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 of*marine* 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 results showed that 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 164 people / day with a utilization area of 4.12 ha, and for beach tourism with a utilization area of 1910 meters, able to accommodate tourists as many as 152 people/day. Thus, the total number of tourists that can be accommodated by both types of tourism activities is 317 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 and Lin (2006) and Zhang and 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 et al. (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).

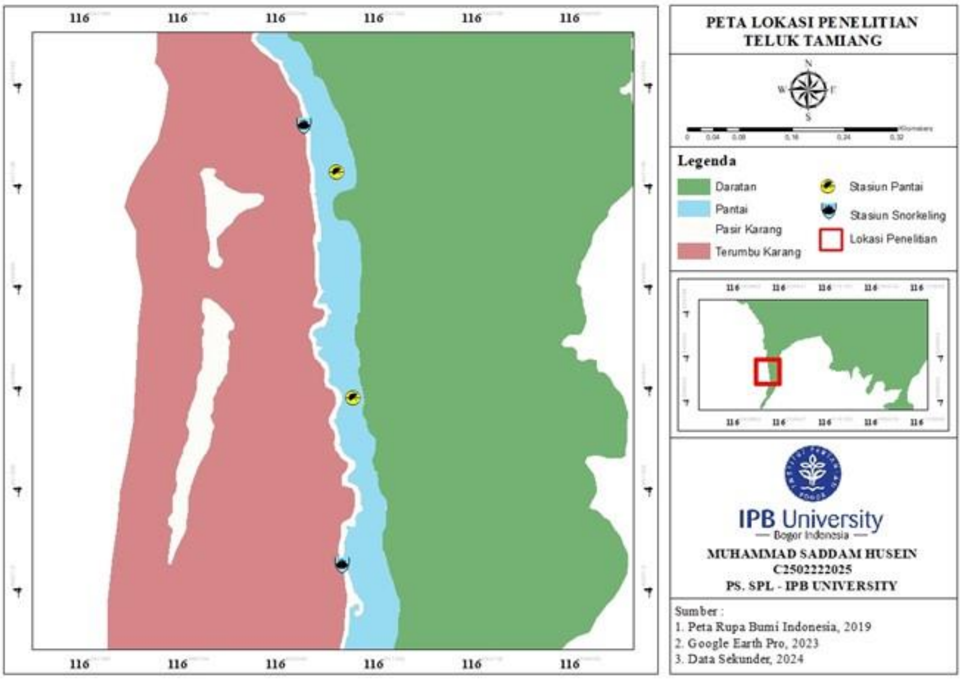

Figure 1 Research Location Map

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.

Biophysical data collection was conducted through direct field observations. The collected data included the following aspects:

1. Coral Reef Cover and Lifeforms

   Data collection followed the guidelines of English et al. (1997) using a 50-meter transect placed parallel to the shoreline. The locations for data collection were determined based on manta-tow results, where a specific point in each location was chosen for transect placement using the Line Intercept Transect (LIT) method. Each coral lifeform encountered along the transect was documented and photographed, then identified based on its condition and taxonomy. The data were used to determine the percentage of coral cover, dominance of lifeforms, number of lifeform types, and categorize corals into live and dead categories.

2. Reef Fish
   Observations of reef fish were conducted using the visual census technique along each LIT transect. The observed reef fish were those within 2.5 meters on either side of the transect line, covering an area of 250 m² (5 m x 50 m), following the guidelines of English et al. (1997). The census began once water conditions were stable (approximately 15 minutes after transect installation). Collected data were recorded on prepared data sheets. To facilitate identification, fish and other coral biota were documented using an underwater camera.
3. Coral Reef Depth
   Coral reef depth measurements were manually conducted using a measuring tape marked at intervals and weighted at the end. The measurement process was carried out from a boat when it was anchored or in a stable position.
4. Water Quality Parameters
   Measured water quality parameters included temperature, salinity, clarity, and current. Measurements were conducted using a multifunction device.

Data Analysis

1. Coral Cover Analysis

The analysis of live coral cover percentage was conducted using the Line Intercept Transect (LIT) method, based on the formula provided by 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
$\sum X_i$ = Total fish count at the i-th observation station
n = Observed coral reef area (m²)

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)
Nmaks = 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
Beach	1	25 m	1 visitor for every 25 meters of beach length
Snorkeling	1	500 m²	1 visitor for every 100 m × 5 m area

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)
Beach	3	6
Snorkeling	3	6

Source: Yulianda *et al*. (2019)

C. RESULTS 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

Teluk Tamiang Waters	Parameter				
	Temperature (˚C)	Salinity (‰)	Clarity (%)	Current (m/s)	Depth (m)
Stasiun 1	29	35	85	0.11	5
Stasiun 2	29	35	90	0.05	3

Source: Processed Data (2024)

Based on the study results from two stations at Teluk Tamiang, the waters had a temperature of 29°C at both stations. This value reflects a natural phenomenon where higher sun exposure results in higher temperatures. According to Nybakken (1988), the ideal temperature for coral growth ranges from 23°C to 25°C, with tolerable extreme temperatures between 36°C and 40°C. Meanwhile, Romimohtarto (2009) explained that most reef-building corals require a minimum water temperature of

20°C to survive. Thus, the recorded water temperature of 29°C at Teluk Tamiang exceeds the optimal range for coral growth (23°C–25°C) but is still below the tolerable extreme temperatures (36°C–40°C). This indicates that the water temperature at Teluk Tamiang supports coral reef life, although not within the optimal range.

Additionally, other water parameters at Teluk Tamiang showed a salinity of 35‰ at both stations, water clarity reaching 85% at a depth of 5 meters at Station 1 and 90% at a depth of 3 meters at Station 2, current speeds of 0.11 m/s at Station 1 and 0.05 m/s at Station 2, and varying depths of 5 meters at Station 1 and 3 meters at Station 2. According to Suharsono (2008), the optimal salinity range for coral growth is between 30 and 35‰. Therefore, the salinity values at both research locations greatly support coral growth and development.

The water clarity at Teluk Tamiang Beach was measured at around 85% at a depth of 5 meters at Station 1 and 90% at a depth of 3 meters at Station 2. These measurements were conducted during the day under clear weather conditions and calm waters without waves. According to Romimohtarto (2009), light indirectly influences marine animals by serving as an energy source for photosynthesis in plants, which forms the base of the food chain. Nybakken (1998) added that water clarity, along with clear water and sufficient light, is a crucial factor in supporting the photosynthesis process.

The currents at Teluk Tamiang exhibited varying speeds of 0.11 m/s at Station 1 and 0.05 m/s at Station 2. Low currents at both stations indicate 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 beneficial when they transport nutrients and organic matter needed by corals but can be detrimental if they cause sedimentation that covers coral surfaces, potentially leading to coral death (Nybakken, 1998).

The measured depths were 5 meters at Station 1 and 3 meters at Station 2, providing favorable conditions for light penetration required by coral reefs. Overall, the water conditions at Teluk Tamiang support the life and growth of coral reefs, as indicated by the physical parameters measured at both stations.

Physical Condition of the Beach

Teluk Tamiang Beach, located in Kotabaru Regency, South Kalimantan, is known for its unique and attractive characteristics. Its primary attraction is the white sandy beach, with a stretch 16 meters wide, allowing visitors to sunbathe and stroll comfortably. The dominant vegetation along the beach consists of coconut trees. To the west of the beach, there is a long stretch of coral acting as a wave barrier. The seawater at Teluk Tamiang Beach is crystal clear, enabling visitors to appreciate the underwater beauty, which supports activities like snorkeling.

The beach's long and curved shoreline enhances its visual appeal and provides ample space for various beach activities. Its relatively calm waves, due to its location on the western part of the bay, make the beach safe for swimming and other water activities. Surrounding the beach, coastal vegetation, such as coconut trees, offers natural shade and adds to the beach's beauty.

Teluk Tamiang Beach is also renowned for its stunning and diverse coral reefs, attracting divers and snorkelers. These coral reefs serve as habitats for various species of fish and marine life, enriching the beach's ecosystem. The beach's gentle slope and smooth transition from land to sea make it easily accessible and suitable for visitors of all ages.

Although located at the southernmost tip of Kalimantan, access to Teluk Tamiang Beach is relatively good, with paved main roads and gravel and stone paths leading to Teluk Tamiang Village. The area also has adequate infrastructure. Overall, Teluk Tamiang Beach offers a perfect combination of natural beauty and sufficient facilities, making it an ideal destination for recreation and relaxation for both local and international tourists.

Physical Condition of Coral Reefs

The coral reef formations at Teluk Tamiang Beach are classified as barrier reefs, with varying coral flats. Barrier reefs develop along the outer edge of lagoons, bays, or coastlines and are located at a certain distance from the mainland. These reefs typically extend parallel to the shoreline and are separated from the mainland by deeper waters, such as lagoons. The primary function of barrier reefs is to protect beaches or coastal areas from the direct impact of strong waves and ocean currents. With barrier reefs, wave energy reaching the shore is reduced, creating calmer waters behind the reefs, which in turn support the development of rich marine ecosystems.

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 marine ecotourism development, the assessment of coral cover includes both hard coral and soft coral, which are considered live corals. Tourists engaging in diving and snorkeling are not only interested in hard coral but also in soft coral as a tourism attraction. According to Nontji (2009), intact coral reefs present an extraordinarily beautiful view unmatched by other ecosystems. Irwan (2010) also stated that soft coral enhances the aesthetic value of an area, which is crucial for developing marine ecotourism.

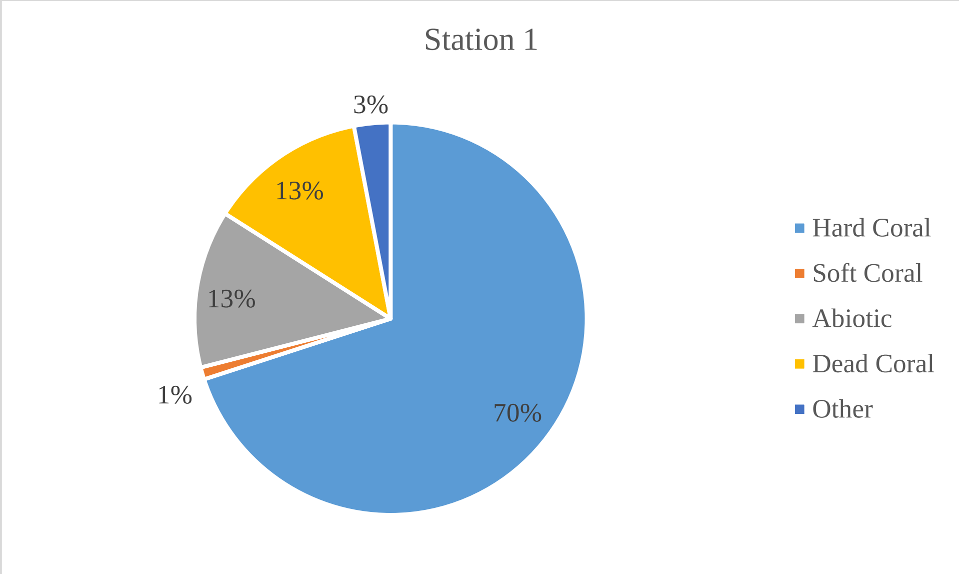

Figure 2 Percentage of coral reef cover at Station 1

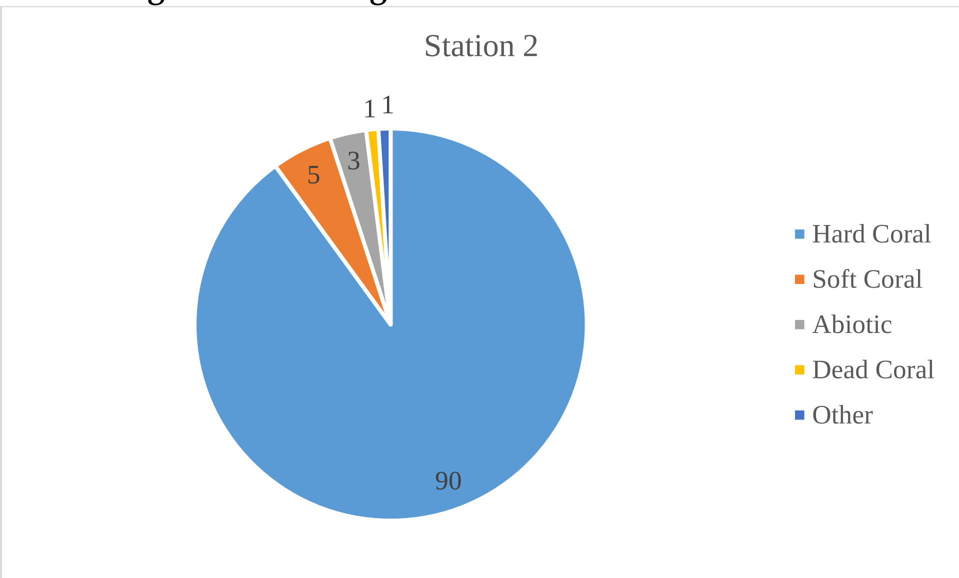

Figure 3 Percentage of coral reef cover at Station 2

Figures 2 and 3 illustrate the composition of coral reef ecosystem cover at Station 1 and Station 2, categorized as good and excellent. However, at several observation points, corals in poor condition were found. The diving results at both observation stations revealed damaged corals (dead coral), as observed at Station 1 and Station 2. Another study by Gladstone et al. (2013) explains that the development of supporting infrastructure for ecotourism in coastal areas can indirectly impact the marine environment and ecosystems.

Another crucial parameter in determining the suitability class of marine ecotourism for snorkeling activities is the type of lifeform. The lifeform types used in determining marine ecotourism activities are based on English et al. (1997). The highest number of lifeforms was found at Station 2, with 13 types, while the lowest number was at Station 1, with 10 types. The same lifeform types were largely found at all observation locations. Physical environmental factors, such as temperature, salinity, clarity, and current velocity at the observation locations, are vital parameters for coral growth (Nybakken, 1998). The physical environmental parameters at the observation locations exhibited insignificant differences in values.

The presence of acropora at both observation stations includes branching, tabular, digitate, and submassive forms. For non-acropora, growth forms consist of submassive, branching, massive, millepora, and foliose. Meanwhile, the presence of soft coral at the observation locations was minimal, influenced by current pressure and tidal movements.

The percentage of dead coral observed at both observation stations was recorded at both sites. The highest percentage of dead coral was found at Station 1 (13%) and at Bucili (1%). Abiotic cover, consisting of sand and rubble, showed the highest percentage at Station 1 (13%) and the lowest at Station 2 (3%). Other lifeform types, including turf algae, bottle brush, and assemblage, fall under the other category. The highest percentage of other cover was observed at Station 1 (3%), with the lowest percentage at Station 2 (1%).

The percentage of coral reef ecosystem potential for marine ecotourism utilization is a crucial parameter for snorkeling activities. According to Yulianda et al. (2010), to assess the suitability of marine ecotourism for snorkeling and diving activities, the percentage of live coral community cover (hard coral and soft coral) must exceed 50–75% to fall under the suitable category and >75% for the very suitable category. This is because one of the main purposes of visitors engaging in diving and snorkeling is to enjoy the beauty of coral reefs and marine biota.

The coral cover analysis results showed that Station 1 had a coral cover percentage of 70%, while Station 2 had a percentage of 90%. Thus, the coral cover percentages at both stations fall into the suitable and very suitable categories.

Reef Fish

Reef fish and other biota are the core of coral reef ecosystems. Reef fish are typically found in coral reefs on islands with clear coastal waters, high oxygen levels, and free from excessive sedimentation, pollution, and freshwater runoff (Nurjanah et al., 2011).

Marine life would lose much of its charm without the presence of diverse and brightly colored biota (Setiawan, 2011). The presence of marine biota living in coral reef ecosystems contributes to the visual appeal of snorkeling activities.

Based on observations of reef fish at Teluk Tamiang Beach, data indicated variations in abundance and composition of reef fish families. Overall, 11 fish families were identified, comprising a total of 496 individuals from 19 fish species at two observation stations. The Pomacentridae family, which includes Damselfish and Clownfish, dominated with a total of 160 individuals, yielding an abundance of 64 individuals per square meter. This indicates that this family is the most abundant in the observation area.

The Chaetodontidae family (Butterflyfish) and the Serranidae family (Grouper/Sea Bass) also exhibited significant numbers, with 55 and 62 individuals, respectively, and abundances of 22 individuals/m² and 24.8 individuals/m². This reflects a relatively high diversity within the reef fish community in the area.

The Muraenidae family, despite having fewer individuals (12), still contributed significantly to the diversity of fish in the coral reefs, with an abundance of 4.8 individuals/m².

Overall, the abundance of reef fish at Teluk Tamiang Beach was recorded at 198.4 individuals per square meter, indicating a high population density of reef fish in this area. This data demonstrates 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 highly suitable for marine ecotourism activities such as snorkeling and diving.

According to Nurjanah et al. (2011), the highest fish abundance comes from the Pomacentridae family. This is attributed to the diurnal activity of this family, as they are active during the day, feeding and residing in coral reef habitats while consuming plankton in their environment (Figure 4).

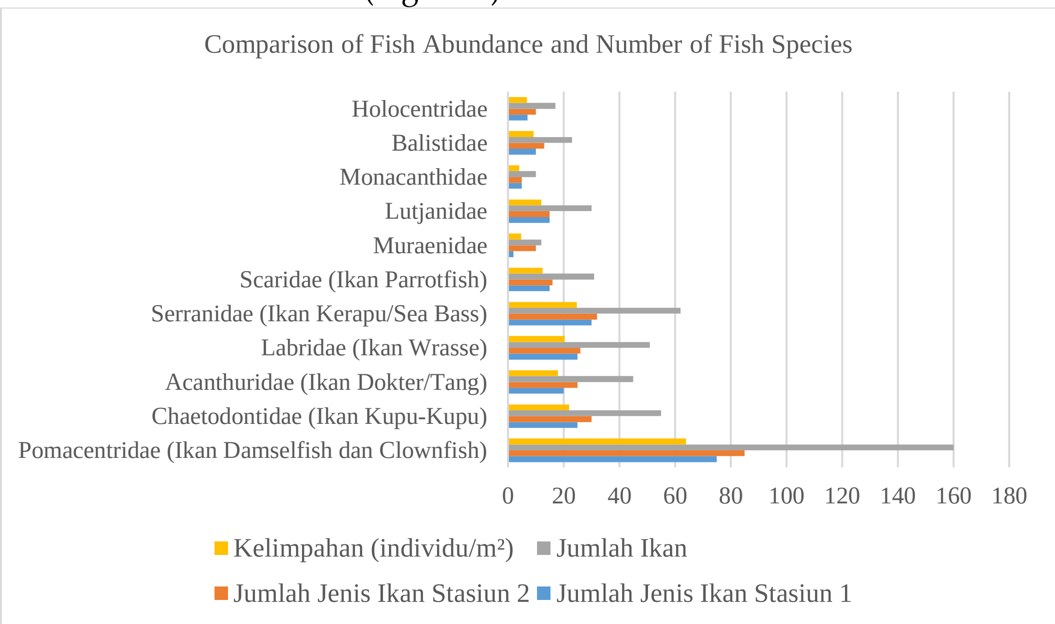

Figure 4 Comparison of Fish Abundance and Number of Fish Species

The interaction between reef fish and coral reefs is critical, especially as a feeding ground and a shelter area for juvenile fish to protect them from predators that threaten their development. Nybakken (1998) mentioned that the high diversity of fish species in coral reefs is due to the habitat variation within the reefs. Romimohtarto & Juwana (2009) explained that some reef fish species are only found in coral reef areas at night, while they are not visible during the day. Additionally, Nybakken (1998) noted that there are differences in fish species active during the day and night, where diurnal fish are active during the day and invisible at night, while nocturnal fish are active and visible at night.

At the observation sites, several predator fish species were identified, including the families Balistidae, Chaetodontidae, Scaridae, and Muraenidae. However, the number of predator fish observed was relatively low. At Station 1, 10 individuals from the Balistidae family, 25 from the Chaetodontidae family, 15 from the Scaridae family, and 2 from the Muraenidae family were recorded. Meanwhile, at Station 2, 13 individuals from the Balistidae family, 30 from the Chaetodontidae family, 16 from the Scaridae family, and 10 from the Muraenidae family were observed. Romimohtarto and Juwana (2009) emphasized that all reef fish species play an important role in the complex food web, maintaining a delicate balance between prey and predator. 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 reef fish species in the waters, forms a unified ecosystem with high aesthetic value, making it a suitable marine ecotourism attraction. Nontji (2009) highlighted the importance of coral reefs as ecosystems and economic resources, emphasizing the need to preserve them. In marine ecotourism development, analyzing coral cover and reef fish diversity is crucial for determining snorkeling suitability classes.

Marine Ecotourism Suitability

The determination of suitability classes for marine ecotourism utilization in activities such as diving and snorkeling is based on marine ecotourism suitability analysis as described by Yulianda et al. (2010). The suitability of areas for diving and snorkeling at the two observation stations falls into the categories of Suitable (S2) and Very Suitable (S1).

Snorkeling Tourism

The suitability class for snorkeling tourism at the observation sites falls under the suitable category. This analysis considers seven parameters: coral community cover, lifeform types, reef fish species, water clarity, coral reef depth, current velocity, and the width of the flat coral area.

The marine ecotourism suitability index for snorkeling at Teluk Tamiang Beach is 64.33 at Station 1 and 87.33 at Station 2. Although the analysis results indicate that the observation sites are in the suitable category, snorkeling activities can only be conducted at certain depths. Considering the coral reef depth parameter, snorkeling is intended to prevent visitors from touching or stepping on the coral reefs (Figure 5).

The snorkeling suitability calculation at Station 2 shows a suitability index falling under the S2 category. The quality of parameters at both stations strongly supports snorkeling suitability. Supporting parameters like coral community cover score 3 at Station 2 and score 2 at Station 1. Although Station 1 has lower coral community cover, other key parameters such as water clarity, lifeform types, and additional parameters support the IKW for snorkeling. Other parameters supporting snorkeling suitability at Station 1 include 19 reef fish species, a current velocity of 0.11 cm/s, a coral reef depth of 5 meters, and a flat coral area width of 150 meters.

Using spatial analysis (GIS), it was determined that the snorkeling tourism area covers 4.12 ha. This analysis highlights the need for careful planning to sustainably utilize marine ecotourism resources in Teluk Tamiang, supported by parameters indicating that the coral reef ecosystem, reef fish, and physical water environment are suitable for marine ecotourism activities.

Beach Tourism

Beach tourism is one of the most popular attractions for visitors. Teluk Tamiang Beach features white sandy beaches in a bay shape, making it a favorite among locals. Similar to snorkeling, beach tourism suitability is assessed using parameters including beach type, beach width, waterbed material, water depth, water clarity, current velocity, beach slope, beach land cover, hazardous biota, and freshwater availability (Yulianda, 2019). Based on these parameters, the beach tourism suitability class at Teluk Tamiang is categorized as very suitable, with a suitability score of 87.66 (Figure 6).

Teluk Tamiang Beach's sandy stretch, mixed with coral fragments, attracts visitors for various activities. The white sand, which absorbs sunlight, ensures that visitors do not feel overly hot. Visitors can engage in activities such as sports and camping on the sandy beach. Djamhur (2014) stated that beach ecotourism offers various attractions that enrich visitors' knowledge through learning about nature. An ideal beach type for tourism features white sand and a width of more than 15 meters (Yulianda, 2019). Field measurements at Teluk Tamiang Beach show widths ranging from 10–20 meters.

Tides affect the beach width and cause changes in the beach slope. The slope at Teluk Tamiang Beach ranges from 5–8 degrees. Field measurements indicate that the slope is ideal for beach tourism activities. Suitable water depths for beach tourism range from 0–3 meters. Measurements at the observation stations showed depths ranging from 1.84 to 2 meters, providing comfort for visitors during activities.

Other parameters supporting beach tourism suitability include waterbed material, current velocity, water clarity, beach land cover, hazardous biota, and freshwater availability. The waterbed material in Teluk Tamiang is predominantly sandy coral, attributed to the barrier reef type in the waters near Teluk Tamiang Village.

The current velocity at the observation sites meets beach tourism suitability standards, with an ideal velocity of 0–17 m/s. Measurements at Teluk Tamiang show velocities of 0.05–0.11 m/s, influenced by the tidal movement in the western bay area. The water clarity is 84%, indicating clear water conditions.

Land use in this area primarily involves gardening. Commonly produced vegetables include spinach, chili, kale, and eggplant, while perennial fruits such as starfruit, durian, guava, oranges, mangoes, papayas, bananas, and others are cultivated year-round. Freshwater availability at the observation sites is adequate, with water sources located about 30 meters away.

Pourebrahim et al. (2011) suggested that spatial planning approaches can be used to assess land suitability based on criteria for specific activities. After calculating marine ecotourism suitability for each activity, the results are presented in thematic maps using GIS. The snorkeling and beach tourism activities analyzed with GIS were then overlaid and compiled into the Teluk Tamiang marine ecotourism suitability map, as per Hossain and Das (2010) (Figure 5).

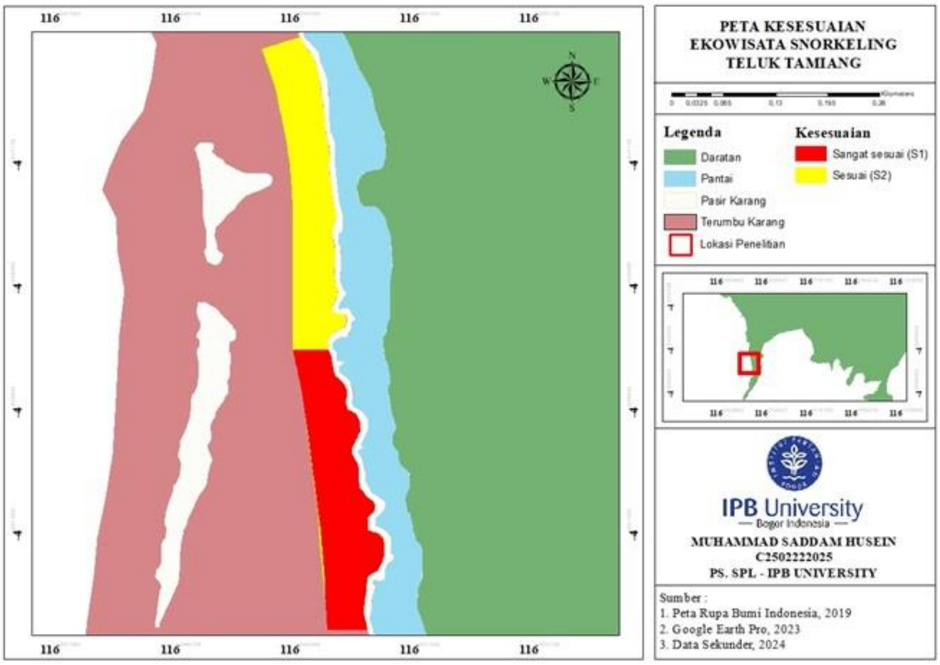

Figure 5 Snorkeling tourism suitability map at Teluk Tamiang

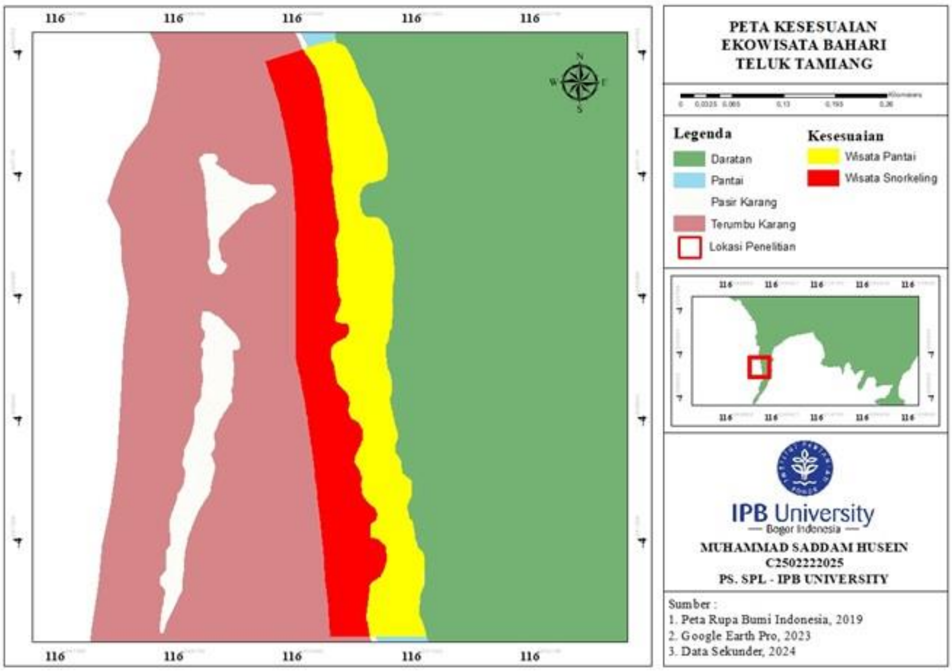

Figure 6 Marine ecotourism suitability map at Teluk Tamiang

Carrying Capacity of Marine Ecotourism in Teluk Tamiang

According to UNEP (2001), most of the world's population resides in coastal areas, where they benefit from the utilization of coastal and marine resources. Resource utilization activities to meet social and economic needs affect environmental processes and ecological systems. Blangy and Mehta (2006) added that the rapid development of tourism worldwide has caused significant damage to several endangered ecological systems. Therefore, in the context of utilizing natural resources in Teluk Tamiang for marine ecotourism, a critical approach is needed to minimize the number of visitors.

As small islands are vulnerable to external activities, balancing the utilization of natural resources as marine ecotourism attractions requires consideration of the Carrying Capacity (CC) for marine ecotourism. The carrying capacity is assessed to determine an area's ability to accommodate visitors. Tratalos and Austin (2001) explained that diving and snorkeling activities could significantly impact coral reef ecosystems if the number of dives exceeds tolerable limits.

Carrying capacity, as a concept based on environmental approaches, is essential in natural resource management studies. It is defined as nature's ability to tolerate human activities. The calculation of marine ecotourism carrying capacity is based on resource characteristics and their designated purposes. Yulianda et al. (2019) stated that the carrying capacity for snorkeling activities is determined by the area of coral reefs available for use, the ecological potential of visitors per unit area, the environment's ability to tolerate visitors, and the estimated time required for each activity.

The calculation of marine ecotourism carrying capacity is based on the results of land suitability analysis for specific tourism activities in areas categorized as Suitable (S1) and Moderately Suitable (S2). Overall, the suitability class for snorkeling and beach tourism activities in Teluk Tamiang falls under the suitable category. Based on the carrying capacity calculation for snorkeling activities, an area of 500 square meters can accommodate approximately 164 people per day. This is based on a space requirement of 4.12 ha per person, an effective activity time of 6 hours per day, and 3 hours spent by each visitor. Hence, the area has a relatively high capacity and can accommodate a significant number of visitors for snorkeling without exceeding its carrying capacity, ensuring a safe and enjoyable experience.

Meanwhile, the carrying capacity calculation for beach tourism activities indicates that an area of 25 square meters can accommodate approximately 152 people per day. This is based on a space requirement of 1910 meters per person, an effective activity time of 6 hours per day, and 3 hours spent by each visitor (Table 23). Sustainable marine ecotourism management must consider limiting factors for each activity to ensure balanced visitor activity intensity.

Table 4. Carrying Capacity of Marine Ecotourism in Teluk Tamiang

No	Activity Type	Area Size	Carrying Capacity
1	**Snorkeling**	4.12 ha	164
2	**Beach Tourism**	1910 m	152
Total			**317 People/Day**

Source: Processed Data (2024)

Table 4 shows the carrying capacity of marine ecotourism in Teluk Tamiang, including snorkeling and beach tourism activities. Coral cover classified as suitable is assumed to be the area available for snorkeling activities. The pristine condition of the beach with white sand is a key parameter in determining ecotourism areas for beach activities. Beach tourism is highly favored by visitors because white sandy beaches offer unique attractions, enabling activities such as sunbathing, beach sports, camping, and enjoying sunrise and sunset. The carrying capacity analysis results indicate that Teluk Tamiang's beach tourism can accommodate 152 people daily, with a beach length of 1910 meters.

The overall analysis of marine ecotourism carrying capacity in Teluk Tamiang shows a total capacity of 317 people per day for the two types of activities. Therefore, its utilization must consider the physical environmental factors as ecotourism objects. Carrying capacity analysis aims to develop marine tourism by sustainably utilizing coastal, beach, and small island resources (Yulianda et al., 2019). Bengen (2012) also stated that carrying capacity is the level of natural resource or ecosystem utilization that ensures sustainability without causing damage to natural resources and the environment.

D. CONCLUSION

Marine tourism activities in Teluk Tamiang, such as diving, snorkeling, and beach tourism, are categorized into two suitability classes: Suitable (S2) and Very Suitable (S1). Snorkeling tourism, covering an area of 4.12 ha, falls into the S1 category at Station 1, while at Station 2, it is categorized as S2. Meanwhile, beach tourism, with a coastline length of 1910 meters, falls into the Very Suitable (S1) category and is distributed across two stations.

The carrying capacity for marine ecotourism in Teluk Tamiang varies by activity type. Snorkeling tourism has a maximum capacity of 164 people per day, while beach tourism can accommodate 152 people per day. Overall, the total carrying capacity for marine ecotourism in Teluk Tamiang is 317 people per day.

Based on stakeholder analysis, the management strategies for ecotourism in Teluk Tamiang Village include:

1. Utilizing marine ecotourism potential while maintaining environmental carrying capacity.
2. Conserving coral reef ecosystems as an essential step in supporting marine ecotourism development.
3. Coordinating among stakeholders to establish zoning-based conservation areas around small islands.

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