The potential of mangroves in supporting fisheries tourism in Banyak Island, Langkat Regency, Indonesia

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Abstract. This research examines the potential of mangrove ecosystems as fisheries-based ecotourism areas using an ecological approach. This research took place from October 2022 to October 2023 in Pulau Banyak Village, Langkat Regency, North Sumatra Province, Indonesia. Mangrove density data collection was carried out using the 10x10 m^2 quadrat transect method (20 transects), with a distance of 20 m between transects. Observation of aquatic biota was carried out around the mangrove area. It was observed that 10 species of mangroves live in the mangrove forest area of Pulau Banyak village, including: *Sonneratia alba, Avicennia marina, Rhizophora apiculata, Rhizophora mucronata, Bruguiera gymnorrhiza, Lumnitzera littorea, Acanthus ilicifolius, Acrostichum speciosum, Pemphis acidula*, and *Nypa fruticans*. The mangrove forest density condition was a high density, with 1520 ind ha^{-1}. Twelve species of aquatic biota inhabit this area, consisting of 5 species of fish (*Lates calcarifer, Eleutheronema tetradactylum, Chanos chanos, Megalops cyprinoides, Plotosus canius*), 3 species of shrimp (*Metapenaeus ensis, Penaeus monodon, Penaeus merguiensis*), 2 species of crabs (*Scylla serrata, Scylla tranquebarica*), and 2 species of bivalves (*Geloina erosa, Geloina expansa*). This shows that this location has the potential to become a fisheries-based tourism area.
Key Words: importance value index, species density, species richness.

Introduction. Mangrove forests play a crucial role in supporting fisheries by providing habitat for fish and crustaceans, acting as nursery areas for juvenile species, and being a good food source for other fauna (Saragih et al 2022; Wanjiru et al 2023; Bindiya et al 2023). The structural complexity of mangroves, such as dense root systems, provides refuge for juvenile fish from larger predators (Hamzah et al 2023). The presence and extent of adjacent seagrass habitats also interact with mangrove forest structures to shape the abundance and diversity of fish and crustaceans (Das et al 2022). Mangroves act as spawning grounds, foraging, and breeding grounds for fish, shrimp, and crabs, benefiting fishermen. Additionally, mangrove forests provide coastal communities with a major source of food, including finfish, shellfish, and other edible invertebrates, contributing to food security in the area (Saragih et al 2022; Wanjiru et al 2023; Bindiya et al 2023). Conservation and sustainable management of mangrove ecosystems are essential to maintain these important functions and support the livelihoods of coastal communities. One form of mangrove forest conservation in Indonesia is through the concept of ecotourism.

Mangrove ecotourism is the utilization of mangrove environments as sustainable tourism destinations. It involves the conservation and limited utilization of mangrove areas for economic, ecological, and social benefits (Abidin et al 2023). The potential for mangrove ecotourism is assessed based on factors such as mangrove thickness, density, species, biota, tides, and biodiversity (Rifdan et al 2023; Novarino et al 2023). The analysis of mangrove potential helps in identifying the attractions and strengths of a

particular mangrove ecotourism destination. The suitability of a mangrove area for ecotourism is determined by considering ecological, socio-economic, and institutional dimensions (Alsita et al 2023). The development of mangrove ecotourism requires strategies such as supporting mangrove conservation, providing infrastructure, promoting education about the benefits of mangroves, and increasing government commitment to mangrove development (Alsita et al 2023; Ningsih et al 2023). This research will examine the potential of mangrove ecosystems to be used as fisheries-based ecotourism areas using an ecological approach in Banyak Island, Langkat Regency, Indonesia.

Material and Method. The methodology employed in this study was the quadrat transect method. Data on mangroves were gathered by tallying both the quantity and species present in each sample plot, which measured 10x10 m^2 and were spaced 20 m apart (Figure 1).

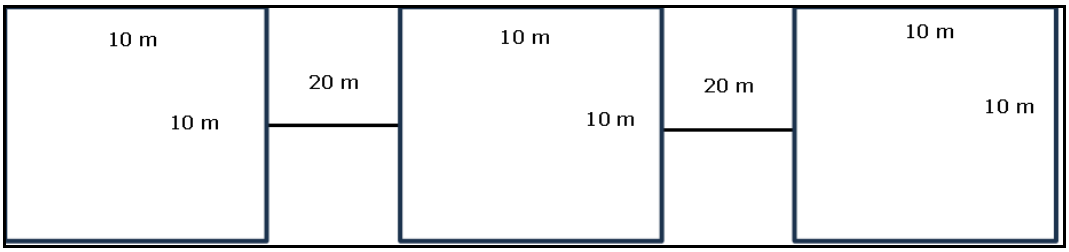

Figure 1. Mangrove observation transect layout.

Collection of data took place from October 2022 to October 2023 in the Banyak Island mangrove eco-tourism area, located in Langkat Regency, North Sumatra Province (Figure 2). Mangrove observations were carried out once a month. Following the installation of transects/plots, leaves, fruits, and roots of mangroves were gathered for each individual species to ascertain the composition of the mangrove community. Identification of mangrove species was carried out using a mangrove recognition guidebook (Noor et al 2006).

Figure 2. Research location.

Data related to fisheries resources were also collected in this study. Data on the taxa of biota caught were determined by direct observation at the fish landing site, then interviews were conducted with fishermen to ensure that the fish caught were from the waters around the study area, and the species of fish caught were recorded and identified using as reference the Market Fishes of Indonesia (White et al 2013).

Data analysis. Mangrove data analysis was conducted to calculate species density, relative density, species frequency, relative frequency, species cover, relative cover, and importance index. All data were analyzed using formula proposed by English et al (1994) (Table 1).

Table 1

Determined indices (English et al 1994)

Data analysis	*Formula*
Species density (D_i)	N_i/A
Relative density (RD_i)	$N_i/\sum n*100\%$
Species frequency (F_i)	$P_i/\sum p$
Relative frequency (RF_i)	$F_i/\sum f*100\%$
Species cover (C_i)	$\sum BA/A$
Relative cover (RC_i)	$C_i/\sum C*100\%$
Importance Value Index (IVI)	$RD_i+RF_i+RC_i$

Note: D_i - density of the i-th species; N_i - total number of individuals of the i-th species; A - total sampling area; RD_i - relative density; $\sum n$ - total number of individuals; F_i - frequency of the i-th species; P_i - number of sampling plots created; $\sum p$ - total number of sampling plots created; RF_i - relative frequency; $\sum f$ - total frequency of all species; C_i - area of cover of the i-th species; BA - basal area of a species; RC_i - relative species cover; $\sum C$ - total area of cover of all species; IVI - importance value index.

Mangrove density criteria were determined based on the Decree of the Minister of Environment of the Republic of Indonesia No. 201 of 2004 (Table 2).

Table 2

Criteria for mangrove density

Criteria	*Density (ind ha^{-1})*
High	≥1500
Medium	≥1000, <1500
Low	<1000

Results and Discussion. Based on the results of observations, there were 10 species of mangroves identified living on the Banyak islands, Langkat Regency (Table 3). These results are similar to those of Hasan et al (2024), who found 9 species of mangroves living in the mangrove agro-ecotourism area Lubuk Kertang, Langkat Regency. Differences in mangrove species can be seen in Table 3.

Mangrove species that have been identified in northern Sumatra include *Acanthus ilicifolius, Rhizophora apiculata, Rhizophora mucronata, Avicennia marina, Avicennia alba, Avicennia officinalis, Soneratia caseolaris, Soneratia alba, Acrostichum aureum, Acrostichum speciosum, Bruguiera parviflora, Bruguiera gymnorhiza, Bruguiera cylindrica, Ceriops tagal, Nypa fruticans, Aegiceras corniculatum, Acanthus ilicifolius, Acrostichum sp,* and *Xylocarpus granatum* (Basyuni et al 2021; Nawar et al 2022; Purwoko et al 2023; Hasan et al 2024).

Table 3

Mangrove species in the Banyak Island mangrove ecotourism area, Langkat

Species	*Location 1*	*Location 2*	*Location 3*	*Hasan et al (2024)*
Sonneratia caseolaris	+	+	+	+
Avicennia marina	+	+	+	+
Rhizophora apiculata	+	+	+	+
Rhizophora stylosa	+	+	+	+
Bruguiera sexangula	+	+	+	+
Lumnitzera littorea	+	-	-	-
Acanthus ilicifolius	+	-	-	-
Acrostichum speciosum	+	-	+	-
Pemphis acidula	+	-	+	-
Nypa fruticans	+	+	+	+
Xylocarpus granatum	-	-	-	+
Ceriops tagal	-	-	-	+
Excoecaria agallocha	-	-	-	+

Note: (+) found; (-) not found.

The vegetation density value is 1520 individuals ha^{-1}, within the high-density category. The highest relative density (RD_i) value for *Rhizophora mucronata* is 18.55%, and the lowest RD_i was observed for is *Pemphis acidula*, with 4.93%. The highest relative frequency was observed for two species, *Rhizophora mucronata* and *R. apiculata*, with 19.57% each, while the lowest relative frequency was observed for *P. acidula*, and *Nypa fruticans*, with 2.17% each. Furthermore, the highest relative dominance value was observed for *R. apiculata*, 18.53% and the lowest for *P. acidula*, 2.67% (Table 4).

Table 4

Density, frequency, dominance, and importance value index of mangroves in Pulau Banyak ecotourism area, Langkat

Species	D_i	RD_i (%)	F_i	RF_i (%)	C_i	RC_i (%)	*IVI*
Sonneratia alba	234	15.39	0.8	17.39	0.0000162	17.44	50.23
Avicennia marina	147	9.67	0.6	13.04	0.0000130	13.94	36.65
Rhizophora apiculata	298	19.61	0.9	19.57	0.0000172	18.53	57.70
Rhizophora stylosa	282	18.55	0.9	19.57	0.0000164	17.62	55.74
Bruguiera sexangula	117	7.70	0.5	10.87	0.0000059	6.38	24.95
Lumnitzera littorea	89	5.86	0.2	4.35	0.0000036	3.86	14.06
Acanthus ilicifolius	97	6.38	0.2	4.35	0.0000045	4.81	15.54
Acrostichum speciosum	83	5.46	0.3	6.52	0.0000028	3.00	14.98
Pemphis acidula	75	4.93	0.1	2.17	0.0000025	2.67	9.78
Nypa fruticans	98	6.45	0.1	2.17	0.0000109	11.73	20.36
Total	1520	100.00	4.6	100.00	0.0000930	100.00	300.00

Note: D_i - density of the i-th species; RD_i - relative density; F_i - frequency of the i-th species; RF_i - relative frequency; C_i - area of cover of the i-th species; BA - basal area of a species; RC_i - relative species cover; IVI - importance value index.

The density of mangroves is influenced by various factors such as physical attributes of the coastal environment, including temperature, tidal range, and sediment supply (McKee 1993). Additionally, salinity gradients play a crucial role in shaping mangrove density, with different species exhibiting varying wood densities in response to levels of salinity (Ellison 2021). The distribution and resilience of mangrove forests can be impacted by climate change-induced changes in sea surface density, potentially altering propagule dispersal patterns and reducing forest resilience (Der Stocken et al 2022). Monitoring changes in mangrove canopy density can be achieved through remote sensing

technology, with water pH identified as a significant parameter affecting mangrove density in specific regions (Virgulino-Junior et al 2020). Understanding these factors is essential for effective mangrove management and conservation efforts.

In addition to the presence of mangrove vegetation, the richness of biota species is also key in developing fisheries-based ecotourism areas. Biota richness is presented in Table 5. Twelve species of aquatic biota are known to live in the mangrove area of Pulau Banyak village in Langkat, including fish, mud crabs, crustaceans, and mollusks (Table 5).

Table 5

Species of aquatic biota found around the mangrove tourism site of Banyak Island village, Langkat

No	*Species*	*Local name*	*Common name*
1	*Scylla serrata*	Kepiting Bakau	Mud crab
2	*Scylla tranquebarica*	Kepiting Bakau	Mud crab
3	Lates calcarifer	Siakap	Barramundi
4	*Eleutheronema tetradactylum*	Ikan senangin	Fourfinger threadfin
5	*Chanos chanos*	Ikan Bandeng	Milk fish
6	*Megalops cyprinoides*	Terubuk padi	Tarpon
7	*Plotosus canius*	Ikan sembilang	Catfish
8	*Metapenaeus ensis*	Udang batu	Brown shrimp
9	*Penaeus monodon*	Udang tiger	Tiger prawn
10	*Penaeus merguiensis*	Udang putih	White prawn
11	*Geloina erosa*	Lokan	Mud shell
12	*Geloina expansa*	Lokan	Mud shell

The diverse fauna in mangrove areas contributes to the ecosystem's richness and productivity (Rajpar & Zakaria 2014). Furthermore, according to Dewiyanti & Sofyatuddin (2012), the bivalve and gastropod species found in mangrove areas include Cerithidae, Isognomonidae, Potamididae, and others, contributing to the diversity and abundance of the ecosystem. Mollusks, specifically gastropods and bivalves, are common biota found in mangrove areas, serving various ecological roles such as detritus consumption and habitat provision (Rifanjani et al 2022).

Conclusions. The condition of the mangrove ecosystem in Pulau Banyak village, Langkat Regency, Indonesia, is very good, with a density of >1500 ind ha^{-1}, as well as IVI values that exceed 50% for *R. stylosa, R. apiculata*, and *Sonneratia alba*. Twelve species of economically valuable aquatic biota living in this ecosystem increase the potential of this area to be used as a fisheries-based ecotourism area.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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