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Analysis of Ecotourism Potential in the Pentadu Timur Mangrove Forest, Gorontalo Province: A Land Suitability Assessment

Sunarty Suly Eraku[1], Mohamad Karmin Baruadi[2], Rusiyah[3], Pratiwi Aladjia[4]

[1,3,4]Department of Earth Science and Technology, Universitas Negeri Gorontalo, Gorontalo, Indonesia.
[2]Department of Indonesian Language and Literature, Universitas Negeri Gorontalo, Gorontalo, Indonesia.

Corresponding Author: Sunarty Suly Eraku

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ABSTRACT

The government's policy on utilizing mangrove forests as ecotourism areas is a strategic step to enhance ecologically and economically community welfare. Pentadu Timur village boasts a unique natural wealth of mangrove forests, featuring distinctive flora and fauna and fertile agriculture with social structures capable of attracting tourists and improving community welfare. Therefore, the potential of the Pentadu Timur mangrove forest needs to be analyzed to map it as an ecotourism area for the sustainability of the mangrove ecosystem. This study aims to analyze the ecotourism potential of the Pentadu Timur mangrove forest based on land suitability. A descriptive method was used, with data collected through direct field observation and documentation. Parameters measured included mangrove thickness, species, density, biota objects, tides, uniqueness, area characteristics, accessibility, and infrastructure. Data analysis was conducted using scoring and land suitability analysis with the Tourism Suitability Index (IKW) formula. Results showed that the dominant mangrove species are Rhizophora apiculata, followed by Rhizophora mucronata and Ceriops decandra, with Ceriops tagal being the least prevalent. Each point had boards indicating the mangrove species, highlighting the area's potential as an ecotourism site to support biodiversity knowledge and conservation. The Pentadu Timur mangrove forest is home to various biota, both aquatic and terrestrial, including fish (Lethrinus lentjam, Lutjanidae, Pseudapocryptes elongatus), birds (Orthotomus ruficeps, Egretta garzetta), and crustaceans. The land suitability categories for the Pentadu Timur mangrove forest are very suitable (S1) at station I and suitable (S2) at stations II and III, as determined by the Tourism Suitability Index. This indicates that the Pentadu Timur mangrove forest is highly suitable for development as an ecotourism area, falling into both the Suitable and Very Suitable categories.

Keywords: Ecotourism, land suitability, mangrove forest

INTRODUCTION

Natural resources are utilized by transforming them into something beneficial to allow humans to enjoy the beauty of nature, one method being the establishment of ecotourism areas. Managing mangrove ecosystems with sustainability in mind is crucial due to their importance for the survival of living organisms. The government’s policy on utilizing mangrove forests as ecotourism areas is a strategic step to enhance ecologically and economically

community welfare. Preserving nature's sustainability without altering its original state is a core principle of ecotourism for communities. This approach aims to develop tourism to minimize the potential for environmental damage, ensuring that the natural state and functionality of ecosystems remain intact, without harming any stakeholders. The substantial potential of the mangrove ecosystem in Pentadu Timur village is a key reason for developing this area into an ecotourism zone. This potential is further supported by Gorontalo's morphological and geological conditions, such as the abundance of natural resources, limestone distribution, and geological structures (Eraku et al., 2017; Permata et al; 2019a; Permana et al., 2019b; Permana et al., 2020; Eraku et al., 2020). Ecotourism potential can be in the form of nature, culture, and human resources. Culture generally influences tourists, eventually leading them to the cultural sites (Correia et al., 2011). Through the tourism business, we have the opportunity to explore history and culture as attractions with the potential to become ecotourism areas. Cultural tourism is also a useful tool for integrating various concepts in ecotourism to promote a holistic, flexible, and reflective view (Canavan, 2016). Correia et al. (2011) explain that the choice of tourist destinations is heavily influenced by cultural characteristics. Therefore, cultural tourism needs to be developed to remain sustainable. Qian et al. (2016) state that one important factor for the sustainability of ecotourism is developing community-based tourism, which ultimately results in the achievement of sustainable tourism development. Moreover, tourism based on local wisdom is one of the foundations of sustainable tourism development if supported by community participation in developing their infrastructure and supporting facilities (Vitasurya, 2015).

Ecotourism integrates tourism activities, conservation, and local community empowerment (Saputra & Setiawan, 2014). The development of tourist attractions, marked by an increasing number of tourist visits and the revenue generated, also brings positive benefits by promoting economic progress for the local tourism actors. This aligns with the primary goal of ecotourism development, which is to improve the welfare and quality of life of the local community (Pramudya, 2008). Ecotourism has now become an alternative form of tourism that people are interested in because it offers something different: the beauty and education of the environment (Prasetyo et al., 2019). It has become a new alternative for both national and international tourists, as it attracts those who not only want to enjoy natural beauty but also want to engage in conservation efforts for the sustainability of tourist attractions.

Ecotourism is a form of travel to natural areas to conserve the environment and preserve the life and well-being of local populations (Fandeli & Muhklison, 2000; Stem et al., 2003). Ideally, ecotourism should meet several criteria, such as conserving biodiversity and culture through ecosystem protection and promoting sustainable use of biodiversity with minimal environmental impact as the main concern (Bunruamkaew & Murayama, 2011). Ecotourism is the most valuable form of sustainable tourism development (Motlagh et al., 2020). It can play an active role in providing solutions to problems that may arise in the development of tourist areas. Haryanto (2014) states that ecotourism offers an integrated value of tourism, balancing the enjoyment of natural beauty with efforts to preserve it. Ecotourism ensures environmentally friendly development based on local community initiatives, preventing and mitigating the impacts of tourist activities on nature and culture, with prevention and mitigation tailored to the characteristics of the local environment and culture (Fandeli & Muhklison, 2000). The development of ecotourism has social, economic, and environmental benefits (Zambrano et al., 2010), utilizing natural resources (Nyaupane

& Poudel, 2011) and directly impacting the local community (Liu et al., 2014).

Pentadu Timur Village possesses unique natural wealth in the form of mangrove forests with fascinating flora and fauna, as well as fertile agricultural land with its social systems, which have the potential to increase tourist visits and improve the welfare of the community. Utilizing the mangrove area to develop it into an ecotourism area is a highly rational alternative to implement in coastal areas, as it can provide economic benefits and environmental services without exploiting the mangroves (Karlina, 2015). The mangrove ecosystem has significant potential for development in enhancing community welfare due to its unique characteristics, such as distinctive root structures and various types of fauna associated with the mangrove ecosystem. These include diverse bird species, snakes, monitor lizards, shrimp, fish, mollusks, and crabs, as well as serving as a habitat for epiphytic plants like orchids. The unique characteristics of the mangrove ecosystem make it a highly potential natural resource for ecotourism development (Sartika et al., 2015; Arfan et al., 2017; Suyanto, 2019). Therefore, the potential of the mangrove ecosystem is highly suitable for development as an alternative ecotourism destination. Consequently, it is essential to analyze the potential of the mangrove forest in Pentadu Timur Village to map it as an ecotourism area for the sustainability and preservation of the mangrove ecosystem. This research aims to analyze the ecotourism potential of the Pentadu Timur mangrove forest based on land suitability.

MATERIALS & METHODS

Pentadu Timur Village is one of the villages located in the Tilamuta District, Boalemo Regency, Gorontalo Province, with an area of approximately 1828.75 km². It has geographic boundaries of 00° 51' 16" North Latitude and 121° 40' 39" East Longitude, and administrative boundaries with Mohungo Village to the north, Tenilo Village to the east, Pentadu Barat Village to the west, and directly bordered by the Tomini Bay Sea to the south. Pentadu Timur Village is located approximately 7 km from the center of Tilamuta District and is accessible by paved roads using private vehicles such as cars and motorcycles. The location can also be reached by sea routes. The Pentadu Timur mangrove forest area has been designated by the local village government as a mangrove tourism site because the area is considered to have significant natural resource potential in the form of well-preserved mangrove forests. The research location map is shown in Figure 1.

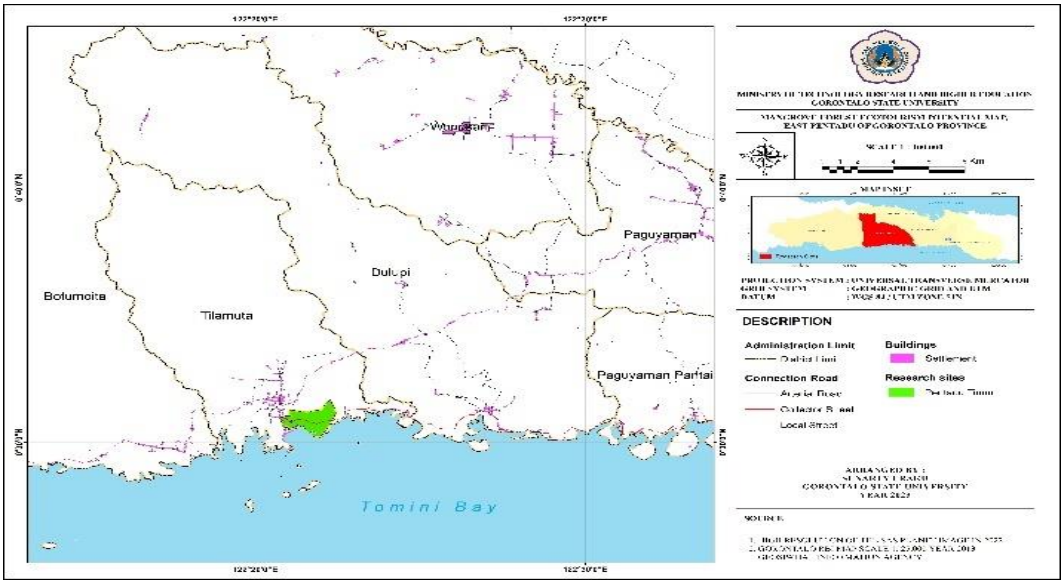

Figure 1. Research Location Map

This research employs a descriptive method. Data collection was carried out through direct observation and documentation in the field. The parameters measured include mangrove thickness, mangrove species, mangrove density, biota objects, tides, uniqueness, area characteristics, accessibility, and facilities and infrastructure. The parameters of mangrove thickness, mangrove species, and mangrove density were measured per station, while the parameters of the presence of biota objects, tides, uniqueness, area characteristics, accessibility, and facilities and infrastructure were measured per research area scope for various reasons.

Data collection was conducted through observation and measurement, including data on mangrove thickness, mangrove density, mangrove species, biota objects, tides, uniqueness, area characteristics, accessibility, and information regarding the facilities and infrastructure at the research location. Mangrove thickness is the width of the mangrove measured from the outermost mangrove tree on the seaside to the outermost mangrove tree on the land side, measured in meters. Mangrove species refer to the variety of mangrove types found in the field based on species (mangrove species names). Mangrove density is the distance between one mangrove species and another, collected directly in the field and analyzed using the formula (Di = ni/A) (Natan, 2008). Biota objects are animals or fauna found within the mangrove forest environment. Tides refer to the regular movement of sea level due to gravitational forces and the gravitational pull of astronomical bodies such as the Earth, moon, and sun. Uniqueness refers to unique animals or plants found in a tourist area and not found elsewhere. Area characteristics are the distinctive features or uniqueness of a tourist area. Accessibility refers to the supporting facilities that indicate whether a tourist area is easy or difficult to reach. Facilities and infrastructure are indicators of whether an ecotourism area is suitable or not for visitation.

Data analysis was carried out using scoring methods and the analysis of mangrove forest suitability with the Tourism Suitability Index (IKW) formula. The IKW formula as presented in Table 1.

Table 1. Ecotourism Land Suitability Matrix for Mangrove

No.	Parameter	Weight	S1 Category	Score	S2 Category	Score	S3 Category	Score	N Category	Score
1	Mangrove Thickness	5	>500	4	200-500	3	50-200	2	<50	1
2	Mangrove Density (100m²)	4	15-25	4	10-15	3	5-10	2	<5	1
3	Mangrove Species	4	>5	4	3-5	3	1-2	2	0	1
4	Biota Objects	3	Fish, shrimp, crabs, mollusks, reptiles, birds	4	Fish, shrimp, crabs, mollusks	3	Fish, mollusks	2	One type of aquatic biota	1
5	Tides(m)	3	0-1	4	1-2	3	2-5	2	>5	1
6	Uniqueness	1	International	4	National	3	Provincial	2	Local	1
7	Area Characteristics	2	4 criteria	4	3 criteria	3	2 criteria	2	1 criteria	1
8	Accessibility	1	4 criteria	4	3 criteria	3	2criteria	2	1 criteria	1
9	Infrastructure	1	Distance <1 km	4	Distance 1-5 km	3	Distance 5-10 km	2	Distance >15 Km	1

Source: Yulinda (2007)

IKW=∑(Ni/Nmax) x 100%

Explanation:

- The maximum value is 96.
- IKW: Tourism Suitability Index

- Ni: Value of the i-th parameter (weight x score)
- Nmax: Maximum value of the tourism category

Tourism Suitability Index Criteria:

- S1 (Highly Suitable): IKW 75% - 100%
- S2 (Suitable): IKW 50% - < 75%
- S3 (Conditionally Suitable): IKW 25% - < 50%
- N (Not Suitable): IKW < 25%

RESULT AND DISCUSSION

Assessment of Mangrove Forest Ecotourism Potential

Based on field survey results, the parameters of mangrove thickness, mangrove species, and mangrove density were taken per station. In contrast, the parameters of biota objects, tides, uniqueness, area characteristics, accessibility, and facilities and infrastructure were taken per research area scope. The biota objects in the mangrove forest area of Pentadu Timur Village are quite diverse, but not all were visible to the researchers during the study. The parameters of uniqueness, area characteristics, accessibility, and facilities and infrastructure were not taken per station because this data represents one research area scope, namely the mangrove forest area of Pentadu Timur Village. Meanwhile, tidal data was also taken to represent one research area scope because the position of the research area between one station and another is the same, being directly affected by tides and having no other activities in the other stations.

The weight for the mangrove thickness parameter is 5, which is the parameter with the highest weight because it is one of the most important land suitability parameters for mangrove ecotourism and has the highest influence on determining whether a mangrove forest area is suitable for ecotourism. The score for the mangrove thickness parameter in Pentadu Timur Village at stations I, II, and III is 3. Field measurements show that the value for these three stations ranges between 200-500 meters, with a category of S2 and a fixed score of 3. The value of 15 is obtained by multiplying the weight and the score; this data applies to stations I, II, and III for the mangrove thickness parameter. One of the factors influencing mangrove thickness or the extent of the mangrove ecosystem is the abiotic factor, such as climate, and tides also influence mangrove thickness. The more frequently the mangrove area is affected by tidal processes, the better its growth and development process.

Data on mangrove species and mangrove density in Pentadu Timur Village show that there are approximately 4 types of mangroves found, namely Rhizophora apiculata, Rhizophora mucronata, Ceriops Decandra, and Ceriops Tagal. These four types of mangroves are spread throughout the mangrove forest area, with data collection carried out per station and each station further divided into plot areas. The score for the mangrove species data in Pentadu Timur Village is 3 because there are 4 types of mangroves. The score for mangrove density data in Pentadu Timur Village at station I is 4 because its density value is 16 ind/m². The fixed score is 4 if the value ranges between 15-25 ind/m². Stations II and III have mangrove density scores of 3 because their density values are 12 ind/m², with a fixed score of 3 if the value ranges between 10-15 ind/m².

Data on biota objects were collected by direct observation in the field. At the research location, the score for the presence of biota objects is 3 because approximately 4 types of biota were found at the location, including fish, shrimp, crabs, and mollusks. Data on tides, uniqueness, area characteristics, accessibility, and facilities and infrastructure were collected or obtained by direct observation in the field, with the tidal data score being 4 because the average tide at the research location is within the range of 0-1 meters. The uniqueness score is 1 because it falls into the local category if the uniqueness is

standard or there is nothing unique at the research location.

The score for area characteristics in Pentadu Timur Village is 2 because there are only 2 criteria: there is a view with its attraction and a beautiful panorama or landscape. The score for accessibility in Pentadu Timur Village is 2 because there are 2 criteria: a fairly good road to the location and many means of transport to reach the location. Meanwhile, the score for facilities and infrastructure is based on 3 types: infrastructure, communication systems, and security systems. Infrastructure is available in the mangrove forest area of Pentadu Timur Village, with a score of 2 because only 2 criteria are met, i.e., available but incomplete. The score for the communication system in the mangrove forest area of Pentadu Timur Village is 0 because none of the established criteria are met.

Analysis of Mangrove Forest Ecotourism Potential in Pentadu Timur Village

Based on the assessment of the ecotourism potential of the mangrove forest in Pentadu Timur Village, the analysis of the potential based on the parameters of mangrove thickness, mangrove species, mangrove density, biota objects, tides, uniqueness, area characteristics, accessibility, and facilities and infrastructure is described as follows:

Mangrove Thickness Parameter

Based on research and measurements from the coastline to the land direction conducted in the Mangrove Forest of Pentadu Timur, the measurement results of the mangrove ecosystem thickness in Pentadu Timur Village are as follows: for station I, the mangrove thickness is 310 m, for station II, it is 280 m, and for station III, it is 298 m. This indicates that the mangrove ecotourism in Pentadu Timur Village is quite extensive and thick, which will undoubtedly attract tourists to come and enjoy the natural beauty of the mangrove ecosystem, including the fresh air characteristic of the mangrove area.

Mangrove Species

Field data collection results show that the mangrove species found in the ecotourism area include Ceriops Tagal, Ceriops Decandra, Rhizophora Apiculata, and Rhizophora Mucronata. The most dominant mangrove species in the area is Rhizophora Apiculata, followed by Rhizophora Mucronata and Ceriops Decandra, with Ceriops Tagal being the least common species. Specific points have been marked with boards indicating the names or species of mangroves, making this area a potential ecotourism site to support biodiversity knowledge and protection.

Mangrove Species Density

The mangrove species density parameter is crucial in proving whether the mangrove forest area is well-maintained. The data on mangrove species density in Pentadu Timur Village is shown in Table 2.

Table 2. Mangrove Species Density in Pentadu Timur Village

Station	Plot	Species	Number of Trees (Ni)	Area (m²)	Density (Di)
I	1	*Rhizophora Apiculata*	13	100	0,13
	2	*Rhizophora Mucronata*	16	100	0,16
	3	*Ceriops Decanra & Ceriops Tagal*	21	100	0,21
Total			**50**	**100**	**0,50**
Average					**0,17**
II	1	*Rhizophora Apiculata*	11	100	0,14
	2	*Rhizophora Apiculata*	13	100	0,16
	3	*Rhizophora Mucronata*	16	100	0,24
Total			**40**	**100**	**0,40**
Average					**0,13**
III	1	*Rhizophora Apiculata*	11	100	0,12

	2	*Rhizophora Apiculata*	12	100	0,13
	3	*Ceriops Decanra*	18	100	0,17
Total			**41**	**100**	**0,41**
Average					**0,14**

Based on the average density values at each station, the data are as follows: station I has a density value of 0.17 ind/m², station II has a density value of 0.13 ind/m², and station III has a density value of 0.14 ind/m². Field data show that Rhizophora Apiculata has the highest density value compared to other species such as Rhizophora Mucronata, Ceriops Decandra, and Ceriops Tagal, indicating that this mangrove area has high potential to be developed into a mangrove forest ecotourism area.

Tidal Conditions

Tidal data were obtained using tidal gauges, with data collected manually every 2 hours. Tidal condition data were collected to determine the extent or magnitude of the tidal influence on the mangrove area. Tidal data are primary data obtained from direct field measurements as presented on Figure 2.

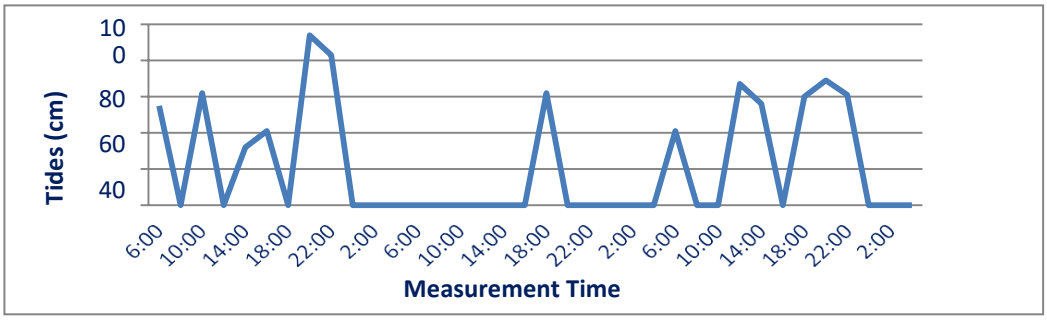

Figure 2. Tidal Graph of Mangrove Forest in Pentadu Timur Village

The sea level data obtained are as follows: the highest tide reaches 94 cm on the tidal gauge, and the lowest tide is 15.4 cm, with an average tidal range of around 61 cm. This tidal range is very suitable for selecting a coastal ecotourism location in the mangrove tourism category, with the tidal parameter being 0-1 meters, considering safety and the impact on the mangrove environment.

Biota Objects

The mangrove forest in Pentadu Timur Village has various types of biota, both aquatic and terrestrial, around the mangrove area. These biota include Katamba fish (Lethrinus lentjan), Snapper fish (Lutjanidae), Mudskipper fish (Pseudapocryptes elongatus), Ashy Tailorbird (Orthotomus ruficeps), Little Egret (Egretta garzetta), and Crustaceans.

The mollusk biota found in the mangrove forest area of Pentadu Timur Village includes the mud crab (Perisesarma darwinensis) and the mud crab (Scylla olivacea). These two types of crabs are aquatic biota commonly found in mangrove forest areas as these biota are well-suited to the mangrove habitat.

Uniqueness

The uniqueness of the research location was determined by observing unique species of animals or plants in the area that are not found elsewhere. In the mangrove forest area, no unique species were found besides local animals and plants that can be commonly found in other places. Therefore, the mangrove forest area in Pentadu Timur Village falls into the local category as it does not have any particularly distinctive characteristics in terms of flora, fauna, or other ecosystems. The mangrove forest area

here is similar to typical mangrove forest areas in general.

Area Characteristic

This mangrove forest ecotourism area features a distinctive panorama or beauty with various pretty colors displayed by the rainbow bridge in the area. A well-constructed wooden bridge, popularly known by the locals as the "Tambatan Hati Pelangi" (Rainbow Heart Bridge), has been built to help tourists get closer to the mangrove forest and enjoy the unique mangrove scenery. The area also has a lovely landscape dominated by mountains, hills, and valleys, which adds to the distinctive characteristics of the Pentadu Timur mangrove forest.

Accessibility

Accessibility to the research location is quite good, with well-established access routes. Both four-wheeled and two-wheeled vehicles (cars, motorcycles) can be used to reach the area, and it is accessible by both land and sea routes. The available facilities and infrastructure in the mangrove forest area are still under development. However, the facilities currently available are quite good, making the area potentially suitable for development into an ecotourism site.

Ecotourism Suitability Level of Mangrove Forest in Pentadu Timur Village

Based on the analysis of the suitability level of the mangrove forest land in Pentadu Timur, the total values at each station were as follows: stations I scored 74, while stations II and III each scored 70. These values were obtained from the sum of the weight values multiplied by the scores for each parameter. The land suitability values in Pentadu Timur Village for each station were 77% for station I, and 73% for both stations II and III. This indicates that station I, with 77%, falls into the category of very suitable for ecotourism, while stations II and III, each with 73%, fall into the suitable category for ecotourism. The results of this study show that the mangrove forest area in Pentadu Timur Village falls into the categories of suitable and very suitable for ecotourism development. The land suitability categories for the mangrove forest in Pentadu Timur Village are very suitable (S1) for station I, and suitable (S2) for stations II and III, as determined by the Tourism Suitability Index as presented in Table 3.

Table 3 Land Suitability Assessment of Mangrove Ecosystem in Pentadu Timur

Parameter	Weight	Station					
		I		II		III	
		Score	Value	Score	Value	Score	Value
Mangrove thickness (m)	5	3	15	3	15	3	15
Mangrove density (Di)	4	4	16	3	1	3	12
Mangrove species	4	3	12	3	12	3	12
Biota objects	3	3	9	3	9	3	9
Tides (m)	3	4	12	4	12	4	12
Distinctiveness	1	1	1	1	1	1	1
Area characteristics	2	2	4	2	4	2	4
Accessibility	1	2	2	2	2	2	2
Facilities and infrastructure	1	3	3	3	3	3	3
Total			74		70		70
Suitability Value (%)			77%		73%		73%
Suitability Category			S1		S2		S2

Primary data analysis (2022)

Based on the analysis results, it can be concluded that the mangrove forest area in Pentadu Timur Village falls into two categories of ecotourism land suitability:

suitable and very suitable for ecotourism development.

CONCLUSION

Based on the research conducted on the mangrove forest in Pentadu Timur Village, it is evident that the area holds substantial potential for ecotourism development. The analysis covered various parameters including mangrove thickness, species diversity, density, tidal conditions, presence of biota, uniqueness, area characteristics, accessibility, and available infrastructure. The findings show that the mangrove forest in Pentadu Timur Village is classified into two categories of ecotourism land suitability: suitable (S2) and very suitable (S1). Station I, with a suitability index of 77%, is classified as very suitable for ecotourism, while stations II and III, each with a suitability index of 73%, are classified as suitable.

The diversity of mangrove species, the significant mangrove thickness, and the overall health of the ecosystem contribute to the area's high potential as an ecotourism site. Additionally, the accessibility by both land and sea, along with the developing infrastructure, further supports the viability of Pentadu Timur Village as an attractive destination for ecotourism. The local community can benefit from the economic opportunities that ecotourism can provide, while also promoting environmental conservation and awareness.

In conclusion, the mangrove forest in Pentadu Timur Village presents a unique opportunity for ecotourism development that can enhance both environmental sustainability and community welfare. The combination of natural beauty, biodiversity, and accessibility makes it an ideal location for promoting ecotourism initiatives that align with conservation goals and socio-economic development.

Declaration by Authors

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