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SUITABILITY AND CARRYING CAPACITY OF MANGROVE ECOTOURISM IN KAMPUNG NIPAH, SEI NAGALAWAN VILLAGE, NORTH SUMATRA

KESESUAIAN DAN DAYA DUKUNG EKOWISATA MANGROVE DI KAMPUNG NIPAH, DESA SEI NAGALAWAN, SUMATRA UTARA

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ABSTRACT

Mangrove ecosystems are highly vulnerable to damage, making their conservation crucial. The development of mangrove ecotourism serves as an approach to utilizing ecosystem services sustainably without causing harm. Ecotourism in mangrove ecosystems is beneficial as it synergizes with conservation efforts to protect the ecosystems. This study aims to assess the suitability and carrying capacity of mangrove ecotourism in Kampung Nipah, Sei Nagalawan Village of North Sumatra. The research was conducted in July 2023 within the mangrove ecotourism area of Kampung Nipah. The research location was selected using the purposive sampling method, consisting of three stations. Primary ecological data were collected through the transect method. The descriptive method was applied to analyze the tourism suitability index (TSI) and the spatial carrying capacity (SCC). The results indicate that the TSI values for the three substations were 1.97, 1.87, and 1.87 out of 3, while the SCC (carrying capacity) was 200 people per day. Based on these findings, the mangrove ecotourism area in Kampung Nipah, Sei Nagalawan Village, is conditionally suitable for tourism. The following recommendations can be implemented to expand the mangrove area to increase ecosystem thickness and maintain a visitor quota system to regulate tourist numbers and ensure sustainability.

Keywords: ecotourism, environmental carrying capacity, mangrove, tourism suitability index

ABSTRAK

Ekosistem mangrove merupakan ekosistem yang rentan terhadap kerusakan, sehingga upaya konservasi sangat diperlukan. Pengembangan ekowisata mangrove menjadi salah satu upaya pemanfaatan jasa ekosistem secara berkelanjutan tanpa merusaknya. Ekowisata di ekosistem mangrove dianggap dapat berintegrasi dengan upaya konservasi, sehingga mendukung perlindungan ekosistem. Penelitian ini bertujuan untuk menilai kesesuaian dan daya dukung ekowisata mangrove di Kampung Nipah, Desa Sei Nagalawan, Sumatra Utara. Penelitian dilakukan pada Juli 2023 di kawasan ekowisata mangrove Kampung Nipah. Lokasi penelitian dipilih menggunakan metode *purposive sampling*, yang terdiri atas tiga stasiun. Data ekologi dikumpulkan melalui metode transek mangrove untuk memperoleh data primer. Metode deskriptif digunakan untuk menganalisis indeks kesesuaian wisata (IKW) dan daya dukung kawasan (DDK). Hasil perhitungan menunjukkan bahwa kawasan ekowisata mangrove Kampung Nipah untuk 3 stasiun adalah 1,97; 1,87; dan 1,87; serta DDK sebesar 200 orang per hari. Artinya, secara keseluruhan ekowisata mangrove Kampung Nipah, Desa Sei Nagalawan termasuk ke dalam kategori tidak sesuai. Beberapa rekomendasi yang dapat diterapkan meliputi memperluas area hutan mangrove sehingga ketebalan ekosistem meningkat dan mempertahankan jumlah kunjungan wisatawan dengan sistem kuota untuk mendukung kelestarian kawasan.

Kata kunci: daya dukung kawasan, ekowisata, indeks kesesuaian wisata, mangrove

INTRODUCTION

The mangrove ecosystem is a coastal ecosystem affected by the tide and flow of seawater and is generally always inundated. Mangrove forests in Indonesia have experienced significant degradation. Since 1999, the area of damage has reached 8.60 million hectares, with around 5.30 million hectares of mangrove ecosystems affected. This damage is generally caused by land conversion into ponds, settlements, oil palm plantations, and industry (Ramadani and Navia 2019). Its existence plays an important role in protecting coastal areas and supporting various ecosystem services along tropical coastlines (Utomo *et al*. 2017). One form of sustainable utilization of this ecosystem is through the development of ecotourism, which is in line with forest conservation efforts. The current condition of mangroves greatly influences the development of ecotourism, so their management needs to be carried out carefully to avoid negative impacts on the environment by considering the tourism suitability index and the carrying capacity of the area (Mukhlisi 2017).

Efforts to develop mangrove ecotourism must be carried out sustainably by optimally utilizing coastal environmental services. Mangrove ecotourism not only supports forest ecosystem conservation but also plays a role in increasing community and stakeholder involvement in maintaining and preserving the coastal environment. Active community participation in mangrove conservation is an important factor in creating a sustainable use of the coastal ecosystem. Therefore, good synergy and communication between the community and stakeholders are needed to increase the effectiveness of mangrove area management and conservation (Suraningsih 2020).

North Sumatra Province is one of the regions with a fairly high level of mangrove ecosystem damage compared to other regions, with 90% of its mangrove ecotourism being damaged. The main cause of this damage is the conversion of mangrove land into agriculture, such as shrimp ponds, oil palm plantations, and other activities, which have resulted in more than 22 thousand hectares of mangrove being damaged (Tambunan 2018).

Mangrove ecosystem damage also occurred in Kampung Nipah, especially in the mangrove ecotourism area in Sei Nagalawan Village of Serdang Bedagai Regency, North Sumatra. Mangrove damage in this area has an impact on the economy of coastal communities. Local people have formed a conservation group known as the Muara Baimbai Group. This group not only focuses on mangrove conservation efforts but also utilizes the area for the development of education-based ecotourism. In addition, the Muara Baimbai Group has obtained a business permit for the utilization of community mangrove forests to support the sustainability of ecotourism in the area.

The limitations of tourism areas in accommodating the number of visitors and the consequences that arise require a study on the suitability and carrying capacity of the area to reduce its negative effects. One of the possible impacts is an increase in waste in the ecosystem, which can affect water quality and have an impact on the growth and existence of the mangrove ecosystem.

The hypothesis based on the results of observations and pre-research surveys is the a lack of mangrove thickness in the Nipah area, causing mangrove ecotourism in Sei Nagalawan Village to not follow the tourism suitability index (TSI) and spatial carrying capacity (SCC). The tourism suitability index (TSI) and spatial carrying capacity (SCC) that do not follow the provisions will cause damage to the mangrove ecosystem (Yulianda 2019). Therefore, research on TSI and SCC needs to be carried out to prevent damage to the mangrove ecosystem. The benefits can be used to support the development of ecotourism and mangrove conservation in the Nipah Village mangrove tourism, especially research related to TSI and SCC, has never been carried out after mangrove rehabilitation in the Nipah Village.

METHODS

Location and time of study

This study was conducted in July 2023 in the Mangrove Ecotourism Area of Kampung Nipah, Sei Nagalawan Village of North Sumatra. The research location was divided into 3 stations, namely, each station area represented the left, right, and middle edges of the mangrove area. The determination of observation stations was made using the purposive sampling method. The research location is presented in Figure 1.

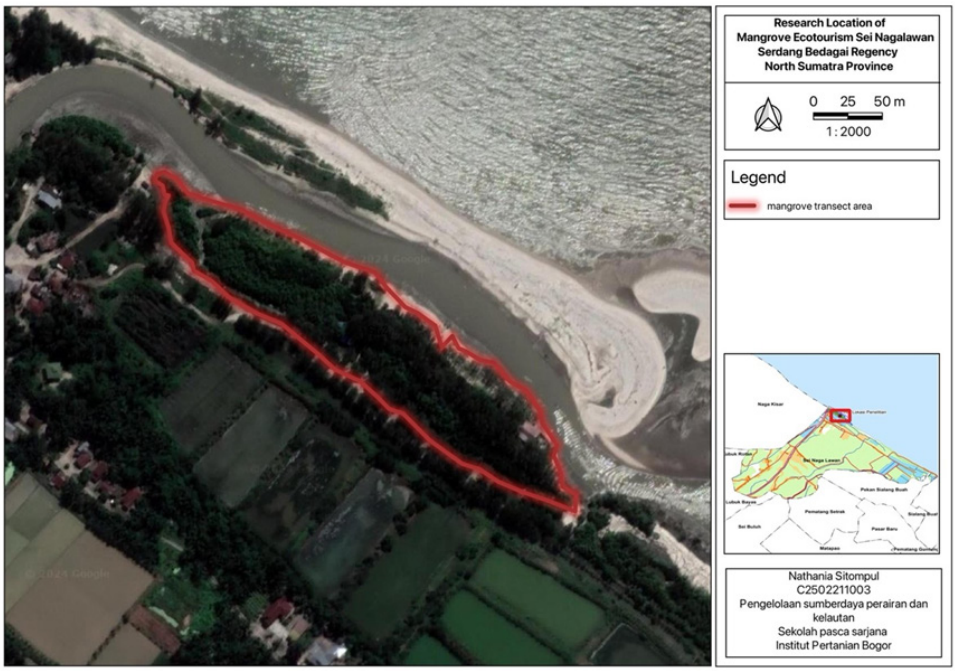

Figure 1. Map of research locations in the Nipah Village Mangrove Ecotourism Area, North Sumatra.

Method of collecting data

The data used in this study included primary data and secondary data. Primary data included mangrove density, mangrove thickness, types of biotas, types of mangroves, and questionnaire data. Secondary data were obtained from the tidal information site www.pasanglaut.com. The determination of station locations and the number of substrates was carried out by applying the purposive sampling method, while the identification of substrate samples was carried out at the PPKS Laboratory (Palm Oil Research Center) in Medan City, North Sumatra.

Density of mangrove species

Species density is the correlation between the number of individuals of a mangrove species (ni) and the total area of the sampling area (Masiyah and Sunarni 2015). To determine species density, data are required on the mangrove species and the number of individuals of each mangrove species, especially those mangrove trees with a dbh (diameter at breast height) ≥10 cm (Hernandi *et al.* 2014). Identification of mangrove species was carried out by observing morphological characteristics, such as leaf shape, root type, fruit, and flowers. The results of the observations were then analyzed using a mangrove identification guidebook by paying attention to morphological characteristics such as color and shape that are typical of each mangrove species.

Thickness of mangroves

Mangrove thickness was measured using a roll meter at each station with a perpendicular measurement method, starting from the land boundary to the sea boundary (Setiawan 2013). In addition, mangrove thickness data were also calculated using the Google Earth application and mapped with QGIS. The calculation was carried out by measuring perpendicularly from the outermost line of the mangrove ecosystem, starting from the sea towards the land until the last point where mangrove vegetation was found.

Biota objects

Data collection of biota objects was carried out using visual methods in ecotourism areas (Bahar 2004) and in conjunction with mangrove ecosystem transect activities (Setyawan *et al.* 2015). The data obtained were then grouped into various categories in the tourism suitability matrix, including fish, reptiles, birds, shrimp, crabs, mollusks, and other biota categories (Yulianda 2019).

Low and high tide

The water level and intensity of the sea tides affect the safety of tourists enjoying the uniqueness of the mangrove forest ecosystem. Tanto *et al.* (2016) explained that tides are an important factor for the mangrove ecosystem because they play a role in coastal mitigation against abrasion, erosion, and high waves. Tidal data were obtained from the website www.pasanglaut.com. Data processing was carried out over one month by adding up the difference between the highest high tide and the lowest low tide. Furthermore, the average difference was calculated to determine the mean sea level.

Depth interview

The determination of respondents was carried out using the accidental sampling method. The target respondents included local people, visitors, and environmental activists. The three respondent objects were selected according to the needs, based on the research objectives, namely, a total of respondents was 30 people. Respondents in this study included members of the indigenous community based on parameters of gender, age, education, occupation, and income. Each individual interviewed was over 15 years old and had prime physical condition and good mental balance.

Data analysis

Density of mangrove species

According to Masiyah and Sunarni (2015), species density is the ratio between the number of individuals of a species (ni) and the total area of the sampling area (A). The calculation of the mangrove density can be analyzed using the following equation (Buwono 2017):

$$Di = ni/A$$

Description:
Di = Density of mangrove species i (ind/m^2)
ni = Number of individuals of a species (ind)
A = Total plot area (m^2)

Thickness of mangroves

Mangrove thickness was measured from the first point where mangrove vegetation was found from the sea, perpendicular to the land, to the last point where the vegetation was identified. The thickness measurements were measured by utilizing Google Earth Pro 2020 satellite imagery (64-bit), which calculated the average value per station in meters. In addition, manual methods using raffia rope and a rolling meter were also applied to determine the width of the mangrove area. This study also utilized satellite imagery because some stations were difficult to reach the last mangrove was found.

Tourism suitability index

The potential of mangrove resources in a tourist area must be considered in its development; of course, the development must be appropriate and follow its designation. This analysis aims to meet the criteria for resources and environmental conditions that are suitable for the development of tourist attractions. Five assessment parameters can be considered with four classifications, as seen in Table 1. The formula used for the suitability of mangrove ecotourism, based on Yulianda (2019), is:

$$TSI = \sum_n (Bi \times Si)$$

Description:
TSI = Mangrove tourism suitability index
Σn = Number of suitability parameters
Bi = Weight of the ith parameter
Si = Score of the ith parameter

Tourism carrying capacity analysis

The analysis of the spatial carrying capacity (SCC) aims to determine the maximum capacity of visitors that can be received at a certain time without causing negative impacts on the environment and society. The SCC calculation used the following formula (Yulianda 2007):

$$SCC = k \times Lp/Lt \times Wt/Wp$$

Description:
SCC = Spatial carrying capacity (people/day)
k = Ecological capacity of visitors per unit area (people)
Lp = Usable area size or length (m)
Lt = Area for specific categories (m)
Wt = Duration allocated by the area for tourist activities in a day (hours)
Wp = The duration visitors spend on each specific activity (hours)

Table 1. Suitability matrix for coastal tourism in the mangrove tourism category.

No.	Parameter	Weight	Category	Score
1	Mangrove thickness	0.380	>500	3
			>200-500	2
			50-200	1
			<50	0
2	Mangrove density	0.250	>15-20	3
			>10-15	2
			05-10	1
			<5	0
3	Mangrove species	0.150	>5	3
			3-5	2
			1-2	1
			0	0
4	High and low tide (m)	0.120	0-1	3
			>1-2	2
			>2-5	1
			>5	0
5	Biota objects	0.100	Fish, shrimp, crabs, mollusks, reptiles, birds	3
			Fish, shrimp, crabs, molluscs	2
			Fish, molluscs	1
			One of the aquatic biota	0

RESULTS AND DISCUSSION

Composition of mangrove species

Mangrove ecotourism represents a unique aquatic resource characterized by distinctive features and significant ecological functions. Ecologically, mangrove forests serve as critical spawning and nursery grounds for various species of fish and crabs, and provide habitat for numerous other organisms (Baharuddin *et al.* 2023). The mangrove species found at the three observation stations consisted of five species of true mangroves. However, several mangrove species were not found at the three stations but grew along the mangrove tracking path passed by visitors. This is in line with the study conducted by Utomo and Afran (2023), who stated that to create educational ecotourism, a diversity of mangrove vegetation is needed so that tourists can recognize the various types of mangroves in the area. The mangrove species found during the study are presented in Table 2.

Five types of mangroves were found in the Kampung Nipah mangrove area, which, according to Yulianda (2007), are included in the good category because they are in the range of 2-5 types. However, the diversity of mangrove species still needs to be increased so that the number can exceed 5 species, so that it can provide wider benefits, especially in terms of educating the community about the importance of planting mangroves. This is in line with the opinion of Utomo and Afran (2023), who stated that one of the educational efforts can be carried out through planting mangroves with various species, so that it not only improves the ecosystem but also becomes a tourist attraction. Fauzi *et al.* (2022) stated that a high diversity of mangrove species within a given area serves as a physical indicator of optimal environmental conditions that support the survival and development of various mangrove. One strategy that can be applied is to plant mangrove seedlings of types that do not yet exist in the research location, thereby enriching the diversity of the ecosystem and increasing the educational value for tourists and the local community.

Table 2. List of mangrove species at each station.

Station	Number	Mangrove Species
1	5	*Rhizophora apiculata* *Lumnitzera rocemosa* *Avicennia marina* *Bruguiera gymnorrhiza* *Soneratia ovata*
2	4	*Rhizophora apiculata* *Avicennia marina* *Bruguiera gymnorrhiza* *Soneratia ovata*
3	4	*Rhizophora apiculata* *Avicennia marina* *Bruguiera gymnorrhiza* *Soneratia ovata*

Mangrove density

The results of vegetation analysis showed that the highest density of mangrove species at each research station was *Rhizophora apiculata*, as many as 1,200 trees/ha at Station I, *Avicennia marina* as many as 1,900 trees/ha at Station II, and *Rhizophora apiculata*, as many as 2,000 trees/ha at Station III. The mangrove density value based on its type at each station can be seen in the graph in Figure 2.

The density of mangrove species in Kampung Nipah was recorded at 20 individuals/m². Based on Yulianda (2007), this value is categorized as good for ecotourism in Kampung Nipah. The difference in density at each station is caused by differences in the adaptation patterns of individual mangroves, which are influenced by various factors. In addition, lower densities at several research stations can also be caused by the condition of the mangrove area and substrate after rehabilitation. Another factor that also has an influence is mangrove zoning, which can affect variations in density levels in an area.

Thickness of mangroves

Mangrove thickness was obtained through satellite image analysis by measuring the length of vegetation from the outermost mangrove line towards the sea and towards the land until the last mangrove meeting. The following are the results of the mangrove thickness measurements in each area. Based on the level of mangrove thickness at three stations measured using Google Earth Pro satellite imagery (64-bit), the lowest thickness was obtained at station 1, which was 56.7 m long, while the widest thickness was at station 2, which was 70.3 m long. Based on the mangrove tourism suitability matrix, the thickness score for each station is one because it is classified as having a thickness of >50 m. This thickness indicates that the mangrove ecosystem in the mangrove tourism area is not yet optimal. The mangrove thickness measurement map in each area is presented in Figure 3.

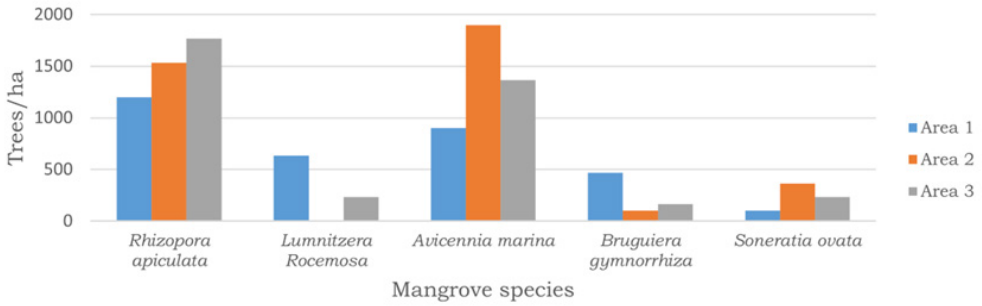

Figure 2. Mangrove density graph for each station in the Nipah Village tourist area.

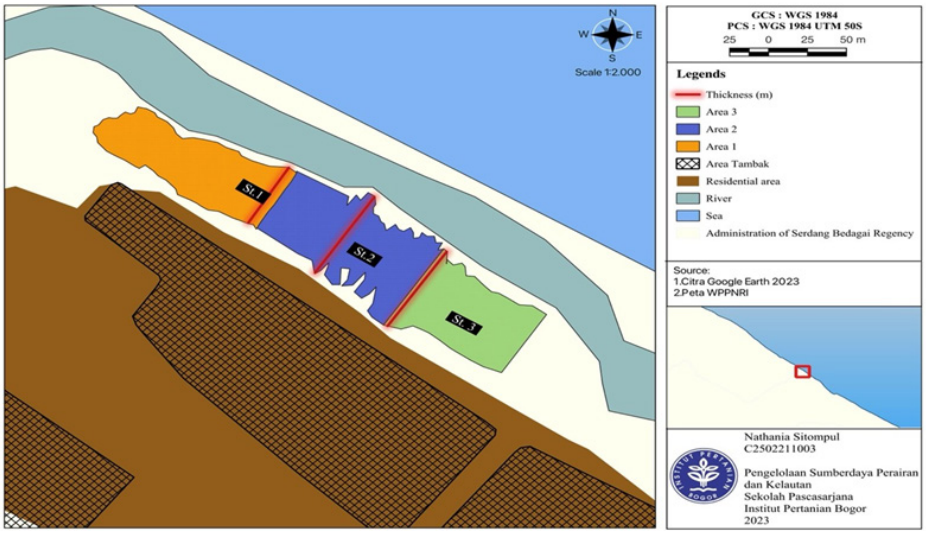

Figure 3. Map of mangrove thickness measurements in each mangrove tourism area of Nipah Village.

Types of biotas

In addition to the types of mangroves, fauna that live and inhabit the mangrove area also have the potential to become ecotourism objects (Agussalim and Hartoni 2014). The terrestrial fauna groups that usually inhabit the upper part of the mangrove tree include insects, snakes, primates, and birds, while the aquatic fauna groups are also found in this ecosystem (Muhammad *et al.* 2012).

Based on the results of observations in the mangrove forest of Kampung Nipah, Sei Nagalawan Village, various types of fauna were found, such as mangrove crabs, long-whisker catfish, giant prawns, mullet fish, white birds, and others. This diversity is an added value for the Kampung Nipah mangrove ecotourism. Latupapua *et al.* (2019) stated that biota diversity is an important indicator in assessing the condition of a mangrove area. Mangrove ecotourism and mangrove education programs can be an attractive alternative for tourists, not only to experience the beauty of nature but also to deepen their understanding of the environment and the important role of the mangrove ecosystem. The results of the study on the types of fauna in the Kampung Nipah mangrove area can be seen in Table 3.

High and low tide

The results of the tidal analysis conducted from July 23 to August 23 showed that the waters of Sei Nagalawan Village had an average sea level of 1.40 m. Based on this value, this area received a score of 2 in the assessment of the suitability of mangrove tourism. According to Yulianda (2007), the tides in this area are still relatively safe and suitable for tourism activities. In addition, Tanto *et al.* (2016) explained that tides are an important factor in mitigating coastal areas such as abrasion, erosion, and the threat of high waves. The tidal conditions in the waters of Sei Nagalawan Village are presented in Figure 4.

Table 3. Biota objects at each station based on observation results in the mangrove forest of Nipah Village, Sei Nagalawan Village.

Station	Object Biota					
	Fish	Shrimp	Crab	Mollusk	Reptile	Bird
1	+	+	+	+	-	-
2	+	+	+	+	-	-
3	+	+	+	+	+	+

Description:
– : Found
\+ : Not found

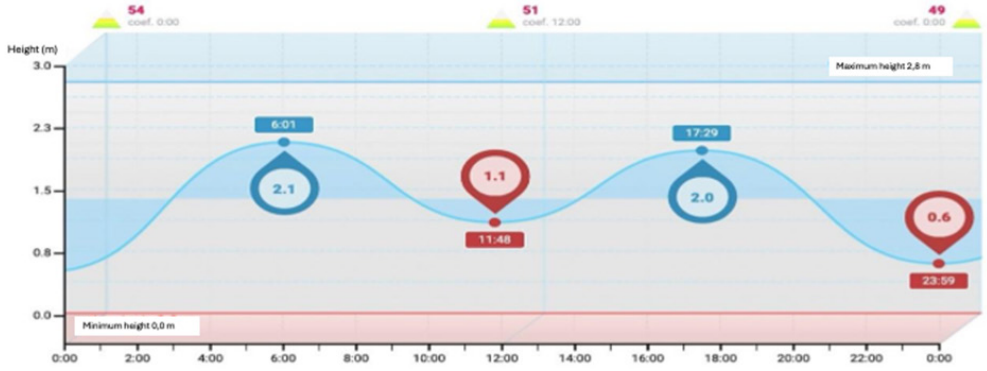

Figure 4. High and low tide of sea water in the waters of Sei Nagalawan Village.

Tourism suitability index (TSI)

The suitability of Kampung Nipah mangrove ecotourism shows that all observation stations are included in the unsuitable category (S3), namely 1.87 (Stations 1 and 2) and 1.97 (Station 3) (Table 4). Based on the study analysis, station 3 can be developed into a suitable area by improving one of the parameters; the factors that can be improved are thickness and density. The mangrove tourism suitability map of Kampung Nipah for each station is presented in Figure 5.

The low thickness of mangroves is caused by the mangrove ecosystem that grows naturally, causing planting/growing distance between individuals to be very close, resulting in very tight competition (Samsi *et al.* 2018). One effort to increase the tourism suitability index is the need for mangrove planting by the community with a distanced planting method so that the density and thickness of the mangrove can increase with the help of adaptation patterns, basic substrates, salinity, and survival of each type of mangrove with different adaptation patterns (Susi *et al.* 2018).

Spatial carrying capacity (SCC)

Mangrove ecotourism in Kampung Nipah has great potential to be developed. Currently, activities such as tracking, boat touring, and ATV motorbikes are available in the area. However, the existing tracking path still needs additional improvements. Currently, the mangrove tracking path is 300 m long with a bridge width of 1.5 m, but the condition of the wood is still not strong enough and is damaged.

The carrying capacity for tracking activities in the Kampung Nipah ecotourism is 24 people per day, which is the maximum number of tourists who can enter the mangrove area. This capacity is divided into four trips a day, where each trip consists of six people with a duration of two hours within an operational time span of eight hours per day. To optimize the use of the mangrove area, additional and improved tracking facilities are needed to make it safer and more comfortable for tourists.

Boating activities in this area use fishing boats with a maximum carrying capacity of 16 people per day. The tourist boat track is 800 m long, but its operation does not take place at all times because it depends on the ebb and flow of the water and the availability of boats. This activity can only be done for 4 trips in one day, with each trip consisting of 4 people per hour in an operational range of 8 hours per day.

Tourists visiting mangrove ecotourism are more interested in ATV motorbike activities, where the length of the ATV motorbike track is 300 m, the time per trip is only 10 minutes with a time provided of 8 hours, this activity is divided into 4 trips in a day so that ATV motorbike activities can be carried out by 40 people/trip. The number of visits of 200 people per day is the ideal number so that tourists can be distributed normally in the area to enjoy the scenery and several tourist activities. This number is dynamic and can change at any time depending on the length of the track and the Wp value or the average time spent by each tourist. The calculation of the carrying capacity of the area based on the SCC formula can be seen in Table 5.

Table 4. Results of the tourism suitability assessment for the Nipah Village mangrove ecotourism.

Parameter	Weight	St1		St2		St3	
		Score	Value	Score	Value	Score	Value
Mangrove thickness	0.38	1	0.38	1	0.38	1	0.38
Mangrove density	0.25	3	0.75	3	0.75	3	0.75
Mangrove types	0.15	2	0.30	2	0.30	2	0.30
High and low tide	0.12	2	0.24	2	0.24	2	0.24
Biota object	0.10	2	0.20	2	0.20	3	0.30
Total	**1**		**1.87**		**1.87**		**1.97**

Figure 5. Map of the suitability of mangrove tourism in Nipah Village at each station.

Table 5. Daily carrying capacity of the Nipah Village mangrove tourism area.

Type of activity	K (Visitor)	Lp (m)	Lt (m)	Wt (Hour)	Wp (Hour)	Spatial carrying capacity (SCC)
Tracking	1	300	50	8	2	24 people/day
Tour boat	1	800	400	8	1	16 people/day
Motor atv	1	300	150	8	0.1	160 people/dayi
Total						**200/day**

CONCLUSION

The Nipah Village mangrove ecotourism at each station has a TSI value less than 2, which is belong to the S3 category (not appropriate). The number of tourist visits on weekdays is relatively low, get higher on weekends and holidays. However, the spike is still within the carrying capacity of the area, which is 200 people per day.

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