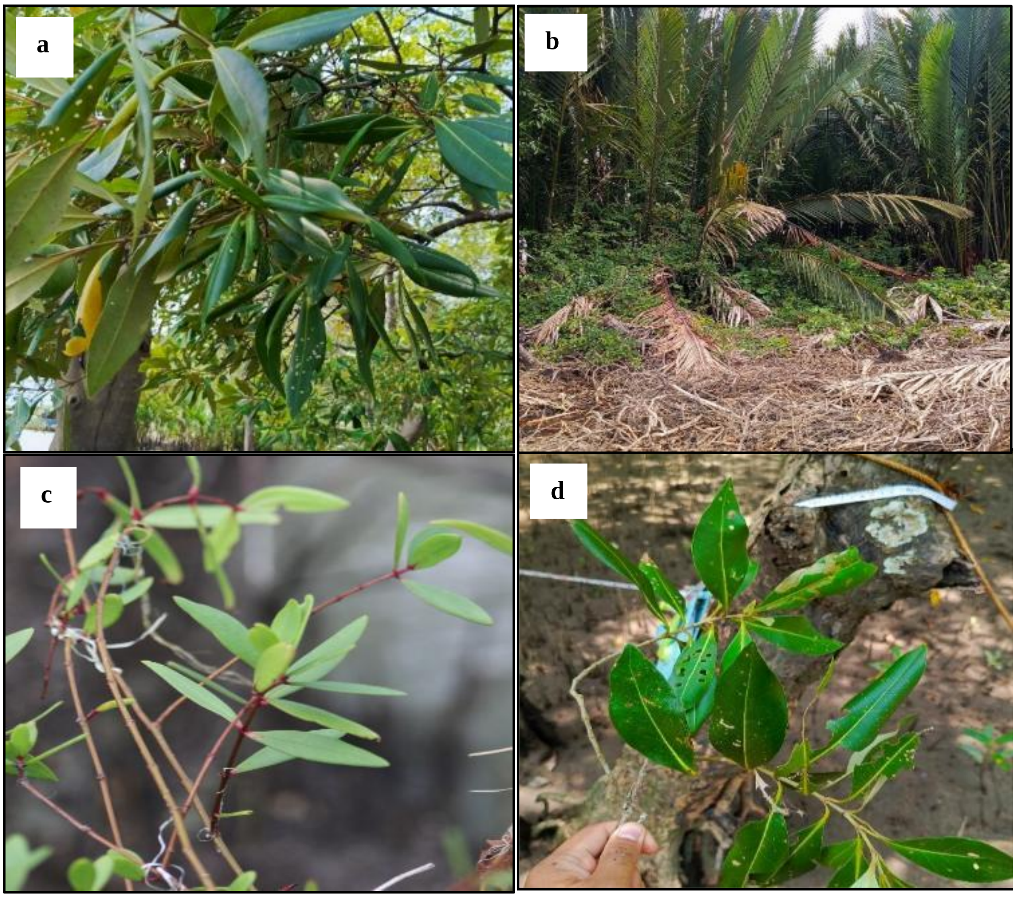

Fig. 4. Species found in this observation: (a) *Avicennia alba*, (b) *Nypa fruticans*, (c) *Sonneratia caseolaris*, and (d) *Kandelia candel*.

3.2. Fauna Survey

3.1.1. Mammals

Mammals play important roles in the sustainability of forest ecosystems, including the mangrove ecosystem, such as seed dispersal, pollinators, prey for carnivores, and controllers of insect populations, which helps maintain the diversity of forest plants and serves as an agent in forest rehabilitation (Lazar et al. 2021; Rosa et al. 2021). Based on the field survey results, two mammal species were identified: *Macaca fascicularis* and *Trachypithecus cristatus* (**Table 5**), both of which are listed as protected species on the IUCN Red List (2023). *Macaca fascicularis* (**Fig. 5**) was observed at both sites, living in groups and actively hunting in the coastal regions. The abundance of this species has decreased due to anthropogenic factors, such as deforestation, which can degrade habitats (Fitriana et al. 2022).

As in our study site, mangrove deforestation has occurred in Banyuasin, resulting in a reduction of approximately 20,546.5 ha between 1993 and 2003 (Eddy et al. 2015). Similarly, in OKI, approximately 544,172 ha of mangrove ecosystem have been utilized for production forest (Utomo et al. 2025), which may lead to a reduction in the abundance of this species. According to the IUCN Red List (2023), a wildlife management program for this species is crucial, particularly in maintaining habitat suitability by reducing habitat loss and mitigating the risk of human–wildlife conflict. Meanwhile, based on research conducted across several locations in South Sumatra Province, particularly in the lowlands, 4,316 individuals of *M. fascicularis* were recorded at 17 sites (Setiawan et al. 2024). A recent survey in South Sumatra reported 1,194 individuals of *M. fascicularis* (Setiawan et al. 2023). It is suggested that the population density in South Sumatra Province is high.

Table 5. Mammals observed at the study site

No.	Scientific names	Local names	Mangrove Site		Protection Status		
			Banyuasin	OKI	GR	IUCN	CITES
1	*Macaca fascicularis*	Monyet ekor panjang	+	+	NP	VU	–
2	*Trachypithecus cristatus*	Lutung kelabu	+	–	P	VU	–
3	*Prionailurus* sp.	Kucing Bakau	+	–	–	–	–

Notes: EN = Endangered, GR = Government Regulation, NP= Not protected, P = Protected, VU = Vulnerable, + = Observed, – = Unobserved / Not assessed.

Trachypithecus cristatus (**Fig. 5**) was only found at the Banyuasin site. This species inhabits arboreal areas near the coastal region on trees. This species has also been classified as vulnerable and is potentially affected by habitat degradation (IUCN Red List 2023). Direct observation reveals that *T. cristatus* interacts sympatrically with *M. fascicularis*, as these species are frequently found in the same tree without apparent conflict. Sympatric interactions can be supported by a niche that promotes positive population growth through food availability and related factors, allowing coexistence between these species (Eloranta et al. 2021).

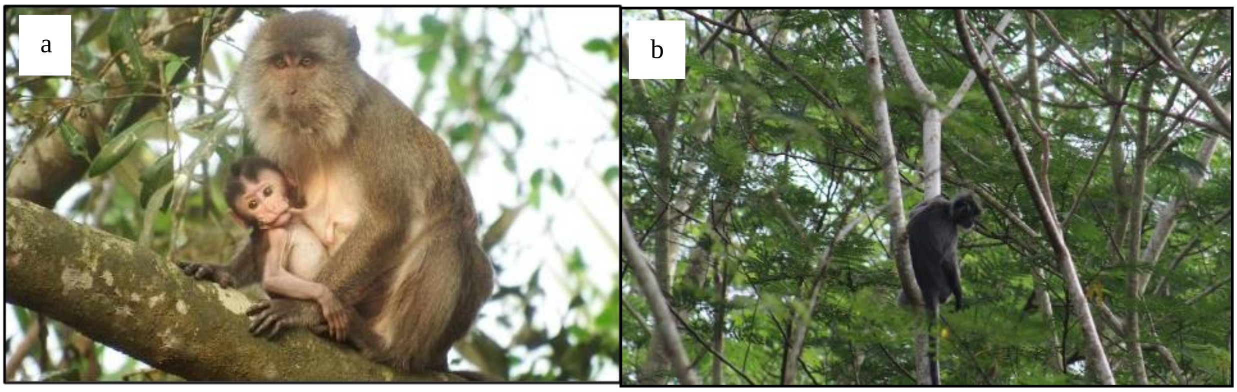

Fig. 5. Mammals observed: (a) *Macaca fascicularis*, and (b) *Trachypithecus cristatus*.

3.2.2. Birds

Birds play crucial roles in maintaining ecological processes and promoting ecosystem resilience, such as pollination, seed dispersal, pest control, and nutrient cycling, which underscores their importance in both natural and agricultural systems (Mariyappan et al. 2023; Sekercioglu et al. 2019). Monitoring of birds as part of conservation efforts is therefore vital to sustaining bird populations and the ecosystems they support. The bird species composition was recorded in these sites, showing both overlap and distinctiveness. Based on our observations, we recorded 23 bird species across both sites (**Table 6**).

Table 6. Birds observed at the study sites

Nu.	Scientific names	Local names	Mangrove Site		Protection Status		
			Banyuasin	OKI	GR	IUCN	CITES
1	*Alcedo* sp.	Raja–udang	+	–	–	–	–
2	*Anas gibberifrons*	Itik benjut	–	+	–	NT	–
3	*Ardea purpurea*	Cangak merah	+	–	NP	LC	–
4	*Ardeola speciosa*	Blekok sawah	+	–	NP	LC	–
5	*Butorides striata*	Kokokan laut	+	–	NP	LC	–
6	*Dendrocopos moluccensis*	Caladi tilik	+	–	NP	LC	–
7	*Egretta garzetta*	Kuntul kecil	+	+	NP	LC	–
8	*Elanus caeruleus*	Elang tikus	+	–	P	LC	II
9	*Gelochelidon nilotica*	Dara laut tiram	–	+	P	LC	–
10	*Haliastur indus*	Elang bondol	+	+	P	LC	II
11	*Himantopus leucocephalus*	Gagang–bayam timur	–	+	–	–	–
12	*Hirundo javanica*	Layang–layang batu	+	+	NP	LC	–
13	*Microcarbo niger*	Pecuk padi kecil	–	+	–	LC	–
14	*Mycteria cinerea*	Bangau bluwok	+	+	P	EN	–
15	*Nycticorax nycticorax*	Kowak–malam abu	+	+	–	LC	–
16	*Orthotomus ruficeps*	Cinenen kelabu	+	+	NP	LC	–
17	*Pellorneum rostratum*	Pelanduk dada–putih	+	+	NP	NT	–
18	*Phalacrocorax sulcirostris*	Pecuk padi	+	–	NP	LC	–
19	*Pycnonotus aurigaster*	Cucak kutilang	–	+	NP	LC	–
20	*Rhipidura javanica*	Kipasan belang	+	+	P	LC	–
21	*Todiramphus chloris*	Cekakak sungai	+	+	NP	LC	–
22	*Tringa tetanus*	Trinil kaki–merah	–	+	–	LC	–
23	*Zosterops simplex*	Kaca–mata sunda	+	+	NP	LC	–

Notes: EN = Endangered, GR = Government Regulation, LC = Least Concern, NE = Not Evaluated, NT = Near Threatened, NP = Not protected, P = Protected, VU = Vulnerable, + = Observed, – = Unobserved / Not assessed.

At the Banyuasin site, a total of 16 bird species were recorded, of which four were legally protected under Indonesian regulations, namely *Elanus caeruleus* (LC, CITES II), *Haliastur indus* (LC, CITES II), *Mycteria cinerea* (EN), and *Rhipidura javanica* (LC). The remaining 12 species were not protected, although *Pellorneum rostratum* was categorized as Near Threatened (NT) by the IUCN. Similarly, on the OKI site, 16 bird species were also observed, including four protected species—*Gelochelidon nilotica* (LC), *Haliastur indus* (LC, CITES II), *Mycteria cinerea* (EN), and *Rhipidura javanica* (LC). Among the unprotected species in OKI, two were of conservation concern: *Anas gibberifrons* and *Pellorneum rostratum*, both listed as Near Threatened (NT) by the IUCN. However, there were distinctive bird community differences between the two sites, with Banyuasin hosting seven species (*Alcedo* sp., *Ardea purpurea*, *Ardeola speciosa*, *Butorides striata*, *Dendrocopos moluccensis*, *E. caeruleus*, and *Phalacrocorax sulcirostris*) that were absent in OKI;

on the other hand, OKI supported six species (*Anas gibberifrons*, *Gelochelidon nilotica*, *Himantopus leucocephalus*, *Microcarbo nige*r, *Pycnonotus aurigaster*, and *Tringa tetanus*). These findings revealed that both sites support populations of legally protected raptors (*E. caeruleus* and *H. indus*) and globally threatened waterbirds (*M. cinerea*), underscoring the importance of South Sumatra's mangrove landscape as critical habitat for species of high conservation value.

Compared with other mangrove areas in Indonesia, the number of bird species recorded at these sites (23 species) is relatively moderate. For example, studies in the Kalagian Besar mangroves at Lampung reported 27 bird species (Nugraha et al. 2019), whereas the mangrove area of the south coast of Bangkalan, Madura Island, recorded 15 species (Ramadhani et al. 2022). Moreover, the lower bird abundance in OKI compared to Banyuasin may reflect greater habitat disturbance and conversion pressures, consistent with our observations of aquaculture expansion. Several species observed are categorized as protected, including *E. caeruleus*, *M. cinerea*, and *H. indus*. The presence of these species, particularly raptors and large waterbirds, suggests that mangroves in Banyuasin and OKI continue to serve as important feeding and roosting habitats for higher-trophic-level species.

E. caeruleus (**Fig. 6**) was known as a small raptor with unique morphological and habitat traits such as distinctive white, gray plumage and black shoulder patches, inhabiting open habitats and also known to use the mangrove edges for hunting (Utomo and Septinar 2022; Wu et al. 2023). In Indonesia, it is protected under Government Regulation No. 7 of 1999 due to its ecological importance and threats to its habitat. *H. indus* (**Fig. 6**) was observed in both Banyuasin and OKI sites. This species is also legally protected and listed in Appendix II of CITES, reflecting the need for regulated international trade (Nainggolan et al. 2019). *M. cinerea* (**Fig. 6**), a stork dependent on wetland habitats, is categorized as Endangered on the IUCN Red List (2023) and is legally protected in Indonesia. Its occurrence at both sites underscores the conservation value of these mangrove wetlands as refugia for globally threatened species.

Although no endemic species were found in these sites, the presence of protected and threatened species underlines the role of South Sumatra's mangroves as important stopover and breeding grounds in regional bird migration networks. Thus, our bird survey not only provides updated biodiversity records but also underscores the ecological value of Banyuasin and OKI mangroves in sustaining avian diversity, thereby supporting broader ecosystem services.

3.2.3. Herpetofauna

The abundance of herpetofauna is significantly affected by climate change, as body temperatures of these animals depend on ambient temperature (Ryan et al. 2016). Therefore, herpetofauna need conservation efforts to minimize distribution shrinkage. A total of six herpetofauna species were recorded across both sites (**Table 7**).

In Banyuasin, all six species were observed, including *Crocodylus porosus*, *Varanus salvator*, *Eutropis multifasciata*, *Hemidactylus frenatus*, *Takydromus sexlineatus*, and *Fejervarya cancrivora*. In contrast, only four species were found in OKI: *Crocodylus porosus*, *Varanus salvator*, *Eutropis multifasciata*, and *Hemidactylus frenatus*, with the notable absence of *Fejervarya cancrivora* and *Takydromus sexlineatus*. Among the recorded species, only *Crocodylus porosus* is legally protected under Indonesian regulation, while the others are common and categorized as Least Concern (LC) by the IUCN. The higher richness in Banyuasin compared to OKI indicates that relatively intact mangrove habitats in Banyuasin still provide niches for amphibians and reptiles with more specific habitat requirements (e.g., *F. cancrivora* in brackish swamps, *T. sexlineatus* in vegetated areas). Meanwhile, the reduced diversity in OKI is consistent with the greater anthropogenic disturbance observed in this region. The fact that *C. porosus* was still recorded in both sites suggests that even degraded mangroves in OKI retain minimal habitat function for wide-ranging apex predators, but may not sustain smaller or more habitat-sensitive species.

Fig. 6. Birds observed: (a) *Elanus caeruleus*, (b) *Mycteria cinerea*, (c) *Haliastur indus*, and (d) *Microcarbo niger*.

Table 7. Herpetofauna observed at the study sites

No.	Scientific names	Local names	Mangrove Site			Protection Status	
			Banyuasin	OKI	GR	IUCN	CITES
1	*Crocodylus porosus*	Buaya Muara	+	+	P	LC	–
2	*Eutropis multifasciata*	Kadal kebun	+	+	NP	LC	–
3	*Fejervarya cancrivora*	Katak	+	–	NP	LC	–
4	*Takydromus sexlineatus*	Kadal rumput	+	–	NP	LC	–
5	*Hemidactylus frenatus*	Cicak	+	+	NP	LC	–
6	*Varanus salvator*	Biawak	+	+	NP	LC	–

Notes: GR = Government Regulation, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, NE = Not Evaluated, P = Protected, NP = Not Protected, + = Observed, – = Unobserved / Not Assessed.

Crocodylus porosus (**Fig. 7**) has experienced a population decline due to habitat loss and illegal hunting, driven by the high economic value of its skin, meat, and other products, despite existing protection regulations (IUCN Red List 2021). As an apex predator, this species can also pose threats to humans, particularly in areas where mangrove habitats overlap with settlements (Amarasinghe et al. 2015). Our survey recorded the species in both Banyuasin and OKI, indicating that mangrove areas in both regions still provide minimal habitat support for wide-ranging predators. However, species richness of the herpetofauna was higher in Banyuasin (6 species) than in OKI (4 species), with the absence of *Fejervarya cancrivora* and *Takydromus sexlineatus* in OKI. This difference suggests that while *C. porosus* can persist even in disturbed or fragmented habitats, whereas smaller and habitat-sensitive reptiles and amphibians are more vulnerable to degradation. Thus, the presence of *C. porosus* in OKI does not necessarily reflect good habitat quality but rather its ecological tolerance, whereas the reduced diversity of other herpetofauna points to poorer mangrove conditions. Conservation actions are therefore urgently required to restore habitat quality in OKI and mitigate potential human–crocodile conflict in both regions.

Fig. 7. Herpetofauna observed at study site, *Crocodylus porosus*.

4. Conclusions

This study provides the first comparative assessment of the diversity of flora and fauna in the mangrove ecosystems of Banyuasin and OKI, South Sumatra. For flora, the diversity index in Banyuasin (H' = 1.61) was higher than in OKI (H' = 1.04), although the difference was not statistically significant. The mangrove community in Banyuasin was dominated by *A. alba*, *N. fruticans*, and *S. caseolaris*, while in OKI, *A. alba* and *S. caseolaris* were the main dominant species. This suggests that higher anthropogenic activities in OKI have reduced structural complexity and diversity compared to Banyuasin. In terms of fauna, Banyuasin supported greater species richness, including three mammals, 17 bird species, and six herpetofauna, compared to OKI, which supported one mammal, 16 bird species, and four herpetofauna. Several species recorded are of global conservation concern. For example, *T. cristatus* (VU), *M. cinerea* (EN), and *H. indus* (LC, CITES II) highlight the conservation importance of these mangroves. Many species observed were classified as Least Concern (LC) on the IUCN Red List, such as *E. garzetta*. However, their presence still indicates the role of these ecosystems as critical habitats. Overall, the findings show that Banyuasin maintains higher biodiversity and habitat integrity than OKI, where human disturbance is more intense. Conservation policies should prioritize stricter regulation of land conversion, protection of dominant and rare mangrove species, and habitat management for threatened fauna. Long-term monitoring and community-based management are urgently needed to sustain mangrove biodiversity and ecosystem services in South Sumatra.

Acknowledgments

We thank PT Kiara Multi Lestari for funding this research. We also thank Muhammad Tareq Akbar and Jon Herwadi for their support in analyzing vegetation and conducting animal surveys.

Author Contributions

S.: Conceptualization, Supervision, Research Funding, Project Administration, Writing – Review and Editing; M.I.: Research Funding, Writing – Review and Editing; D.: Formal Analysis, Writing – Review & Editing; Y.O.: Methodology, Data Curation, Formal Analysis, Writing – Original Draft Preparation, Writing – Review and Editing; G.P.: Methodology, Data Curation, Formal Analysis, Writing – Original Draft Preparation.

Conflict of Interest

The authors declare no conflict of interest.

Declaration of Generative AI and AI-Assisted Technologies in the Manuscript Preparation

Not applicable.

References

Agustriani, F., Iskandar, I., and Muhammad Yazid, F. 2023. Economic Valuation of Mangrove Ecosystem Services in Sembilang National Park of South Sumatra, Indonesia. *Journal of Hunan University Natural Sciences* 50(1): 156–168. DOI: 10.55463/issn.1674-2974.50.1.16

Akram, H., Pasaribu, N., and Siregar, E. S. 2019. Tree Species Diversity, Richness and Similarity in Disturbed and Undisturbed Forest of Ketambe Research Station, Southeast Aceh Regency. *IOP Conference Series: Earth and Environmental Science* 305(1): 012094. DOI: 10.1088/1755-1315/305/1/012094

Alongi, D. M. 2015. The Impact of Climate Change on Mangrove Forests. *Current Climate Change Reports* 1(1): 30–39. DOI: 10.1007/s40641-015-0002-x

Amarasinghe, A. T., Madawala, M. B., Karunarathna, D. S., Manolis, S. C., de Silva, A., and Sommerlad, R. 2015. Human–Crocodile Conflict and Conservation Implications of Saltwater Crocodiles *Crocodylus Porosus* (Reptilia: Crocodylia: Crocodylidae) in Sri Lanka. *Journal of Threatened Taxa* 7(5): 7111–7130. DOI: 10.11609/jott.o4159.7111-30

Amelia, I., Dewinta, A. F., Hasibuan, J. S., and Sivaipram, I. 2024. Seedling Growth Evaluation of Rehabilitated Mangrove and Estimation of Potential Carbon in Two Types of Mangroves in Perlis, Langkat, North Sumatra. *Journal of Sylva Indonesiana* 7(2): 89–96. DOI: 10.32734/jsi.v7i02.13463

Arifanti, V. B., Novita, N., Subarno, and Tosiani, A. 2021. Mangrove Deforestation and CO_2 Emissions in Indonesia. *IOP Conference Series: Earth and Environmental Science* 874(1): 012006. DOI: 10.1088/1755-1315/874/1/012006

Bimantara, Y., Basyuni, M., and Selamet, B. 2021. Exploration of Data on the Formation of Two Mangrove Seedling Species to Establish a Growing Stability Point. *IOP Conference Series: Earth and Environmental Science* 713(1): 012021. DOI: 10.1088/1755-1315/713/1/012021

BPS OKI. 2023. *Kabupaten Ogan Komering Ilir dalam Angka 2023*. BPS Kabupaten Ogan Komering Ilir, South Sumatera, Indonesia.

Bunting, P., Rosenqvist, A., Hilarides, L., Lucas, R., Thomas, N., Tadono, T., Worthington, T., Spalding, M., Murray, N., and Rebelo, L. 2022. Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. *Remote Sensing* 14(15): 3657. DOI: 10.3390/rs14153657

Carugati, L., Gatto, B., Rastelli, E., Lo Martire, M., Coral, C., Greco, S., and Danovaro, R. 2018. Impact of Mangrove Forests Degradation on Biodiversity and Ecosystem Functioning. *Scientific Reports* 8(1): 13298. DOI: 10.1038/s41598-018-31683-0

Eddy, S., Mulyana, A., Ridho, M. R., and Iskandar, I. 2015. Dampak Aktivitas Antropogenik terhadap Degradasi Hutan Mangrove di Indonesia. *Jurnal Lingkungan dan Pembangunan* 1(3): 240–254. DOI: 10.31219/osf.io/xd9cb

Eloranta, A., Finstad, A., Sandlund, O., Knudsen, R., Kuparinen, A., and Amundsen, P. 2021. Species Interactions, Environmental Gradients and Body Size Shape Population Niche Width. *The Journal of Animal Ecology* 91(1): 154–169. DOI: 10.1111/1365-2656.13611

Fachrul, M. F. 2007. *Metode Sampling Bioekologi*. PT Bumi Aksara, Jakarta, Indonesia.

Fitriana, Y. S., Sulistyadi, E., Rifaie, F., Tohir, K. R., Lubis, A. M., Supriatna, N., Suardi, Kamarduddin, D. S., and Nirsyawita. 2024. Introduced Non-Human Primates and Potential Wildlife-Human Conflict: A Case Study of the Long-tailed Macaque (*Macaca fascicularis*) Population on Bonerate and Kalao, Selayar Islands, South Sulawesi. *Jurnal Biologi Indonesia* 20(2): 85–95. DOI: 10.47349/jbi/20022024/85

Harbi, J., Heripan, H., Milantara, N., Yuwono, H., Suharyadi, S., Romantik, R., Alhusna, I. S., and Al-Ansori, M. A. L. 2024. Analyzing the Conditions, Potentials, and Trends of Vegetation Biodiversity in Conservation Zones Located within the Business License Area of PT PHE Ogan Komering. *Journal of Global Sustainable Agriculture* 4(2): 108–115. DOI: 10.32502/jgsa.v4i2.8227

Hongwiset, S., Rodtassana, C., Poungparn, S., Umnouysin, S., and Suchewaboripont, V. 2022. Synergetic Roles of Mangrove Vegetation on Sediment Accretion in Coastal Mangrove Plantations in Central Thailand. *Forests* 13(10): 1739. DOI: 10.3390/f13101739

IUCN Red List. 2021. *IUCN Red List of Threatened Species. Version 2021–1*. <https://www.iucnredlist.org> (Nov. 02, 2024).

IUCN Red List. 2023. *IUCN Red List of Threatened Species. Version 2023–1*. <https://www.iucnredlist.org> (Nov. 02, 2024).

Kindt, R. and Coe, R. 2005. *Tree diversity analysis: A manual and Software for Common Statistical Methods for Ecological and Biodiversity Studies*. <https://www.worldagroforestry.org> (Nov. 02, 2024).

Lazar, A., Benedek, A., and Sîrbu, I. 2021. Small Mammals in Forests of Romania: Habitat Type Use and Additive Diversity Partitioning. *Forests* 12(8): 1107. DOI: 10.3390/f12081107

Manoj, K., Arumugam, T., and Prakash, A. 2024. A Comparative Study on Carbon Sequestration Potential of Disturbed and Undisturbed Mangrove Ecosystems in Kannur District, Kerala, South India. *Results in Engineering* 21(6): 101716. DOI: 10.1016/j.rineng.2023.101716

Mariyappan, M., Rajendran, M., Velu, S., Johnson, A., Dinesh, G., Solaimuthu, K., Kaliyappan, M., and Sankar, M. 2023. Ecological Role and Ecosystem Services of Birds: A Review. *International Journal of Environment and Climate Change* 31(6): 76–87. DOI: 10.9734/ijecc/2023/v13i61800

Moritsch, M. M., Young, M., Carnell, P., Macreadie, P. I., Lovelock, C., Nicholson, E., Raimondi, P. T., Wedding, L. M., and Ierodiaconou, D. 2021. Estimating Blue Carbon Sequestration Under Coastal Management Scenarios. *Science of the Total Environment* 777(3): 145962. DOI: 10.1016/j.scitotenv.2021.145962

Nainggolan, F., Dewi, B., and Darmawan, A. 2019. Bird Conservation Status: Case Study in Cugung Village Forest Kesatuan Pengelolaan Hutan Lindung Model Rajabasa Rajabasa

Regency District South Lampung. *Jurnal Sylva Lestari* 7(1): 52–61. DOI: 10.23960/jsl1752-61

Nauta, J., Lammers, C., Lexmond, R., Christianen, M. J. A., Borst, A., Lamers, L. P. M., van Lavieren, H., Naipal, S., and Govers, L. L. 2023. Habitat Complexity Drives Food Web Structure along a Dynamic Mangrove Coast. *Marine Pollution Bulletin* 196: 115597. DOI: 10.1016/j.marpolbul.2023.115597

Nizam, A., Rawoof, A., and Adot, V. 2024. Comparative Root Transcriptome Analysis of *Kandelia candel* Druce and *Rhizophora mucronata* Lam. Germinating Propagules Under Salinity Gradients Reveal Their Tolerance Mechanisms and Ecological Adaptations. *Plant Growth Regul* 103(3): 539–563. DOI: 10.1007/s10725-024-01125-1

Oksanen, J., Simpson, G., Blanchet, F., Kindt, R., Legendre, P., Minchin, P., O'Hara, R., Solymos, P., Stevens, M., Szoecs, E., Wagner, H., Barbour, M., Bedward, M., Bolker, B., Borcard, D., Borman, T., Carvalho, G., Chirico, M., De Caceres, M., Durand, S. et al. 2025. *Vegan: Community Ecology Package. R Package Version 2.8-0*. <https://vegandevs.github.io/vegan> (Nov. 02, 2024).

Pohos, R., Sondak, C. F., and Rumengan, A. P. 2021. Struktur Komunitas Mangrove di Kelurahan Tapuang, Kecamatan Tahuna, Kabupaten Sangihe. *Jurnal Pesisir dan Laut Tropis* 9(3): 179–185. DOI: 10.35800/jplt.9.3.2021.38611

Pragustiandi, G., Aprillia, I., Setiawan, A., and Yustian, I. 2024. Diversity of Flora in a Pulp Plantation of Sumateran Elephant *Elephas maximus Sumateranus* Habitat in Air Sugihan Wetlands, Ogan Komering Ilir, South Sumatera. *Bio Palembanica* 1(1): 26–34. DOI: 10.36982/bio.v1i1

Richards, D. R., and Friess, D. A. 2016. Rates and Drivers of Mangrove Deforestation in Southeast Asia, 2000–2012. *Proceedings of the National Academy of Sciences* 113(2): 344–349. DOI: 10.1073/pnas.1510272113

Rosa, D., Brocardo, C., Rosa, C., Castro, A., Norris, D., and Fadini, R. 2021. Species–Rich but Defaunated: The Case of Medium and Large–Bodied Mammals in a Sustainable Use Protected Area in the Amazon. *Acta Amazonica* 51(4): 323–333. DOI: 10.1590/1809-4392202101481

Ryan, M. J., Latella, I. M., Giermakowski, J. T., Snell, H., Poe, S., Pangle, R. E., and McDowell, N. G. 2016. Too Dry for Lizards: Short-Term Rainfall Influence on Lizard Microhabitat Use in an Experimental Rainfall Manipulation within a Piñon-Juniper. *Functional Ecology* 30(6): 964–973. DOI: 10.1111/1365-2435.12595

Sapardi, C., Irwanto, I., and Komul, Y. 2024. Struktur dan Komposisi Vegetasi Hutan Alam Negeri Amahusu Kecamatan Nusaniwe Kota Ambon. *MARSEGU: Jurnal Sains dan Teknologi* 1(8): 766–783. DOI: 10.69840/marsegu/1.8.2024.766-783

Sarkar, P., Banerjee, S., Biswas, S., Saha, S., Pal, D., Naskar, M. K., Srivastava, S. K., Barman, D., Kar, G., and Mukul, S. A. 2024. Contribution of Mangrove Ecosystem Services to Local Livelihoods in the Indian Sundarbans. *Sustainability* 16(16): 6804. DOI: 10.3390/su16166804

Sarno, Ridho, M. R., Absori, A., and Kadarisman, R. 2020. *Konservasi Mangrove: Fenologi, Distribusi, dan Demplot Kandelia candel di Taman Nasional Sembilang*. Penerbit ZSL, Bogor, Indonesia.

Sekercioglu, C. H., Wenny, D. G., and Whelan, C. J. 2019. *Why Birds Matter: Avian Ecological Function and Ecosystem Services*. University of Chicago Press, Chicago, United States.

Septinar, H., Putri, Y. P., Midia, K. R., and Bianto, B. 2023. Upaya Pelestarian Hutan Mangrove Melalui Pembibitan di Desa Sungsang IV Kabupaten Banyuasin. *Environmental Science Journal (ESJo): Jurnal Ilmu Lingkungan* 1(2): 77–88. DOI: 10.31851/esjo.v1i2.11920

Setiawan, A., Iqbal, M., Pormansyah., Indriati, W., Pragustiandi, G., Sevli, M., Pratiwi, P. R., Handayani, R., and Yustian, I. 2024. A Wide Survey to Assess Population of Long–Tailed Macaque *Macaca fascicularis* (Primate: Cercopithecidae) in Lowland Region of South Sumatera. *Conserva* 2(01): 22–31. DOI: 10.35438/conserva.v2i1.204

Setiawan, A., Iqbal, M., Setiawan, D., Pormansyah., Saputra, R. F., Indriati, W., Sulistyadi, E., Maharadatunkamsi, and Yustian, I. 2023. Estimate Population of Long-Tailed Macaque *Macaca fascicularis* (Primate: Cercopithecidae) in Calik River, South Sumatera. *Conserva* 1(01): 23–33. DOI: 10.35438/conserva.v1i1.185

Singgalen, Y. A. 2020. Mangrove Forest Utilization for Sustainable Livelihood Through Community-Based Ecotourism in Kao Village of North Halmahera District. *Jurnal Manajemen Hutan Tropika* 26(2): 155–155. DOI: 10.7226/jtfm.26.2.155

Utomo, B., and Septinar, H. 2022. Analisis Perubahan Tutupan Lahan di Hutan Mangrove di Kawasan Hutan Lindung Air Telang Kabupaten Banyuasin, Indonesia. *Majalah Ilmiah Globë* 24(2): 91–99.

Utomo, B., Sumarmi, Utaya, S., and Bachri, S. 2025. Economic and Environmental Sustainability in Silvofishery of Mangrove Ecosystem in 1 Ogan Komering Ilir Protected Forest, Ogan Komering Ilir Regency, Indonesia. *Research Square* 99(7): 207. DOI: 10.21203/rs.3.rs-5928474/v1

Win, T. Z. N., Kyu, T. T., and Win, S. U. 2019. Diversity and Distribution of True Mangroves in Myeik Coastal Areas, Myanmar. *Journal of Aquaculture and Marine Biology* 8(5): 154–161. DOI: 10.15406/jamb.2019.08.00256

Wu, C. F., Lai, J. H., Chen, S. H., and Trac, L.V. T. 2023. Key Factors Promoting the Niche Establishment of Black-Winged Kite *Elanus caeruleus* in Farmland Ecosystems. *Ecological Indicators* 149(5): 110162. DOI: 10.1016/j.ecolind.2023.110162

Wu, W., Feng, X., Wang, N., Shao, S., Liu, M., Si, F., Chen, L., Jin, C., Xu, S., Guo, Z., Zhong, C., Shi, S., and He, Z. 2024. Genomic Analysis of *Nypa fruticans* Elucidates Its Intertidal Adaptations and Early Palm Evolution. *Journal of Integrative Plant Biology* 66(4): 824–843. DOI: 10.1111/jipb.13625

Yudha, R. P., and Sillanpää, M. 2022. The Dynamics of Secondary Mangrove Forests in Bintuni Bay, West Papua after Harvested on the First 30-year Rotation Cycle. *Jurnal Sylva Lestari* 10(1): 83–106. DOI: 10.23960/jsl.v10i1.575

Yuliana, E., Hewindati, Y., Winata, A., Djatmiko, W., and Rahadiati, A. 2019. Diversity and Characteristics of Mangrove Vegetation in Pulau Rimau Protection Forest, Banyuasin District, South Sumatra, Indonesia. *Biodiversitas* 20(4): 1215–1221. DOI: 10.13057/biodiv/d200438

Yustian, I., Zulkifli, H., Setiawan, A., Setiawan, D., Iqbal, M., Aprilia, I., Indriati, W., Saputra, R. F., Sumantri, H., Pratama, R., Prasetyo, C. Y., Noberio, D., and Pragustiandi, G. 2017. *Panduan Survei Cepat Keanekaragaman Fauna di Sumatera Selatan*. Universitas Sriwijaya. South Sumatera, Indonesia.