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IS THE MANGROVE BEACH OF SERDANG BERDAGAI REGENCY, NORTH SUMATRA SUITABLE AS AN ECOTOURISM SITE?

Uswatul Hasan[1,4]*, Siti Mardiana[2], Syahbudin Hasibuan[3]
[1]Doctoral Student of Agricultural Science, Medan Area University, Indonesia,
[2,3]Graduate, School of Agricultural Science, Medan Area University, Indonesia
[4]Faculty of Fisheries, Dharmawangsa University, Indonesia
**Email: uswatuhasan@dharmawangsa.ac.id*
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ABSTRACT: Mangrove ecosystems have various potentials, one of which is as a tourist area. This study aims to assess the suitability of mangrove ecosystems as ecotourism areas, which can later be used as a basis for developing ecotourism on mangrove beaches in Serdang Bedagai Regency, North Sumatra Province. The research method used was survey. The research was conducted during the period July to October 2023. Mangrove observations were made using the 10 x 10 metre quadratic transect method as many as 20 pieces placed on the shoreline area towards land. thickness and density of mangroves. The results showed that there were two mangrove species, Avicennia marina and Rhizophora mucronata with a total density of 1,015 individuals per hectare (10.15 individuals per 100 m²). There are 16 types of biota associated with mangrove ecosystems consisting of 3 types of bivalves, 1 type of gastropod, 6 types of fish, 3 types of crustaceans, 2 types of arthropods, and 1 type of mammal. The results of the ecotourism suitability index analysis show that this area is suitable to be used as a mangrove ecotourism location with a suitability value of 54.75%. Thus, it can be concluded that the mangrove beach is suitable to be used as an ecotourism area.
Keywords: agrotourism, mangrove ecosystem, serdang berdagai regency, north sumatra.

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INTRODUCTION

The Mangrove Coast in Serdang Bedagai, North Sumatra, is a vital ecological and economic resource characterized by rich biodiversity and ecotourism potential. The region, particularly in Bandar Khalifah and Sei Nagalawan, features a variety of mangrove species, including *Acanthus ilicifolius* and *Rhizophora apiculata*, which are essential for local culinary products such as dodol and crackers (Purwoko et al., 2023) However, mangrove ecosystems face challenges such as damage from fishing activities and the impact of the COVID-19 pandemic on tourism (Manurung et al., 2022). Efforts to rehabilitate mangrove forests and promote sustainable tourism are essential to improve local livelihoods and preserve ecological functions (Muhtadi et al., 2020; Harahap & Absah, 2022). Community engagement through mangrove nurseries and educational initiatives has shown promise in restoring these vital coastal ecosystems (Muhtadi et al., 2020; Manurung et al., 2022). Overall, the integration of conservation and economic strategies is key to the sustainable development of Mangrove Beaches in this region (Purwoko et al., 2023).

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The potential for mangrove ecotourism in Serdang Bedagai is significant, driven by community empowerment and ecological benefits. Research shows that areas such as Sei Nagalawan Village have successfully integrated creative economic strategies, increasing local income through activities such as selling mangrove-based products and offering boat rentals to tourists (Harahap & Absah, 2022; Sari et al., 2024). However, challenges remain, including degraded vegetation and inadequate infrastructure, which hinder accessibility and overall development potential (Ulfa & Harahap, 2022). The COVID-19 pandemic has further exacerbated these issues, necessitating innovative promotional strategies to revive visitor interest (Aulia et al., 2022). A holistic approach that combines sustainable practices with community engagement is essential to drive long-term growth in the sector (Mashur et al., 2024). Overall, while the foundations of ecotourism exist, strategic improvements and government support are essential to realize its full potential in Serdang Bedagai (Ulfa & Harahap, 2022; Sari et al., 2024).

Sustainable management of mangrove beaches in Serdang Berdagai, North Sumatra, is critical for ecological preservation and community development. The development of ecotourism is heavily influenced by ecological self-awareness, which enhances individuals' attitudes towards sustainable practices and tourism (Nakonechnykh et al., 2021). Communities with a strong awareness of their ecological resources are more likely to engage in sustainable tourism practices, enhancing the potential for ecotourism development (Fiseha, 2019). The region's mangrove ecosystems, which include diverse species such as *Rhizophora apiculata* and *Avicennia*, provide significant ecological and economic benefits through ecotourism (Basyuni et al., 2018; Harefa et al., 2024). Effective management strategies, such as community-based approaches and participatory techniques, improve local livelihoods while promoting biodiversity and climate resilience (Tjahjono et al., 2022; Arfan et al., 2024).

Studies show that integrating ecological, economic, and social dimensions into mangrove management can lead to sustainable practices that support the Sustainable Development Goals (SDGs) (Arfan et al., 2024). In addition, a balance between conservation and restoration is essential to maintain forest structure and carbon dynamics, which are critical for combating climate change (Hanggara et al., 2021). Overall, sustainable mangrove management fosters environmental protection and socioeconomic benefits for local communities (Basyuni et al., 2018).

METHOD

This study was conducted from July to October 2023 in Serdang Berdagai, North Sumatra Province (Figure 1). Various data were collected in this study, including mangrove thickness, mangrove density, biota diversity, and tides. Mangrove identification was carried out by referring to the Handbook of Mangrove Introduction in Indonesia (Noor et al., 1999). Mangrove density measurements were carried out using the transect quadrat method, transect quadrats were made of as many as 20 pieces with a size of 10 x 10 meters (Figure 2), and transect laying starts from the coastal area towards the mainland (Hasan et al., 2024; Hasan et al., 2024b) Measurement of mangrove thickness is done by calculating the distance from the shoreline towards the land that still has mangroves.

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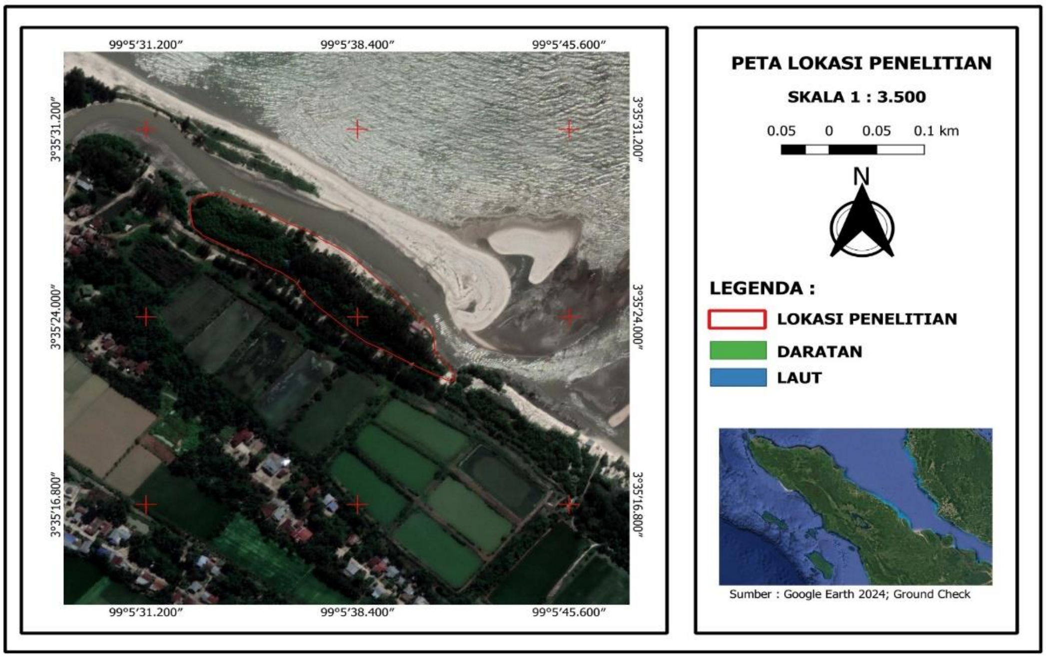

Figure 1. Map of Research Location

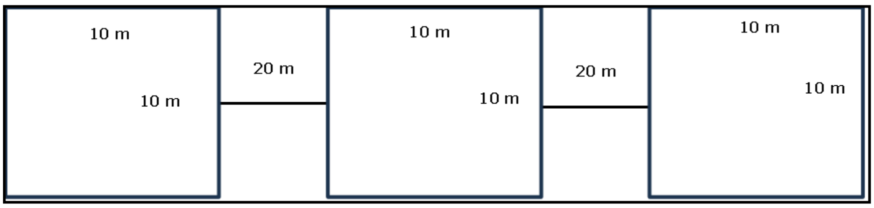

Figure 2. Sampling Plot Illustration

Data Analysis

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

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

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):

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

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:

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 mangrove areas is done by using a matrix of the suitability of the area for the mangrove tourism beach tourism category. The assessment is carried out based on the weighting and value indicated by the magnitude of the score, which is then carried out by combining several variables of the difference in value between classes to determine the classification of the suitability of mangrove areas in Serdang Berdagai North Sumatra.

Table 1. Suitability Matrix of Mangrove Tourism

Parameter	Bobot	Category	Skor
Mangrove thickness (m)	0.380	>500	4
		>200-500	3
		50-200	2
		<50	1
Mangrove density (100m^2)	0.250	>15-20	4
		>10-15; >20	3
		10-15	2
		<5	1
Mangrove species	0.150	>5	4
		3-5	3
		2-1	2
		0	1
Low tides (m)	0.120	0-1	4
		>1-2	3
		>2-5	2
		>5	1
Biota objects	0.100	Fish, shrimp, crabs, mollusks, reptiles, birds and typical/endemic/rare animals	4
		Fish, shrimp, crabs, mollusks	3
		Fish, mollusks	2
		One of the aquatic biota	1

RESULT AND DISCUSSION

Mangrove Thickness

The results of mangrove thickness measurements in the Serdang Berdagai mangrove coastal area, North Sumatra showed that the thickness of mangroves was approximately 39.8 meters (Table 4). In addition, research using LiDAR technology has mapped the height of mangrove canopies in East Kalimantan, revealing that the

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majority of mangrove forests reach heights between 10-30 meters, with some exceeding 54 meters (Hisyam et al., 2023). In Tongke-Tongke Village, Papua, mangrove forests show high levels of thickness ranging from 200 to 300 meters (Samsi et al., 2018).

Mangrove Species Density

Based on observations, the study site only has *A. marina* and *R. mucronata* species with a density of 1,015 ind/Ha (10.15 ind/100 m^2) (Table 4). The average density of *A. marina* plants varies greatly in different regions and environmental conditions. One study showed that mangrove forests, including *A. marina*, had an average density of about 12.65 meters, with the highest density recorded at 44.94 meters. *A. marina*, commonly known as Grey Mangrove, exhibits ecological benefits and potential medicinal compounds, making it the subject of extensive research. This resilient species thrives in the intertidal zone, showing unique adaptations to salinity and environmental stresses, including the synthesis of bioactive compounds with potential pharmacological applications (Abdellatif & Arafat, 2024). In addition, A. marina has significant antimicrobial properties, inhibits pathogenic bacteria, and shows promise in bioremediation due to its heavy metal accumulation ability (Alrubaye et al., 2024).

Tidal

The highest tide occurred in September 2023 with a height of 2.05 meters and the lowest tide was 0.35 meters. Meanwhile, the average tidal height during the study was 1.66 m (Table 2).

Table 2. Average tidal range in Serdang Berdagai, North Sumatra, During the Study

Month	Hight Tides (HT)	Low Tides (LT)	HT-LT
July	2	0.37	1.63
Augustus	2.03	0.38	1.65
September	2.05	0.35	1.7
October	2.03	0.39	1.64
Average			1.66

Tidal flows are significantly influenced by local topography, particularly bathymetric features, which can alter flow dynamics and velocity. Studies have shown that variations in bathymetry, such as those found at inlets and narrowed channels, can enhance or disrupt tidal currents, leading to complex interactions between tidal and residual flows (Robinson & Tilburg, 2023). Tidal data from mangrove beaches across the hemisphere reveal significant variations in hydrodynamics and salinity influenced by tidal patterns. “Mini Buoy” technology has been used effectively to monitor tidal inundation and current velocities in various locations, including the Bay of Fundy and North Sumatra, providing critical data for mangrove restoration efforts (Balke et al., 2020). In addition, research in tropical mangrove estuaries has documented the interaction between seawater and freshwater during tidal cycles, highlighting how the ebb tide introduces seawater while the flowing tide facilitates freshwater drainage, thus significantly affecting salinity levels.

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Object Biota

The variety of biota observed at the Serdang Berdagai mangrove site consisted of bivalves, gastropods, fish, birds, crabs, and mammals (Table 3).

Table 3. Biota Object in the Beach Mangrove Area of Serdang Berdagai, North Sumatra Utara

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
	Penaeus monodon	Tiger Prawn
Crustacean	*Penaeus merguensis*	White Prawn
	Metapenaeus ensis	Brown Shrimp
Arthropoda	*Scylla serrata*	Mud Crab
	Scylla tranqueberica	Mud Crab
Mamalia	*Macaca fascicularis*	Crab-Eating Monkey

Mangrove ecosystems are critical for maintaining ecological balance, particularly through their rich diversity of mollusks, including gastropods and bivalves, which serve as important detritivores that recycle nutrients within the substrate (Muhtadi et al., 2020; Sitio et al., 2023) Studies show that these mollusks contribute significantly to the food web, supporting a variety of fish species that depend on them as a food source, alongside phytoplankton and crustaceans. Studies in various regions, such as North Sulawesi and East Java, have documented high mollusk diversity, with findings of up to 25 species in certain areas, highlighting their ecological importance and the need for sustainable mangrove habitat management (Basyuni et al., 2018; Sitio et al., 2023). Furthermore, the structural composition of these mollusk communities is influenced by sediment characteristics, which affect their abundance and diversity, underscoring the intricate relationships within mangrove ecosystems (Muhtadi et al., 2020; Darmarini et al., 2023). Overall, the preservation of these ecosystems is crucial to support local biodiversity and ecological functions.

Index Tourism Suitability

Based on the results of the analysis of ecotourism suitability, it is known that the value of the tourism suitability index is 54.75% with a very suitable category (Table 4).

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Table 4: Tourism Suitability Index

Parameter	Weight	Category	Mangrove Beach			
			Score	Result	B x S	Ni/Nmax
Mangrove thickness (m)	0.38	> 500 >200-500 50-200 <50	4 3 2 1	39.6	0.38	0.095
Mangrove density (100m^2)	0.25	>15-20 >10-15; >20 10 s/d 15 <5	4 3 2 1	10.15	0.75	0.1875
Mangrove type	0.15	>5 3 s/d 5 2 s/d 1 0	4 3 2 1	2	0.3	0.075
Tidal	0.12	0 sd 1 >1-2 >2-5 >5	4 3 2 1	1.66	0.36	0.09
Object Biota	0.1	Fish, shrimp, crabs, mollusks, reptiles, birds and typical/endemic/rare animals Fish, shrimp, crabs, mollusks Fish, mollusks One of the aquatic biota	4 3 2 1	Fish, shrimp, crabs, mollusks, mammals	0.4	0.1
∑total					**2.19**	**0.548**
Tourism Suitability Index						**54.75**
Category					**Suitable**	

Likewise, Reroroja Village achieved a suitability score of 71.5%, indicating the potential for ecotourism development (Calumba et al., 2023). The Karangsong region reported an impressive suitability index of 83.7% with a capacity of 803 visitors per day (Prihadi et al., 2024). Finally, the suitability index of Budo Village was recorded at 54.6%, with a capacity of 116 visitors (Tambunan et al., 2023). The difference in suitability index values can be caused by various factors, including tides, biota diversity and mangrove species density.

CONCLUSION

Based on the results of the study, it can be concluded that the mangrove ecosystem in Serdang Berdagai is suitable as a mangrove ecotourism destination because this area has abundant biota diversity and other balanced supporting factors.

RECOMENDATION

Further monitoring is needed to monitor and ensure that all biota conditions are in a balanced state so that mangrove ecotourism in Serdang Bedagai can continue to grow.

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