Ecotourism Management at Teluk Tamiang Beach, Pulau Laut Tanjung Selayar, Kotabaru, South Kalimantan

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Abstract

The coastal area in Teluk Tamiang Village has a relatively high potential for biological natural resources. The potential of natural resources owned by this island can be seen in the ecosystem of coral reefs, reef fish, ornamental fish, seagrass beds and fisheries. In addition to having an ecological function, this ecosystem also has a high aesthetic value for the development ofmarine tourism. The purpose of this study was to determine the suitability class and carrying capacity of marine ecotourism for snorkeling and beach activities that can be utilized in Teluk Tamiang Village, Tanjung Selayar Laut Island District, Kotabaru Regency, South Kalimantan Province. The suitability class of marine ecotourism in Teluk Tamiang was in the appropriate and very suitable category, with a capacity for snorkeling tourism activities of 681 people/day with a utilization area of 17.04 ha, and for beach tourism with a utilization area of 1000 meters, able to accommodate tourists as many as 80 people/day. Thus, the total number of tourists that can be accommodated by both types of tourism activities is 761 people/day.

***Keywords**: Carrying Capacity, Marine Ecotourism, Natural Resource, Small Island.*

A. INTRODUCTION

The Teluk Tamiang Village in Kotabaru Regency possesses significant marine and coastal resource potential. The activities of the Teluk Tamiang Village residents predominantly revolve around the coast and sea, such as fishing, fish/seaweed farming, transportation, and other activities. Generally, the condition of coral reefs in the waters of Teluk Tamiang Village and its surroundings is still classified as good (Koriyandi et al., 2016). Additionally, the climate condition in Kotabaru Regency is tropical. The average humidity in 2022 ranged from 77% to 90%, with an average air temperature between 26.3°C and 27.7°C. On the other hand, the minimum air pressure was 1,005.7 mb, and the maximum was 1,012.4 mb (BPS, 2023). Therefore, diving activities in the well-preserved coral reef locations will provide an enjoyable experience. Consequently, such activities can indirectly impact the development of diving tourism and benefit the local community.

Ecotourism is a type of responsible travel to areas with pristine conditions to conserve or preserve the environment and provide livelihood to the local population, including education (TIES, 2015). Sustainable marine ecotourism management must consider ecological aspects as the main attraction and involve the community as tourism actors to achieve economic benefits. Small islands are unique and beautiful areas often found in coastal and marine regions, making marine ecotourism the most suitable activity for development. According to Yulianda et al.

(2010), marine ecotourism is a concept of sustainable utilization of coastal natural resources through environmental service systems prioritizing life cycles. The main focus of marine ecotourism in coastal areas and small islands lies in the large potential of small islands as marine tourism assets, supported by geological potential and their proximity to coral reefs, especially hard corals. Furthermore, the uninhabited condition of small islands offers high biodiversity and pristine beauty, making them highly attractive for developing marine ecotourism activities such as diving and snorkeling.

According to Dahuri (2009), although Indonesia's marine tourism potential and opportunities are increasingly growing, they have not fully become a competitive advantage that can significantly contribute to the national economy. The Teluk Tamiang coastal area is one of the small islands with great potential for developing small island-based marine ecotourism. Coral reef ecosystems, reef fish, ornamental fish, and fisheries are significant natural resources. On the other hand, the local community can utilize the coastal and marine resources at Teluk Tamiang Beach for livelihood, gardening, and fishing. However, this utilization will alter the ecosystem in the area. According to Tsaur & Lin (2006), and Zhang & Lei (2012), human actions significantly impact the environment. The ecological sustainability of small islands will be influenced by the pressures of human activities on natural resources.

According to Bengen & Retraubun (2012), small islands have biogeophysical characteristics, including being small and separated from the main island or larger islands, limited freshwater resources, low terrestrial biodiversity but many endemic species, high marine biodiversity, small climate variations, larger water areas than land areas, and lacking hinterlands. These biogeophysical characteristics of small islands pose complex challenges for development, including at Teluk Tamiang Beach. Therefore, managing marine ecotourism at Teluk Tamiang Beach requires a small-island-based and ecological management approach.

Permenbudpar No. KM.67/UM.001/MKP/2004 states that the development of tourism activities and supporting facilities on small islands will impact the physical, social, cultural, and economic environments of these islands. Therefore, tourism development on small islands must carefully consider the site's conditions to ensure compliance with ecotourism suitability and carrying capacity. To prevent the destruction of coastal and marine ecosystems due to overexploitation, resource management based on the Carrying Capacity (CC) concept is necessary. Furthermore, analyzing the roles of stakeholders in utilizing environmental resources is a crucial aspect that must be scientifically studied. This aims to develop sustainable marine ecotourism management strategies.

This study aims to determine the suitability class of marine ecotourism based on CC and evaluate the roles of stakeholders in managing marine ecotourism. The focus is on snorkeling and beach tourism activities that can be utilized in Teluk Tamiang Village, Pulau Laut Tanjung Selayar District, Kotabaru Regency, South Kalimantan Province.

B. METHODS

This study was conducted from April to July 2024. The research location was in Teluk Tamiang Village. Administratively, this village is part of the Pulau Laut Tanjung Selayar Subdistrict, Kotabaru Regency, South Kalimantan Province. The research location map is shown in (Figure 1).

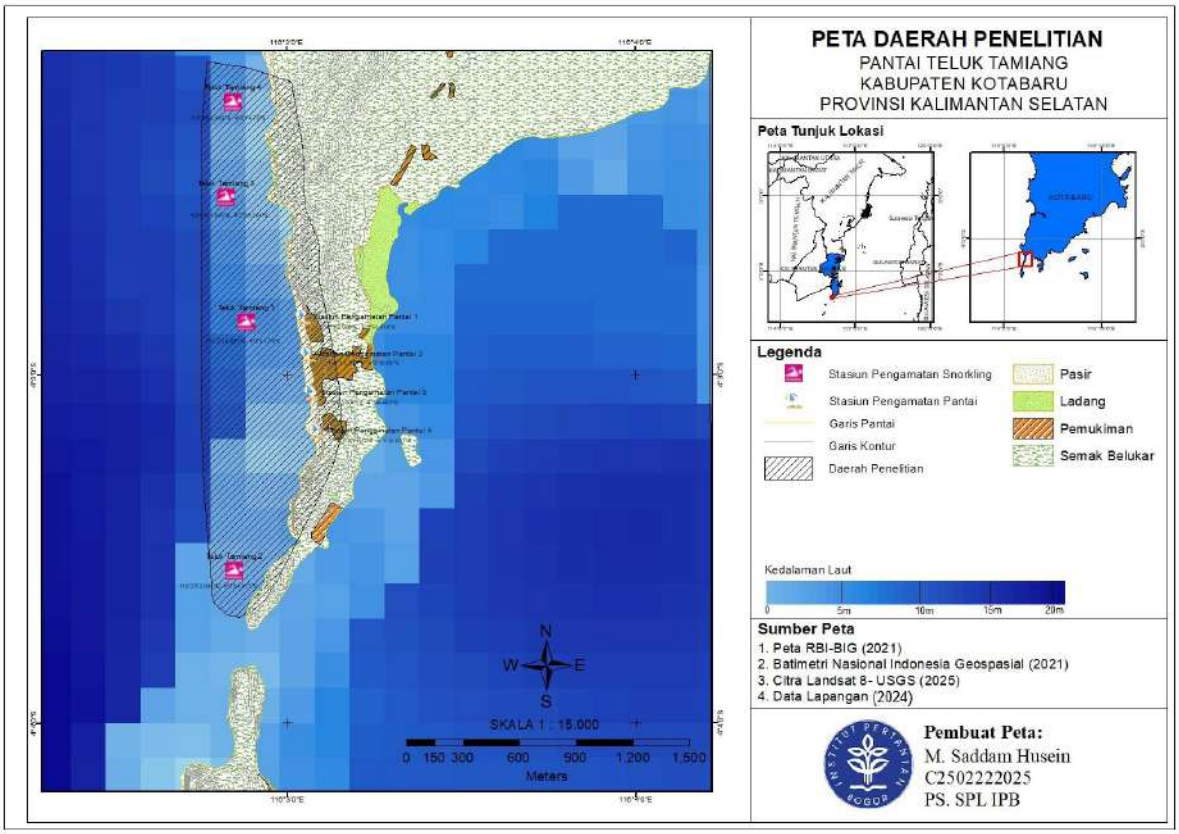


Figure 1 Research Location Map

This study utilized both primary and secondary data. Primary data were collected directly from the field through purposive sampling, a method of sample selection based on specific considerations and reasons, such as the selection of data collection locations. Meanwhile, secondary data were obtained from various sources, including research reports and activities at the same location, scientific publications, regional regulations, as well as data from government agencies, private organizations, non-governmental organizations, and information related to the area's historical background.

1. Coral Cover Analysis

From the LIT data, the percentage cover of live coral (both hard coral and soft coral) for each category of biota and substrate located beneath the transect line can be calculated. The analysis of live coral cover is based on the line intercept transect (LIT) method using a 50-meter long transect parallel to the shoreline (English et al. 1997).

$$L = L_i/N \times 100$$

Explanation:

L = Percentage of coral cover

L_i = Total length of the i-th cover

N = Transect length

The criteria for interpreting coral community cover percentages are based on Gomez & Yap (1988) in Setyobudiandi et al. (2009), with the following categories: 0.0–24.9% (poor), 25.0–49.9% (fair), 50.0–74.9% (good), and 75.0–100.0% (excellent).

2. Reef Fish Analysis

The analysis of reef fish abundance was calculated using the formula provided by Odum (1994) as follows:

$$X = \frac{\sum X_i}{n} \times 100$$

Explanation:

X = Fish abundance

∑Xi = Total fish count at the i-th observation area

n = Observed coral reef area (m^2)

3. Water Clarity

Once the values for D1 and D2 in meters are obtained, water clarity can be calculated using the formula:

$$K = \frac{D2}{D1} \times 100$$

Explanation:

K = Water clarity

D1 = Depth of water when the Secchi disk is no longer visible

D2 = Depth of water when the Secchi disk becomes visible again

4. Current Velocity

The velocity of the water current (V) can be determined using the general formula (Sudarto, 1993):

$$V = \frac{S}{T} \times 100$$

Explanation:

V = Current velocity (cm/second)

S = Distance traveled (cm)

T = Travel time (seconds)

5. Marine Ecotourism Suitability Analysis

The suitability analysis in this study focused on the designation of marine ecotourism areas, specifically for diving and snorkeling activities. Weights were assigned based on the importance of each parameter, while scores were determined by the quality of each parameter. The suitability index for marine ecotourism was calculated using the formula from Yulianda et al. (2010):

$$IKW = \sum [N_i / N_{maks}] \; x \; 100\%$$

Explanation:

IKW = Tourism Suitability Index

Ni = Value of the i-th parameter (Weight × Score)

N max = Maximum value for the tourism category

The determination of land suitability classes for specific categories was conducted by calculating the class interval values from each marine ecotourism suitability score. The classification of marine ecotourism suitability refers to Yulianda (2007) and is divided into three categories: Very Suitable (S1) with IKW > 75%, Suitable (S2) with IKW 50–75%, and Not Suitable (TS) with IKW <50%. After the class interval values were determined, suitability class mapping was carried out using spatial analysis. This approach utilized Geographic Information Systems (GIS) with ArcGIS software to identify space utilization.

6. Carrying Capacity Analysis

Carrying Capacity (CC) is the maximum number of visitors that can be physically accommodated in a specific area over a certain period without causing disturbances to the natural environment or human activities. The calculation of CC is based on the method described by Yulianda et al. (2010).

$$DKK = K\ x\ L_p/L_t x W_t\ /W_p$$

Explanation:

DDK = Carrying capacity

K = Ecological potential of visitors per unit area

L_p = Usable area or length of the area

L_t = Unit area for a specific category

W_t = Time allocated by the area for tourism activities in one day

W_p = Time spent by visitors on each specific activity

The ecological potential of visitors performing activities is based on the area size and time utilized for each type of activity, as shown in Tables 1 and 2.

Table 1. Ecological Potential of Visitors (K) and Activity Area Size (Lt)

Activity Type	K (Visitors)	Unit Area (Lt)	Description
Snorkeling	1	500 m²	1 visitor for every 100 m × 5 m area
Beach	1	25 m	1 visitor for every 25 meters of beach length

Source: Yulianda *et al*. (2019)

Table 2. Time Required for Each Tourism Activity

Activity Type	Time Required (Wp - hours)	Total Time per Day (Wt-Hours)
Snorkeling	3	6
Beach	3	6

Source: Yulianda *et al*. (2019)

C. RESULT AND DISCUSSION

1. Physical Conditions of Waters

The observed physical parameters of the waters at Teluk Tamiang Beach include environmental factors affecting coral reef development, such as temperature, salinity, clarity, currents, and depth. According to Suharsono (2008), coral growth, coverage, and growth rate are highly influenced by the physical conditions of the aquatic environment. The main factors influencing the vertical distribution of coral reefs are light intensity,

oxygen, temperature, and water clarity. Measurements of physical parameters in the waters of Teluk Tamiang Beach showed that the conditions are classified as good.

Table 3. Physical Parameters of Waters

Observation Location	Parameters				
	Temperature (˚C)	Salinity (%)	Brightness (%)	Current (m/sec)	Depth (m)
Teluk Tamiang 1	29.3	35.5	95	0.12	4
Teluk Tamiang 2	29.3	35.5	90	0.13	3
Teluk Tamiang 3	29.3	35.5	86	0.13	5
Teluk Tamiang 4	29.3	35.6	85	0.13	5

Source: Processed Data (2024)

Based on the research results from four research stations in Teluk Tamiang, the waters have a temperature of 29.3°C in both areas. This value reflects a natural phenomenon where higher solar movement results in higher temperature values. According to Nybakken (1988), the ideal temperature for coral reef growth ranges from 23°C to 25°C, with extreme temperatures that can still be tolerated between 36°C to 40°C. Meanwhile, Romimohtarto (2009) explains that most reef-building corals require a minimum water temperature of 20°C to survive. Thus, the recorded water temperature in Tamiang Bay, which is 29.3°C, is above the ideal temperature range for optimal coral growth (23°C - 25°C), but still below the extreme tolerable temperature (36°C - 40°C). This indicates that the water temperature conditions in Tamiang Bay still support coral reef life, although they are not within the optimal temperature range. Additionally, other water parameters in Tamiang Bay show a salinity of 35.5‰ in both areas, water clarity reaching 95% in area 1 and 86% in area 2, with current speeds of 0.12 m/s in Area 1 and 0.13 m/s in Area 2, as well as different water depths, namely 3 meters in area 1 and 5 meters in area 2. According to Suharsono (2008), the optimal salinity range for coral growth is between 30 to 35‰. Therefore, the salinity values at both research locations greatly support coral growth and development.

The water clarity at Tamiang Bay beach was measured with results reaching around 95% at a depth of 3 meters in area 1 and 85% at a depth of 5 meters in area 2. This measurement was conducted during the day under clear weather conditions and calm waters without waves. According to Romimohtarto (2009), light has a significant indirect influence on marine animals, as it serves as an energy source for the photosynthesis process of plants, which form the basis of the food chain. Nybakken (1998) added that the level of brightness with clear waters and sufficient light is the most important factor to support the process of photosynthesis.

The current in Tamiang Bay shows varying speeds, namely 0.11 m/s in Area 1 and 0.14 m/s in Area 2. The low current in both areas indicates relatively calm water conditions, which are also beneficial for coral reef growth. Currents can have both positive and negative impacts on coral growth. Currents are positive if they bring nutrients and organic materials needed by the corals, but they can have a negative impact if they cause sedimentation that covers the coral surface. This sedimentation

can result in coral death (Nybakken, 1998).

The measured depth shows 3-4 meters in area 1 and 5 meters in area 2, providing sufficiently good conditions for the light penetration needed by coral reefs. Overall, the water conditions in Tamiang Bay support the life and growth of coral reefs, as indicated by the physical parameters measured in both areas.

2. Physical Condition of the Beach

Teluk Tamiang Beach is one of the beaches located in Kotabaru Regency, South Kalimantan. This beach is known for its interesting and distinctive characteristics. The white sandy beach is the main attraction with a stretch of 20-22.9 meters, allowing visitors to sunbathe and stroll along the beach comfortably. The dominant vegetation on this beach is coconut trees. To the west of this beach, there is an elongated reef that serves as a wave barrier. The sea water at Teluk Tamiang Beach is very clear, making it easy for visitors to see the beauty of the underwater life. This condition also supports activities such as snorkeling.

The long and curved coastline adds to the visual beauty of this beach and provides a wide area for various beach activities. The relatively calm waves due to its location on the western part of the bay make this beach safe for swimming and other water activities. Around the beach, there is coastal vegetation such as coconut trees that provide natural shade and enhance the beauty of the beach.

Teluk Tamiang Beach is also known for its beautiful and diverse coral reefs, attracting the interest of divers and snorkelers. These coral reefs serve as habitats for various types of fish and other marine life, enriching the beach ecosystem. The gentle topography of the beach with a smooth transition from land to sea makes this beach easily accessible and friendly for visitors of all ages.

Although located at the edge of South Kalimantan, access to Teluk Tamiang Beach is quite good, with a paved main road and a road to Teluk Tamiang Village that has been hardened with gravel and stones. The infrastructure in this area is also quite adequate.

3. Physical Condition of Coral Reefs

The coral reef formation at Teluk Tamiang Beach belongs to the barrier reef type, with varied coral flats. A barrier reef is a type of coral formation that develops along the outer edge of a lagoon, bay, or coastline, and is located at a certain distance from the main land. This reef extends parallel to the coastline and is separated from the land by deeper waters such as a lagoon. The main function of the barrier reef is to protect the beach or coastal area from the direct impact of strong waves and ocean currents. With the presence of the barrier reef, the wave energy reaching the beach is reduced, so the beach behind this reef usually has calmer waters and more stable conditions, which support the development of a rich marine ecosystem.

According to English et al. (1997), coral growth is classified into six categories: acropora, non-acropora, dead coral, abiotic, soft coral, and others. For

marine ecotourism analysis, coral growth forms were grouped into five categories based on observation data: Live coral: Including acropora, non-acropora, and soft coral, Dead coral: Comprising dead coral and dead coral with algae, Abiotic: Consisting of sand and rubble, Others: Including turf algae, bottle brush, and assemblages.

In the development of marine ecotourism, the assessment of coral cover includes not only hard coral but also soft coral, which is considered living coral. Tourists who engage in diving and snorkeling are not only interested in enjoying hard coral but also soft coral as tourist attractions. According to Nontji (2009), in terms of esthetics, intact coral reefs display a very beautiful view that is rarely matched by other ecosystems. Irwan (2010) also stated that soft coral can enhance the esthetic value of an area, which is important in the development of marine ecotourism. Percentage of coral community coverage (Figure 2).

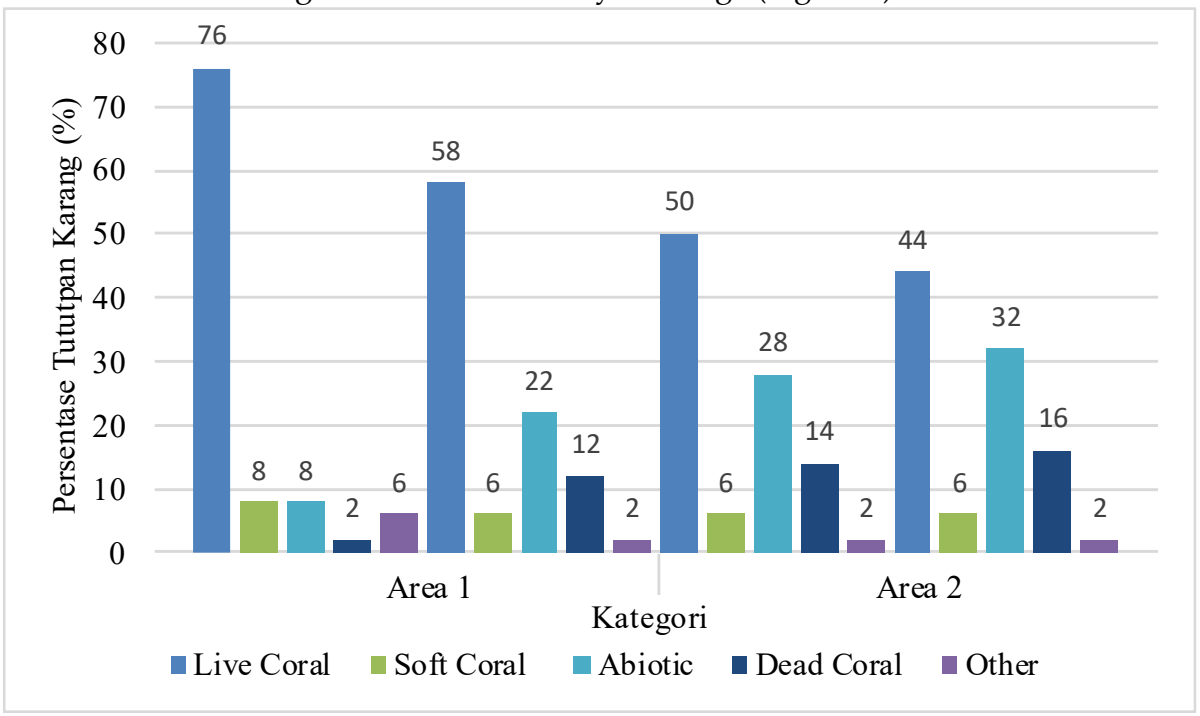


Figure 2 Percentage of Coral Reef Cover in Tamiang Bay

Figure 2 shows the composition of coral reef ecosystem cover in Teluk Tamiang 1 (satisfactory), Teluk Tamiang 2 (good), Teluk Tamiang 3 (good), and Teluk Tamiang 4 (moderate). However, the diving results in two observation areas found coral in a damaged condition (dead coral). Another study conducted by Gladstone et al. (2013) explains that the construction of ecotourism support infrastructure in coastal areas can indirectly impact the environment and marine ecosystems.

Another important parameter in determining the suitability class for marine ecotourism activities, such as snorkeling, is the type of lifeform. The lifeforms used in determining marine ecotourism activities are referenced in English et al. (1997). The most life forms were found in Teluk Tamiang 1 and 2 with 12 and 11 life forms, respectively. The lowest number of life forms was found in Teluk Tamiang 3 and 4

with 9 and 9 life forms, respectively. The presence of the same types of life forms was mostly found at all observation locations. Physical environmental factors such as temperature, salinity, brightness, and current speed at the observation sites are important parameters for coral growth (Nybakken 1998). The physical environmental parameters at the observation sites have values that do not differ significantly.

The presence of Acropora in the observation area consists of Acropora Branching (ACB), Acropora Digitate (ACD), Acropora Encrusting (ACE), Acropora Submassive (ACS), and Acropora Tabulate (ACT). For Non-Acropora, the growth includes Coral Branching (CB), Coral Encrusting (CE), Coral Foliose (CF), Coral Heliofora (CHL), Coral Massive (CM), Coral Mushroom (CMR), and Coral Submassive (CS). Meanwhile, the presence of soft coral at the observation site only has minimal coverage, which is influenced by the pressure of currents and tidal changes.

The percentage of Dead Coral observed in the study area is found in Teluk Tamiang 1, 2, 3, and 4. The highest Dead Coral percentages are in Teluk Tamiang 4 and 3 at (14% and 16%), and the lowest are in Teluk Tamiang 1 and 2, with percentages of (4% and 10%). Abiotic cover based on observational results, which consists of Sand and Rubble, was found to have the highest percentages in Teluk Tamiang 3 and 4, at (30% and 26%), and the lowest in Teluk Tamiang 1 and 2, at (10% and 18%). Other life forms consisting of sponges fall into the other category. The highest percentage is found in Teluk Tamiang 1, at (6%), and the lowest in Teluk Tamiang 2, 3, and 4, with a percentage of (2%).

The percentage of coral reef ecosystem potential for marine ecotourism utilization is an important parameter for snorkeling activities. Yulianda et al. (2010) state that to assess the suitability of marine ecotourism for snorkeling and diving activities, the parameters of live coral community coverage (hard coral) and (soft coral) must have a percentage greater than 50-75%, which falls into the suitable category, and a percentage greater than 75% is very suitable. This is because one of the visitors' goals for snorkeling and diving tourism is to enjoy the beauty of coral reefs and coral biota. The results of coral cover analysis in Teluk Tamiang 1 and 2 have cover percentages of (76% and 58%), while in Teluk Tamiang 3 and 4, the percentages are (50% and 44%). Therefore, the coral cover percentages in these two areas fall into the very suitable and suitable categories.

4. Reef Fish

Coral fish and other biota are the core of the coral reef ecosystem. Coral fish are usually found in coral reefs on islands that have clear coastal waters, high oxygen levels, and are free from sediment, pollution, and excessive freshwater runoff (Nurjanah et al., 2011).

Marine life will lose its beauty without the presence of diverse and generally brightly colored biota (Setiawan, 2011). The presence of marine biota living in coral reef ecosystems becomes part of the visual appeal in snorkeling tourism activities.

Based on the observation results of coral reef fish at Teluk Tamiang Beach, data was obtained showing variations in abundance and composition of coral reef fish families. The diversity of coral fish species varies at each observation station. Station 1, at a depth of 3 meters, found 65 species of reef fish with a total of 660 individuals per square meter, consisting of 14 families. Meanwhile, at station 2, at a depth of 4 meters, there were 54 species, with 413 individuals/m² from 12 families. Station 3, at a depth of 5 meters, recorded 45 species, 321 individuals/m², and 11 families. Station 4, at a depth of 5 meters, found 41 species, 290 individuals/m², and 10 families.

The abundance of reef fish at Teluk Tamiang Beach is recorded at (0.53-1.29) individuals/m2, indicating a relatively high density of reef fish population in this area. This data shows that the coral reef ecosystem at Teluk Tamiang Beach is in good condition and continues to support the sustainability of marine life. The high diversity and abundance of reef fish also make this location very potential for marine ecotourism activities such as snorkeling.

According to Nurjanah et al. (2011), the highest abundance of fish comes from the Pomacentridae family. This is due to the activity of fish from this family, which tend to be diurnal, as they search for food and reside in coral reef habitats, consuming plankton present in the environment (Figure 3).

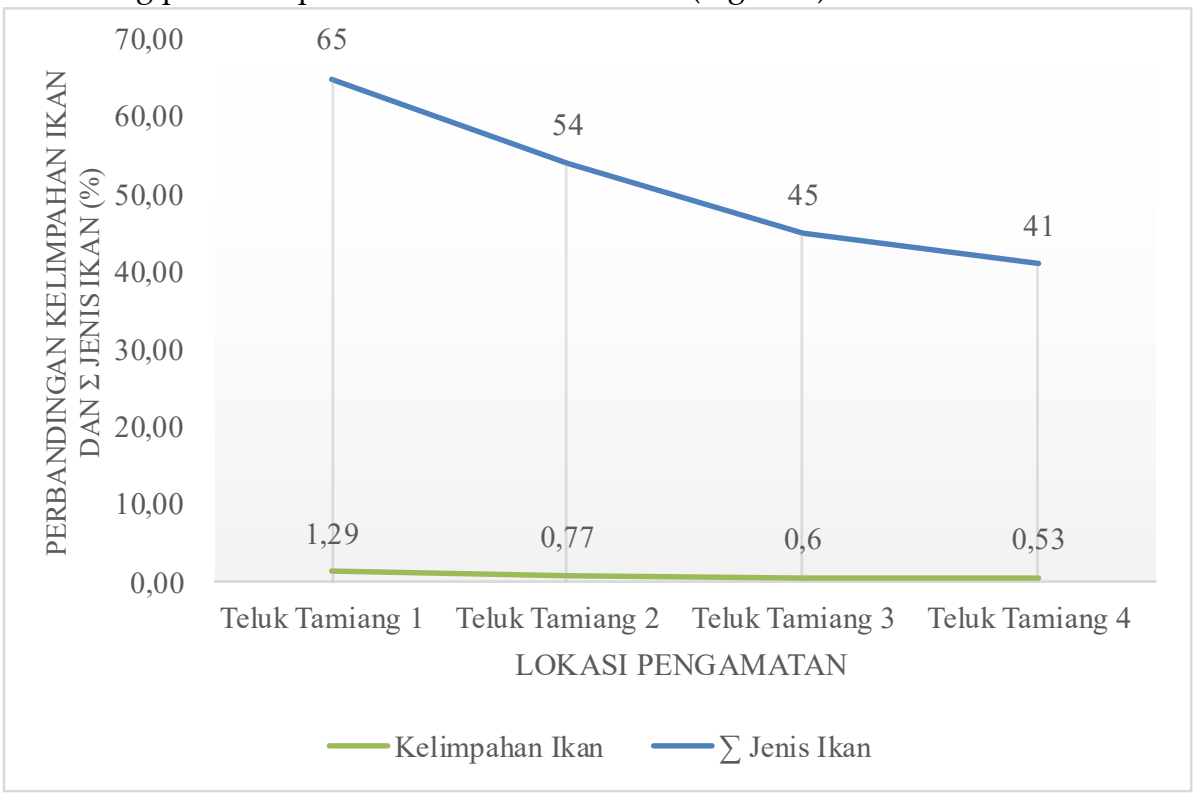


Figure 3 Comparison of Fish Abundance and the number of Fish Species

The interaction between reef fish and coral reefs has a significant direct relationship, especially as a feeding ground and a refuge area for juvenile fish from predators that threaten their development. Nybakken (1998) mentioned that the high diversity of fish species in coral reefs is caused by the habitat variations present within them. Romimohtarto & Juwana (2009) stated that some coral fish species are

only found in the reef area at nite, while during the day they are not visible. Nybakken (1998) added that there are differences in the types of fish that are active during the day and nite, where diurnal fish are active during the day and not visible at nite, while nocturnal fish are the opposite, active and visible at nite.

Romimohtarto & Juwana (2009) explain that all types of reef fish play an important role in the complex food web, creating a delicate balance between prey and predators. This predation process is influenced by the availability of food and the need for space for breeding and growth.

The coral reef ecosystem with its diverse types of reef fish in a body of water constitutes a unified ecosystem that possesses high esthetic value and can be utilized as a marine ecotourism object. Nontji (2009) stated that the importance of coral reefs as both an ecosystem and an economic resource is the main reason for preserving their sustainability. In the study of marine ecotourism utilization, analysis of coral cover parameters and the number of coral fish species is very important to determine the suitability class for snorkeling and diving activities.

5. Marine Ecotourism Suitability

Technically, the determination of the suitability class of areas for marine ecotourism utilization, including snorkeling and beach tourism activities, refers to the marine ecotourism suitability analysis according to Yulianda (2019). The suitability of the area for snorkeling and beach activities in the observation area shows that the suitability value falls into the appropriate and highly suitable categories.

6. Snorkeling Tourism

The suitability class for snorkeling tourism activities at the observation site falls into the appropriate category. This suitability analysis is conducted by considering seven parameters. The parameters used in calculating the snorkeling tourism suitability index include coral community cover, life form types, coral fish types, water clarity, reef depth, current speed, and the width of the flat reef area.

The suitability of marine ecotourism for snorkeling at Pantai Teluk Tamiang 1 shows a tourism suitability index (IKW) value of 96.67%, Teluk Tamiang 2 80.83%, Teluk Tamiang 3 76.17%, and Teluk Tamiang 4 58.83% (Figure 4). Although the analysis results show that the observation locations fall into the Very Suitable (S1) and Suitable (S2) categories, the utilization of marine ecotourism for snorkeling can only be conducted at certain depths. Considering the coral reef depth parameters, the snorkeling activities are intended so that visitors do not touch or step on the coral reefs. The quality of the parameters in those two areas has scores that support snorkeling activities.

Using spatial analysis (GIS), it is evident that the snorkeling tourism area that can be utilized has a length of 17.04 ha. Based on this analysis, the management of natural resource potential in Tamiang Bay requires careful planning for the sustainable use of marine ecotourism. This is supported by parameters indicating

that the potential of coral reef ecosystems, reef fish, and physical environmental parameters in Tamiang Bay are suitable for use as a marine ecotourism area.

7. Beach Tourism

Beach tourism is one of the most popular tourist attractions among visitors. Teluk Tamiang Beach has a type of white sandy beach with a bay-shaped shoreline, making it a favorite among the local community. Just like snorkeling tourism, beach tourism can also be assessed based on suitability parameters that include beach type, beach width, waterbed material, water depth, water clarity, current speed, beach slope, beach land cover, dangerous biota, and freshwater availability (Yulianda 2019). Based on these suitability parameters, the suitability class for beach tourism can be determined. Beach tourism in Teluk Tamiang falls into the very suitable category, with a tourism suitability calculation result of 93.33 (Figure 5).

Teluk Tamiang Beach has a stretch of white sand mixed with coral fragments, which attracts visitors to engage in activities. One of the reasons for choosing white sand is its ability to absorb sunlight, so visitors do not feel too hot. In addition, visitors can engage in various activities on the sandy beach, such as sports, camping, and more. Djamhur (2014) states that coastal ecotourism offers various tourist attractions that can enhance tourists' knowledge thru learning about nature. The ideal beach type parameter for beach tourism is white sand with a beach width of more than 15 meters (Yulianda 2019). Field measurements show that the width of Teluk Tamiang beach is around 20-22.9 meters.

The ebb and flow of the sea will affect the width of the beach and cause changes in the beach slope. The slope of the beach at Teluk Tamiang is around 8 degrees. The measurement results at the observation site indicate that the beach slope is still considered ideal for beach tourism activities. The water depth suitable for beach tourism is between 0-3 meters. Measurement results in the observation area show a depth ranging from 1.84-2 meters. Beach tourism with a depth of 0-3 meters aims to provide comfort to tourists during their activities.

In addition to the above parameters, the suitability of beach tourism is also supported by other factors such as the substrate material of the water, current speed, water clarity, beach land cover, hazardous biota, and the availability of freshwater. The substrate material in Teluk Tamiang generally consists of sandy coral. This is due to the type of coral reef found in the waters of Teluk Tamiang Village, which is a barrier reef type.

The current speed at the observation location still meets the criteria for beach tourism suitability, with an ideal current speed standard of 0-17 m/s. Current speed measurements in Tamiang Bay show 0.11-0.14 m/s. The current speed is influenced by the observation location, situated in the western part of the bay, causing the mass of seawater to be affected by the tides. The water clarity at the observation site shows 85%-95%, indicating that the water conditions are still clear.

The community in this area generally utilizes land for gardening. Several seasonal vegetable commodities that are continuously produced throughout the

year include spinach, bird's eye chili, water spinach, and eggplant. Meanwhile, the annual fruit commodities that are also continuously produced during this period include starfruit, durian, water apple, guava, Siam orange, mango, jackfruit/cempedak, pineapple, papaya, banana, rambutan, salak, sapodilla, soursop, breadfruit, and petai. The distance to water at the observation site is not too far, approximately 30 meters.

Furthermore, Pourebrahim et al. (2011) added that the spatial planning approach can be used for land use suitability assessment based on the criteria of each type of activity to be developed. After calculating the suitability of marine ecotourism for each activity, the analysis results will be presented in the form of thematic maps using GIS. All types of snorkeling and beach tourism activities that have been analyzed using GIS will then be overlaid and created into a marine ecotourism suitability map for Teluk Tamiang Beach (Figure 6).

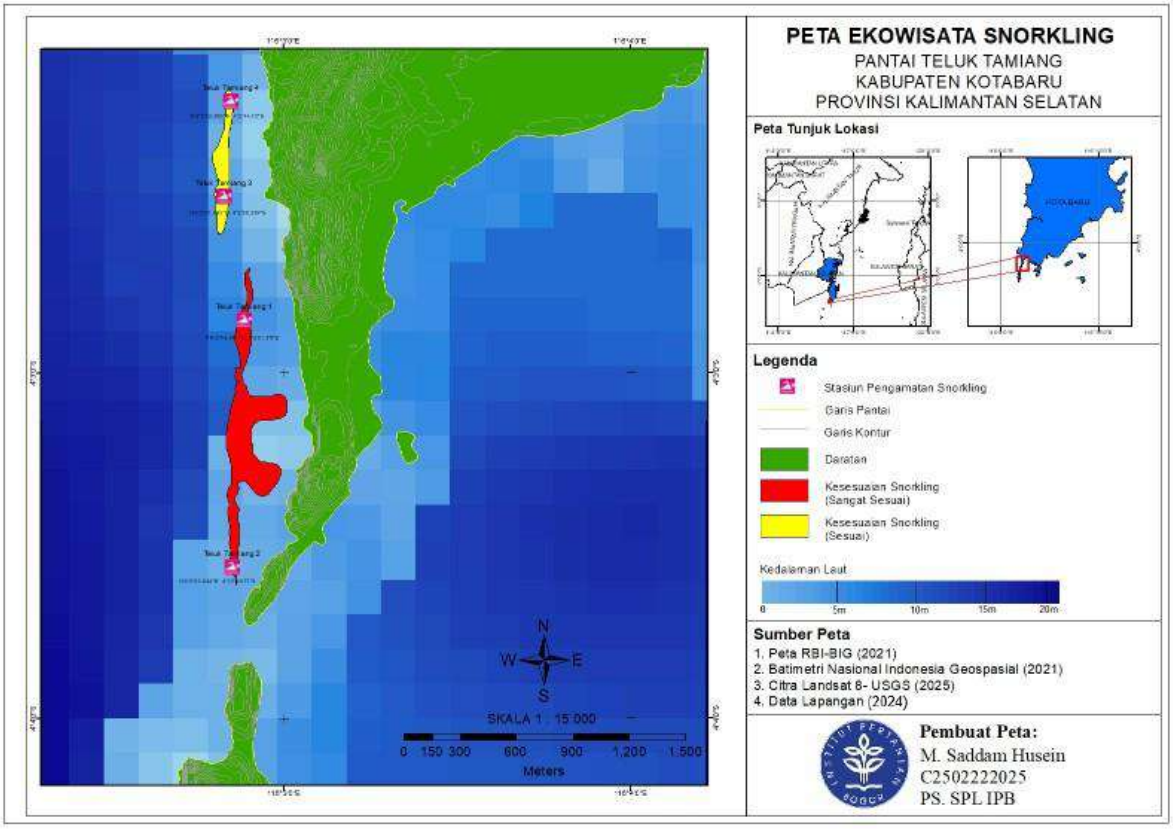


Figure 4 Snorkeling Tourism Suitability Map at Teluk Tamiang

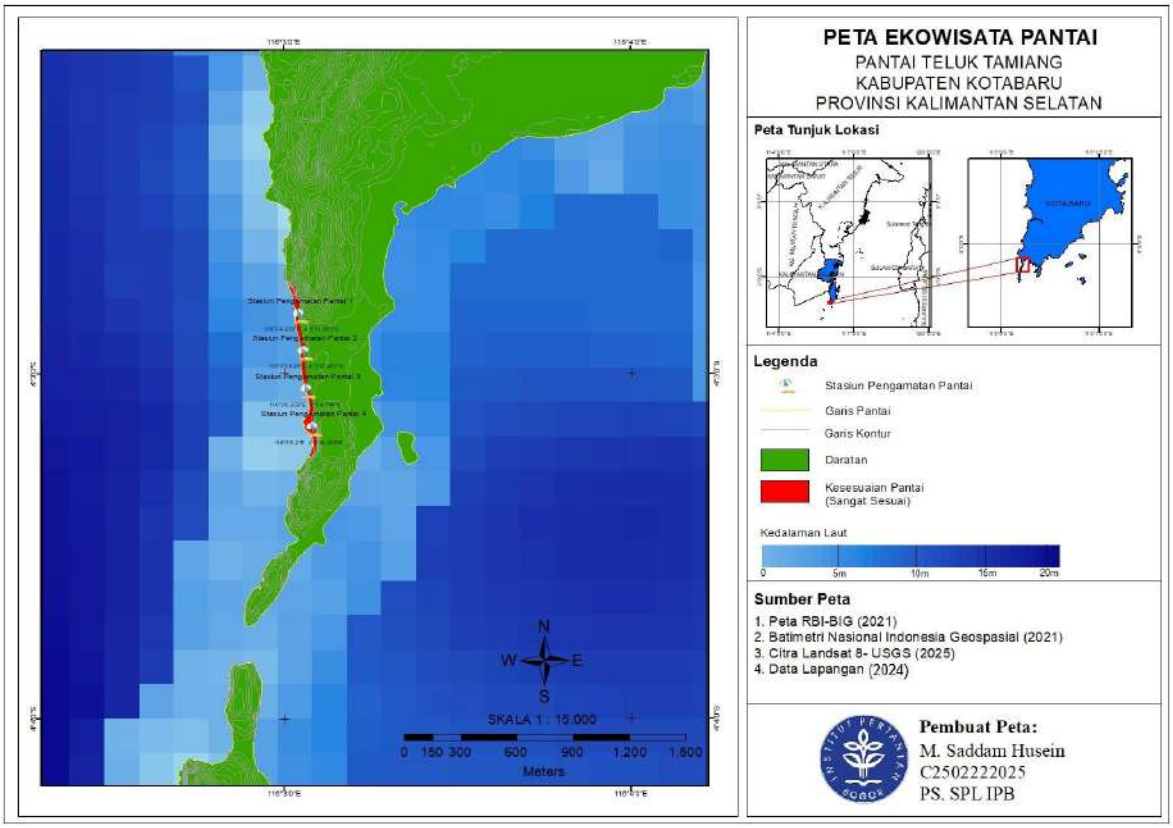


Figure 5 Beach Tourism Suitability Map at Teluk Tamiang

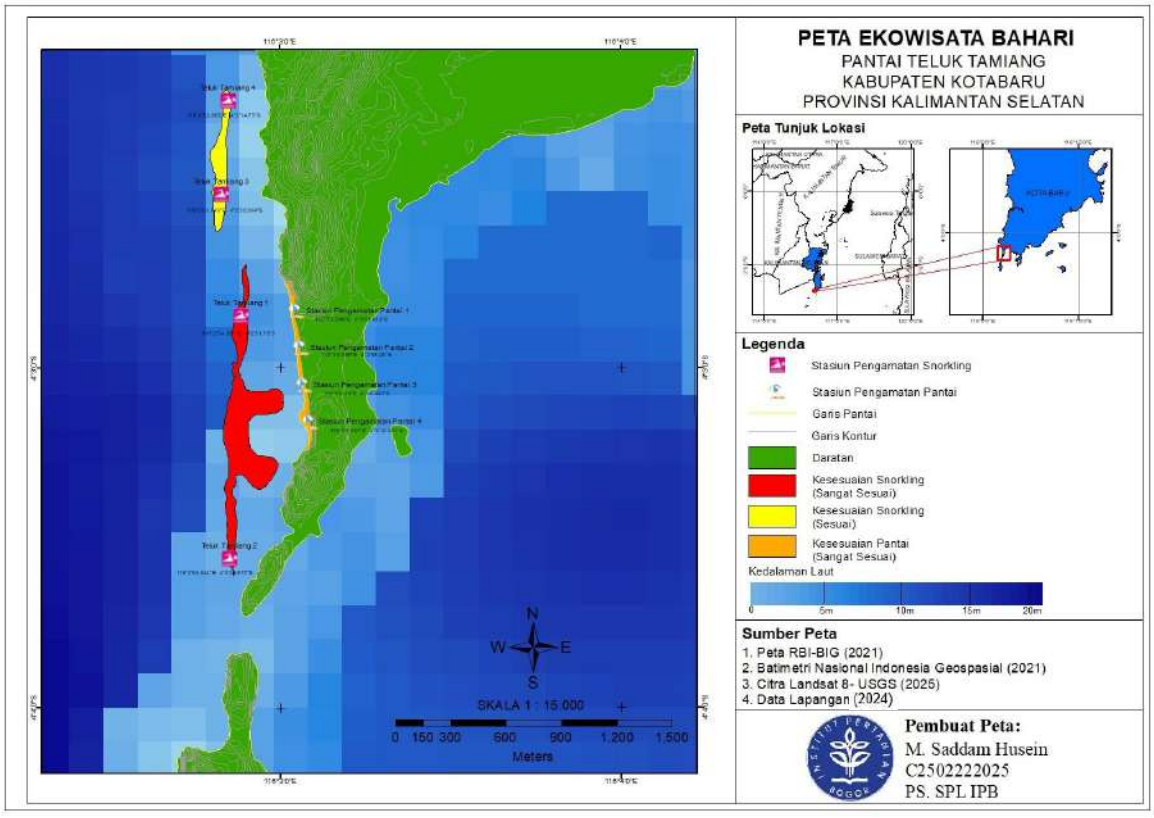


Figure 6 Marine Ecotourism Suitability Map at Teluk Tamiang

8. Carrying Capacity of Marine Ecotourism in Teluk Tamiang

According to UNEP (2001), most of the world's population lives in coastal areas, and the majority of that population benefits from the use of coastal and marine resources. The activity of utilizing natural resources to meet social and economic needs will affect environmental processes and ecological systems. Blangy and Mehta (2006) added that the rapid development of tourism worldwide has caused countless damage to several endangered ecological systems. Therefore, in relation to the utilization of natural resources in Tamiang Bay for marine ecotourism, a critical approach is needed to minimize the number of visitors.

As small islands vulnerable to external activities, to balance the utilization of natural resources as marine ecotourism objects, it is necessary to consider the carrying capacity of the area (CCA) for marine ecotourism. The Carrying Capacity Assessment (CCA) for marine ecotourism is conducted to evaluate the ability of an area to accommodate the number of visitors. Tratalos & Austin (2001) explain that diving and snorkeling ecotourism activities can have a significant impact on coral reef ecosystems if the number of dives exceeds the tolerable capacity.

Carrying capacity as a concept based on an environmental approach and is an important part of the study of natural resource management. Carrying capacity is defined as the ability of nature to tolerate human activities. The calculation of the carrying capacity of marine ecotourism areas is based on the characteristics of the resources and their allocation. Yulianda et al. (2019) state that the carrying capacity for snorkeling activities is determined based on the area of coral reefs that can be utilized, the ecological potential of visitors per unit area used for activities, the natural ability to tolerate the presence of visitors, and the estimated time required for each type of activity.

The calculation of the DDK for marine ecotourism is based on the results of land suitability analysis for each specific type of activity with suitability values in categories S1 and S2. The overall suitability class for snorkeling activities at Teluk Tamiang Beach falls into categories S1 and S2. The DDK calculation for marine ecotourism in the form of snorkeling activities is 17.04 ha with a capacity to accommodate 681 people/day, and beach recreational tourism activities have a carrying capacity of 80 people/day with a beach area of 1000 m. The analysis of the carrying capacity of marine ecotourism at Teluk Tamiang Beach shows that the number of people/day that can be accommodated reaches 761 people for the two types of tourism activities. (Table 4). The approach to sustainable marine ecotourism management must consider limiting factors for each type of activity to be utilized. The carrying capacity of marine ecotourism is expected to balance the intensity of visitor activities for each existing activity.

Table 4. Carrying Capacity of the Marine Ecotourism Area of Teluk Tamiang Beach

Activity Type	Area Length/Width	Carrying Capacity
Snorkeling	17.04 ha	681
Beach	1000 m	80
Total		**761 People/Day**

Source: Processed Data (2024)

Table 4 above shows the carrying capacity of the area for marine ecotourism in Tamiang Bay, which includes snorkeling and beach tourism activities. The analysis of the carrying capacity of marine ecotourism in Teluk Tamiang shows that the capacity reaches 761 people per day for two types of activities. Therefore, in its utilization, it must still pay attention to the physical environmental factors as an ecotourism object. The carrying capacity analysis aims to develop marine tourism by utilizing the potential of coastal, beach, and small island resources sustainably (Yulianda et al. 2019). Bengen (2012) also stated that carrying capacity is the level of utilization of natural resources or ecosystems sustainably without causing damage to natural resources and the environment.

D. CONCLUSION

The suitability value in the Very Suitable (S1) category for snorkeling activities in Teluk Tamiang 1, Suitable (S2) category at stations 2, 3, and 4. The suitability of beach recreation activities at all stations is in the Very Suitable (S1) category. The percentage of live coral cover is 44%–76%, coral fish diversity is 41-59 species, 10-14 families, and a total of 1686 fish. The carrying capacity of the coastal tourism area for beach recreation is 864 people/day and for snorkeling is 681.6 people/day. Marine ecotourism management strategy at Teluk Tamiang Beach, formulating priority strategies, including: a). Utilizing potential as marine ecotourism by considering environmental carrying capacity, b). Conservation efforts for coral reef ecosystems for the development of marine ecotourism, c). Coordination among interested stakeholders to establish zonation-based conservation areas in the coastal region.

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