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Tourism Suitability Index of The Mangrove Area of Pulau Banyak Village, Langkat, North Sumatra: An Ecological Approach

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Abstract

This study aims to obtain data on the suitability of ecotourism areas based on ecological parameters. The parameters observed were mangrove density & thickness, tidal height, mangrove species diversity, and the types of biota that live in it. To calculate mangrove density, the quadratic transect method was used with a size of 10 x 10 m as many as 20 plot pieces. While mangrove thickness is calculated by measuring the outer distance of mangroves towards the mainland. Furthermore, the parameters of biota diversity were carried out by direct observation techniques at the research site. The results of the analysis showed a mangrove thickness of 197.37 metres with a density of 1,520 individuals / ha. There are 10 mangrove species including Sonneratia alba, Avicennia marina, Rhizophora apiculate, R. mucronate, Bruguiera gymnorrhiza, Lumnitzera littorea, Acanthus ilicifolius, Acrostichum speciosum, Pemphis acidula, Nypa fruticans. The average tide height is 1.24 m and 20 species of biota consisting of 3 bivalve species, 1 Gastropoda, 6 fish, 6 birds, 2 shrimps, and 2 crabs. The results of the tourism suitability analysis showed 91% with a very suitable category

Keywords: *Banyak island; Ecological approach; Mangrove ecotourism; Suitability Index*

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INTRODUCTION

Mangrove ecotourism refers to the sustainable utilization of mangrove ecosystems for tourism purposes, combining ecological preservation, economic benefits, and community involvement (Farid et al., 2023; Ginantra, 2023; Novianti et al., 2022; Rifdan et al., 2023; Tjahjono et al., 2022). These ecosystems, rich in diverse flora and fauna, serve as unique attractions for ecotourism, scientific education, and community engagement in conservation efforts (Rifdan et al., 2023). The development of mangrove ecotourism

involves principles of preservation, protection, and sustainable use, aiming to balance economic gains with environmental conservation (Farid et al., 2023; Ginantra, 2023). Strategies for successful mangrove ecotourism include enhancing infrastructure, promoting intensively, implementing special policies, integrating with local culture, and empowering local communities (Novianti et al., 2022). Sustainable mangrove ecotourism not only benefits the economy but also contributes to ecological preservation and community well-being (Tjahjono et al., 2022). The development of mangrove ecotourism areas cannot be separated from the condition of the ecosystem itself.

The mangrove condition in North Sumatra, particularly in areas like Medan City, Lubuk Kertang Village, and Pantai Labu Subdistrict, faces various challenges and restoration efforts. Studies highlight significant changes in mangrove cover over the years, emphasizing the importance of integrated approaches involving remote sensing, GIS, and AHP (Rahmawaty et al., 2023). Additionally, mangrove rehabilitation efforts through planting propagules and seedlings have shown promising results in terms of survival rates and carbon storage, contributing to ecosystem restoration (Amelia et al., 2023). Evaluating mangrove functionality through macrozoobenthic communities has been proposed as a practical indicator for restoration success, with community assemblages reflecting different management conditions in North Sumatra and Aceh (Basyuni et al., 2022). Furthermore, assessments of water quality and sediment fractions in mangrove areas around North Aceh reveal varying conditions, with some areas showing heavy metal pollution concerns (Harifia et al., 2022). Physical factors like slope, soil, water, tides, and climate play crucial roles in the growth and development of mangroves in the Coastal area of Pantai Labu Subdistrict (Yuniastuti et al., 2019).

Various research related to the development of mangrove ecotourism areas in North Sumatra have been published including (Harahap & Absah, 2022). The research on mangrove ecotourism at Sei Nagalawan Village, North Sumatra, highlights economic, ecological, and social benefits for the community through tourism activities, income generation, and environmental conservation efforts. Ambarita et al., (2018) the research focuses on landscape planning and economic valuation of mangrove ecotourism in North Sumatra, Indonesia, emphasizing spatial planning, economic value assessment, and community benefits. Furthermore (Basyuni et al., 2022) developing community-based mangrove management through eco-tourism in North Sumatra, Indonesia, focusing on enhancing mangrove ecotourism in Langkat and Serdang Bedagai, emphasizing biodiversity, suitability, carrying capacity, and SWOT analysis. However, no publications have been found on the suitability of mangrove ecotourism areas from Pulau Banyak village, Langkat Regency. This research will focus on assessing the suitability of mangrove ecotourism areas based on physical and biological parameters.

METHOD

This research was conducted in Pulau Banyak village, Langkat district, North Sumatra province (Figure 1) from October 2022 to September 2023. Biological parameters observed included the types of aquatic and terrestrial biota, and mangrove density, while physical parameters were tidal height. Mangrove density measurements using the quadratic transect method. 10 x 10 meters transects were made of as many as 20 pieces

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with a distance of 20 meters between transects (Figure 2). Data on mangrove species were taken using the cruising survey method carried out in each transect, where each mangrove species was identified, recorded, and grouped according to its type (Tuwongkesong et al., 2018; Suwardi, 2013). Mangrove trees were identified based on the types of roots, stems, flowers, and fruits using Noor et al., (2006) the handbook of Mangrove Recognition in Indonesia. Mangrove thickness is measured based on the distance from the shoreline to the final limit of mangroves found towards the mainland.

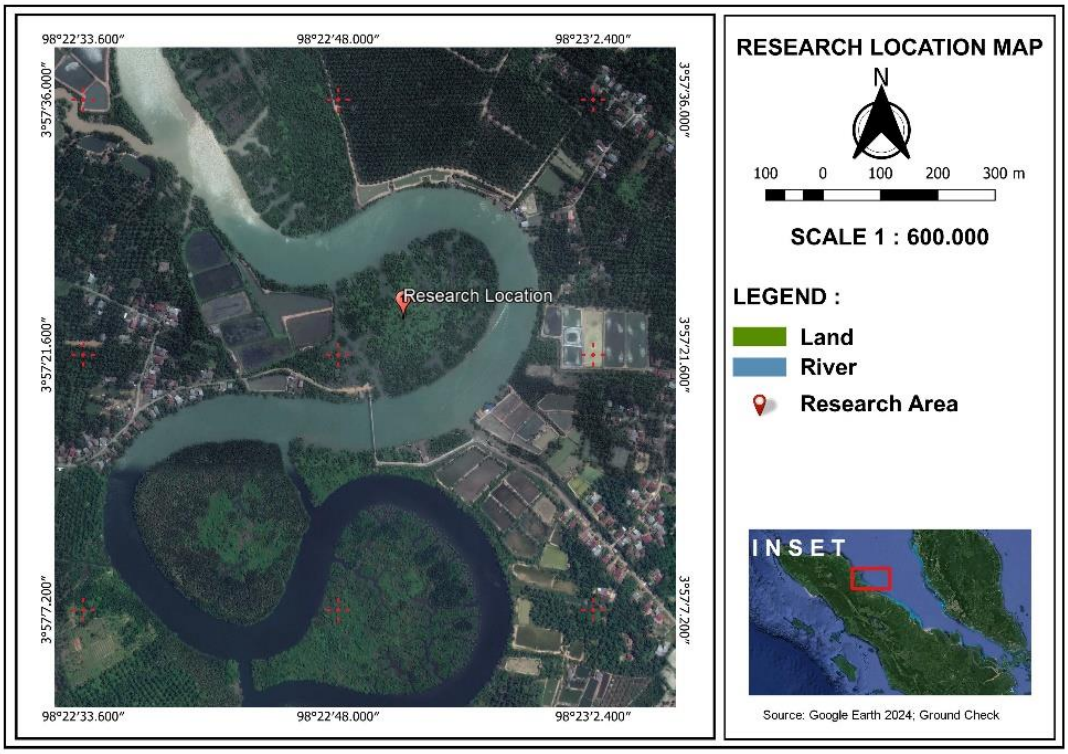

Figure 1. Research location Map

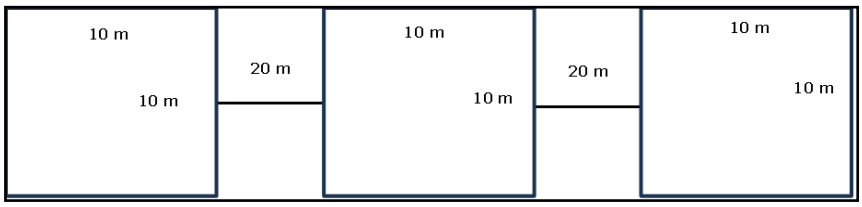

Figure 2. Illustration of quadratic transects

Mangrove biota was observed visually during the study, in addition, fish species were observed based on the catch of fishermen around the study site. Furthermore, physical data form of high tides were obtained from the meteorological and geophysical agency, (BMKG) Medan Station. The overall biology and physical data that has been collected will be used in the ecotourism suitability index analysis.

Data Analysis

Mangrove density was calculated using the formula by (English et al., 1994) :

$$Di=\frac{Ni}{A} \quad (1)$$

Where :
Di = density of the i-th species
Ni = total number of individuals of the i-th species
A = total sampling area

The ecotourism suitability index was calculated using the formula (Yulianda, 2007)

$$IKW=\sum\left[\frac{N_i}{N_{Max}}\right] x\ 100\% \quad (2)$$

Where :
IKW = Tourism Suitability Index
N_i = The value of the i-th parameter (Weight x Score)
N_{max} = Maximum score (4)

The value of the tourism suitability index obtained is then adjusted to the following categories (Yulianda, 2007):
S1 = Very Suitable, with IKW > 75-100%
S2 = Suitable, with IKW> 50-75%
S3 = Conditionally Suitable, with a value of > 25-50%
N = Not Suitable, with a score > 25%

Assessment of the level of suitability of mangroves is done by using a matrix of the suitability of the area for the coastal tourism mangrove tourism category. Assessment is done based on weighting and the value indicated by the magnitude of the score, which is then done by combining several variables of the difference in value between classes to determine the classification of the suitability of mangrove areas in Pulau Banyak Village, Langkat Regency.

Table 1. Suitability matrix of mangrove tourism

Parameter	Bobot	Category	Skor
Mangrove thickness (m)	0.380	>500	3
		>200-500	2
		50-200	1
		<50	0
Mangrove density ($100m^2$)	0.250	>15-20	3
		>10-15; >20	2
		10-15	1
		<5	0
Mangrove species	0.150	>5	3
		3-5	2
		2-1	1
		0	0
Low tides (m)	0.120	0-1	3
		>1-2	2
		>2-5	1

Parameter	Bobot	Category	Skor
		>5	0
Biota objects	0.100	Fish, shrimp, crabs, mollusks, reptiles, birds and typical/endemic/rare animals	3
		Fish, shrimp, crabs, mollusks	2
		Fish, mollusks	1
		One of the aquatic biota	0

RESULTS AND DISCUSSION

Mangrove Thickness

Mangrove thickness is measured based on the distance from the shoreline to the final limit of mangroves found towards the mainland. measurement results known as mangrove thickness at the location of this study is 197.37 meters. The results of this study are not much different from the results of research from Tuwongkesong et al., (2018), which was conducted in Tongkaina Village, Bunaken District, Manado City with an average mangrove thickness of 138.65 meters. Furthermore, Tambunan et al., (2023) obtained an average mangrove thickness of 143.3 meters in Budo Village, North Minahasa Regency.

Mangrove Density and Species

There are 10 species of mangroves that live in Pulau Banyak Village, Langkat Regency, North Sumatra. Mangrove density at the research site was known to be 1520 ind/ha or 15.2 ind/100 m^2, with the densest species being *R. apiculata* (298 ind/ha), and *R. mucronata* (282 ind/ha) (Table 2). These results are not much different from those obtained by Hasan et al., (2024) in the Lubuk Kertang ecotourism area, Langkat Regency with the densest type of *R. apiculata* 431 ind/ha.

Table 2. Density Mangrove species in the Banyak Island, Langkat Regency, Indonesia

Species	Density (Ind/Ha)
Sonneratia alba	234
Avicennia marina	147
Rhizophora apiculata	298
Rhizophora mucronata	282
Bruguiera gymnorrhiza	117
Lumnitzera littorea	89
Acanthus ilicifolius	97
Acrostichum speciosum	83
Pemphis Acidula	75
Nypa fruticans	98
Total	**1520**
Density/100 m^2	**15.2**

Physical factors like temperature, coastal typology, sediment supply, and tidal range influence mangrove density. Human impacts, climate change, and sea level rise can reduce mangrove resilience (Ellison, 2021). Some of the impacts of human activities in the study area include waste generation, illegal logging, and conversion of mangrove land into ponds. Salinity gradient influences wood density in mangrove trees, varying among species, diameter classes, and saline zones, impacting growth strategies and carbon assimilation in response to environmental conditions (Virgulino-Júnior et al., 2020). Furthermore Samsi et al., (2018) Environmental factors and human activities influence mangrove density. Competition for space and nutrients among species also impacts density levels in mangrove ecosystems.

Tides high

The height of the tide was measured 1 time in 1 month during the 12 months of the study. The height of the tide was obtained by subtracting the value of the highest tide minus the lowest tide, so that the average tide in 1 year was 1.24 meters (table 3). This result is not much different from the research Tambunan et al., (2023) in Manado Bay with an average tidal height of 2 meters.

Table 3. Average of low tides in Banyak Island Mangrove ecotourism area during the research conduct

Month	High Tides/HT (m)	Low Tides/LT (m)	(HT-LT)
October 2022	1.87	0.8	1.07
November 2022	1.73	0.89	0.84
December 2022	1.7	1.02	0.68
January 2023	1.7	0.87	0.83
February 2023	1.75	0.8	0.95
March 2023	1.8	0.65	1.15
April 2023	1.91	0.49	1.42
May 2023	1.88	0.43	1.45
June 2023	1.91	0.35	1.56
July 2023	2	0.37	1.63
August 2023	2.03	0.34	1.69
September 2023	2	0.37	1.63
	Average		**1.24**

Muhidin et al., (2020) stated that tidal events in every region on the earth's surface are not always the same, this is thought to be due to differences in the attractive forces of the moon and sun in each region depending on the condition of the underwater form. Tides are one of the physical factors that can affect mangrove ecosystems. Estimates of high and low tidal parameters are needed for tracking activities to take place properly. Masud et al., (2020) stated that mangrove ecosystems will be more difficult to access for tourists if high tides are occurring, but are useful for activities outside tracking such as photography activities otherwise, if the tide recedes tracking activities become easier.

Object of biota

Biota observed in the mangrove ecosystem area of the Banyak island village comes from groups of crustaceans, fish, birds, crabs, and mollusks (Table 4). The existence of associated biota objects in mangrove ecosystems can be enjoyed directly to provide satisfaction for tourists and become an added value in the mangrove ecosystem area (Sadik et al., 2017). According to Nugroho et al., (2019), flora and fauna in mangrove forests are a combination of two groups, namely: (1) Fauna groups living on land (land and air); (2) Aquatic biota consisting of two types, namely: species that live in water, such as fish and shrimp, and species that live in hard substrates (mangrove tree roots and trunks) and soft (mud), especially crabs, crustaceans, and many other species.

Table 4. Biota object in the mangrove area of Banyak Island village, Langkat Regency

Group	Species	Common Name
Bivalva	*Geloina erosa*	Mud Shells
	Geloina expansa	Mud Shells
	Glauconome virens	Razor Clam
Gastropoda	*Telescopium telescopium*	Mangrove snails
Pisces	*Mugil sp*	Flathead grey mullet
	Lates calcaliver	Barramundi
	Megalops cyprinoides	Indo-Pacific Tarpon
	Eleutheronema tetradactylum	Fourfinger threadfin
	Chanos chanos	Milkfish
	Plotosus canius	Gray eel-catfish
Aves	*Tringa glareola*	Wood Sandpiper
	Centropus sinensis	Greater Coucal
	Streptopellia chinensis	Spotted dove
	Leptoptilos javanicus	Lesser Adjutant
	Corvus enca unicolor	Corvus unicolor
Crustacean	*Penaeus monodon*	Tiger Prawn
	Penaeus merguensis	White Prawn
	Metapenaeus ensis	Brown Shrimp
Arthropoda	*Scylla serrata*	Mud Crab
	Scylla tranqueberica	Mud Crab

Tourism Suitability Index

Based on the results of the suitability analysis, it is known that the mangrove area of Pulau Banyak village in Langkat district is very suitable for tourist sites with a suitability value of 91% (table 5). Other research conducted by Tambunan et al., (2023) shows that the value of suitability for mangrove ecosystems in the coastal areas of Budo Village is 54.6%, with the appropriate category. Furthermore, Tuwongkesong et al., (2018), obtained the suitability index value of mangrove ecosystems on the coast of Tongkaina Village, Bunaken District, Manado City, which is 51.2% with the appropriate category. According to Pratiwi & Muhsoni (2021) this suitability index can be increased in various ways 1) by replanting pre-existing species; 2) by increasing the

level of mangrove density through mangrove rehabilitation activities; 3) by maintaining the existence of existing associated biota objects; 4) by improving accessibility, such as road improvements to ecotourism sites; and 5) limiting the number of visitors. Meanwhile, for the mangrove area of Pulau Banyak village in Langkat Regency with a very suitable category, only monitoring efforts are needed so that there is no decrease in the index value. Iswahyudi et al., (2019) mention that the Monitoring efforts are very important to support ecotourism activities and support the role of mangrove ecosystems ecologically

Table 5. Suitability Index for Mangrove ecoyourism base on various parameters

Parameter	Bobot	Category	Skor	Result	Bobot x Skor	Ni/ Nmax
Mangrove Thicknes (m)	0.38	> 500	3			
		>200-500	2			
		50-200	1			
		<50	0	50-200	0.38	0.13
Mangrove density ($100m^2$)	0.25	>15-20	3			
		>10-15; >20	2			
		10 s/d 15	1			
		<5	0	>15-20	0.75	0.33
Mangrove Species	0.15	>5	3			
		3 s/d 5	2			
		2 s/d 1	1			
		0	0	>5	0.45	0.20
Low Tides	0.12	0 sd 1	3			
		>1-2	2			
		>2-5	1			
		>5	0	>1-2	0.24	0.12
Biota Object	0.1	Fish, Shrimp, Crab, Mollusk, reptile, Bird and Unic biota/endemic/rare	3	Fish, Shrimp, Crab, Mollusk, reptile, Bird		
		Fish, Shrimp, Crab, Mollusk	2			
		Fish, Mollusk	1			
		One of waters biota	0		0.3	0.13
		∑			2.12	0.91
		Tourism Suitability Index				91%
		Suitability category				**Very Suitable**

CONCLUSION

The mangrove ecosystem area of Pulau Banyak village, Langkat Regency is very suitable to be used as a mangrove ecotourism area, this is because all the key parameters of mangrove ecotourism are in good condition.

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