Suitability Index of Snorkeling Tourism In Sepulu District, Bangkalan, Indonesia

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Abstract. Bangkalan is one of the districts in Madura with a coastal area that can be developed as a marine tourism location for snorkelling, and their northern coast facing the Java Sea has only been used for coastal tourism. This research aimed to assess the suitability index of snorkelling tourism in Sepulu waters, Bangkalan. The research was carried out during September–October 2021. Coral cover, fish diversity, water conditions, and an analysis of tourism suitability and the carrying capacity of snorkelling tourism were assessed. Hard coral cover in Sepulu waters ranges from 22-38%, while the per cent of coral cover (including soft corals) ranges from 34-55.5%. The number of coral growth forms found in Sepulu waters ranged from 6-8 forms. Reef fish found in Sepulu district water were between 7-12 species. The tourism suitability index of Sepulu Waters, Bangkalan, which ranges from 61.40 – 75.44%, is included in the category of quite suitable. The area's carrying capacity for snorkelling tourism activities is 152-500 people daily. Sepulu waters, especially Tengket and Labuhan waters, have a high potential to be used as snorkelling tourism objects.

Keywords: Snorkeling, Coral cover, Reef fish, Marine tourism suitability index, Carrying Capacity, Bangkalan

1. Introduction

Indonesia's vast sea area gives these waters the potential for great natural wealth with a high level of biodiversity. Coastal areas and small islands in Indonesia also have high tourism potential to be developed [1]. Bangkalan is one of the Madura districts with coastal areas that can be developed as snorkelling marine tourism sites. So far, the coastal area of Bangkalan, especially the north coast facing the Java Sea, has only been used for beach tourism [2]. The northern coastal area of Bangkalan, which has a stretch of coral reefs and is the primary capital for snorkelling tourism, is in the Sepuluh sub-district area [3]. In Sepulu District, many beach tourist destinations can be developed into snorkelling marine tourism, including Tabuhan Beach, Lembung Paseser Beach, Tengket Beach, and Maneron Beach. Coral cover in these four beaches is moderately good [3, 4] and has several coral forms and species [5].

Coastal areas and small islands provide productive natural resources such as coral reefs, seagrass beds, mangrove forests, fisheries and conservation areas, which are the main factors in marine tourism development [6, 7]. For example, a location suitable for snorkelling marine tourism requires clear water conditions, good coral reef conditions, and many types of fish [8]. However, damage to coral reefs and

excessive harvesting of reef fish causes many locations to be less suitable and reduce their potential for marine snorkelling tourism.

To develop snorkelling tourism in the Sepuluh sub-district area, it is necessary to do good planning through an analysis of coral reef cover, fish diversity, and water conditions, as well as an analysis of tourism suitability and the carrying capacity of snorkelling tourism so that the tourism activities to be carried out do not add environmental pressure that can damage the aquatic ecosystem. In the absence of comprehensive data on coral cover, its ecosystems, and its carrying capacity, this research is urgently needed.

This paper aims to analyse coral reef cover, fish diversity, and water conditions in the Sepulu District of Bangkalan, to analyse the Snorkeling tourism suitability index, and to determine the carrying capacity of snorkelling tourism of Sepulu District, Bangkalan.

2. Material and Method

Data collection was carried out at locations in Sepulu District, Bangkalan, which is known to have coral reef ecosystems, namely Labuhan Beach, Lembung Paseser Beach, Tengket (Maneron) Beach, and Prancak Beach from June-November 2021.

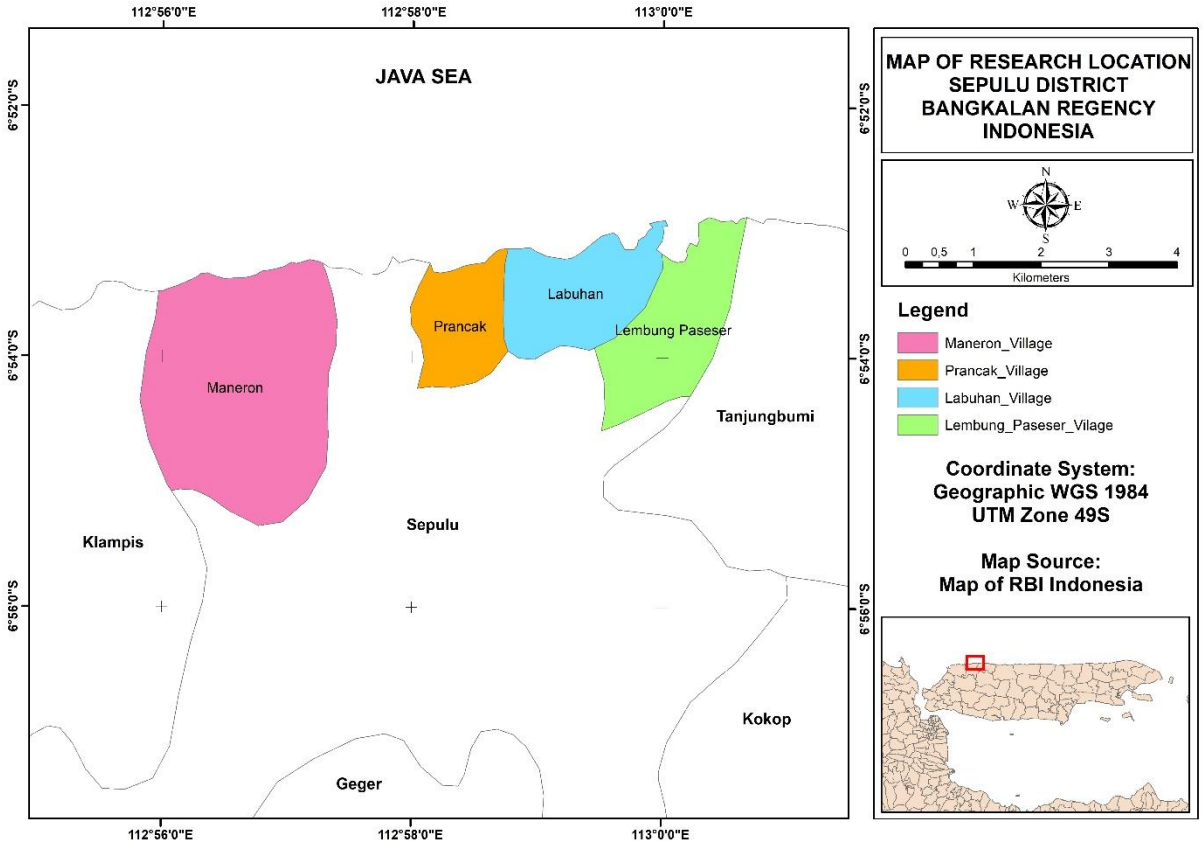

Figure 1. Research location in Sepulu sub-district.

2.1. Method of collecting data

2.1.1. Water clarity

The brightness of the waters is measured in situ using a secchi disk. Secchi disk is lowered into the water until it is invisible, the depth is measured, then lowered even deeper. Then the piece is lifted back, and if the piece is almost visible again, the depth is measured again. The average value of the two measurements is used as the brightness of the waters.

2.1.2. Coral cover and number of coral life form

Coral data was collected using the LIT (Line Intercept transect) method, which is a line transect using 100 meters parallel to the shoreline. At each location, 1-3 transects were observed, depending on the width of the reef. Based on the category and percentage of live coral (Lifeform), the higher the percentage of live coral cover, the better the condition of the coral reef ecosystem, and the more critical it is to protect coral reefs. The live coral cover data percentage was obtained based on the line intercept transect (LIT) method. According to [9], to assess the existing coral reefs, the percentage of live coral cover was formulated as follows:

$$Coral\ cover\ percentage = \frac{benthic\ form\ length}{total\ transect\ length}\ x\ 100$$

Data on the condition of coral reef cover obtained from the above equation is then categorized based on the Decree of the Minister of the Environment No. 4 of 2001 and [10]. Meanwhile, the number of coral growth forms found was recorded based on the data collection results above.

2.1.3. Number of Reef Fish

Reef fish data were collected using the underwater visual census method on the same line transect used for corals. The line transect was stretched 100 meters parallel to the shoreline set up to represent the reef flat (Reef Flat). The observation area for reef fish is 2.5 meters to the left and 2.5 meters to the right of the line transect. Reef fish data were collected by identifying reef species in the transect area [9].
The density of fish is calculated using the formula:

$$N = n/A$$

Note: N = Density of individual fish (ind/volume unit)
n = Number of individual fish
A = Area of observation

2.1.4. Current and depth

Current is measured using a conjecture ball, while depth is measured using a depth gauge on diving equipment.

2.1.5. Reef area

The reef area was calculated by secondary data analysis through satellite imagery data. Satellite image data from Landsat ETM-7 were collected to identify the coral reef area. Information on reef location and distribution was extracted from Landsat ETM-7 imagery data using the Lyzenga Algorithm, which made the differentiation of benthic cover into classifications, such as coral reefs, sand, sea grass, rocks, or mud, including reef area.

2.1.6. Snorkelling Marine Ecotourism Suitability Analysis

The data obtained were then analyzed using the suitability method for marine ecotourism areas in the snorkelling category. According to [11], the suitability matrix for snorkelling ecotourism is presented in Table 1. The suitability of snorkelling marine ecotourism considers seven supporting parameters, including live coral cover, lifeform type, water brightness, reef fish species, current speed, depth, and width of coral reef.

Table 1. Matrix of Suitability Index for snorkelling tourism

No	Parameter	Weight	Class and Suitability					
			Suit		Moderate		Unsuit	
			S1	Score	S2	Score	S3	Score
1.	Water Clarity (%)	5	100	3	80-<100	2	20-80	1
2.	Coral cover (%)	5	>75	3	>50-75	2	25-50	1
3.	Number of Coral Lifeform	3	>12	3	>7-12	2	4-7	1
4.	Number of reef fish	3	>50	3	30-50	2	10-30	1
5.	Current (cm/s)	1	0-15	3	>15-30	2	30-50	1
6.	depth (m)	1	1-3	3	>3-6	2	6-10	1
7.	Reef area (m^2)	1	>500	3	100-500	2	20-100	1

After determining the weight and score of each criterion, the value of the tourism suitability index (TSI) is calculated using the following formula:

$$\text{TSI} = \sum [\frac{Ni}{Nmax}] \, x \, 100$$

Description :
TSI: Tourism Suitability Index
Ni: i-th Parameter Value (Weight x Score)
Nmax: Maximum Value of a Tourism Category (57)

According to [11], the Marine ecotourism suitability index is divided into four suitability classes: very suitable, quite suitable, conditionally suitable, and not suitable. Each of these suitability classes is defined as follows:

1. Very suitable
   A suitable class is defined by the absence of a heavy limiting factor in a particular sustainable use in an area, or the limiting factor is less significant and has no real influence on ecotourism activities. Values for very suitable categories range from 83-100%.
2. Quite suitable
   A suitable class is defined by several limiting factors in a certain sustainable use in an area, or these limiting factors are meaningful and have a real influence on ecotourism activities. Values for the category are pretty suitable, ranging from 50-<83%.
3. Conditionally suitable
   Conditionally suitable class is defined by the existence of severe limiting factors in an area that is used as ecotourism activities sustainably but is still possible to be overcome or improved, where if there is an improvement treatment with a higher level of technology introduction or additional treatment is carried out at reasonable cost, this area can still be improved to be suitable. Values for conditionally suitable categories range from 17-<50%.
4. Not suitable
   Not suitable class is defined by the presence of a very severe limiting factor permanently in an area for specific natural uses. This class is different from an area to be used as a tourist activity, the presence of heavy limiting factors will hamper the area's productivity. The value for the not suitable category ranged from <17%.

2.1.7. Area Carrying Capacity Analysis

The carrying capacity analysis calculates the maximum number of visitors who can be physically accommodated in the available area at any given time without causing disturbance to nature and humans. The calculation of the Area Carrying Capacity (ACC) can be seen in the following equation (Modified from [11]):

$$ACC=K \times \frac{Lp}{Lt} \times \frac{Wt}{WP}$$

Description :
ACC: Area carrying capacity
K: Ecological potential of visitors per unit area
Lp: The area or length of the area that can be used
Lt: The area of the unit area for snorkelling needs (500 m^2)
Wt: Time provided by the Region for tours in a day (6 hours)
Wp: Time spent by visitors for each snorkelling activity (3 hours)

3. Results And Discussion

3.1. Per cent of Coral Cover

The percentage of hard coral cover in Sepulu waters ranges from 22-38%, while the percentage of coral cover (including soft corals) ranges from 34-55.5% (Figure 1). The highest percentage of coral cover, without and with soft coral, was found in Tengket waters, while the lowest per cent cover was found in Lembung Paseser waters. According to their reef cover, coral reefs in Sepulu District were in low (bad) to average condition. The per cent of coral cover in Sepulu waters is lower than the Percent of Cover in Gili Labak waters [12], lower than the per cent of coral cover in Bawean, but similar to the per cent of coral cover in Bangsring (Banyuwangi) and Gili Genting (Sumenep) waters [13].

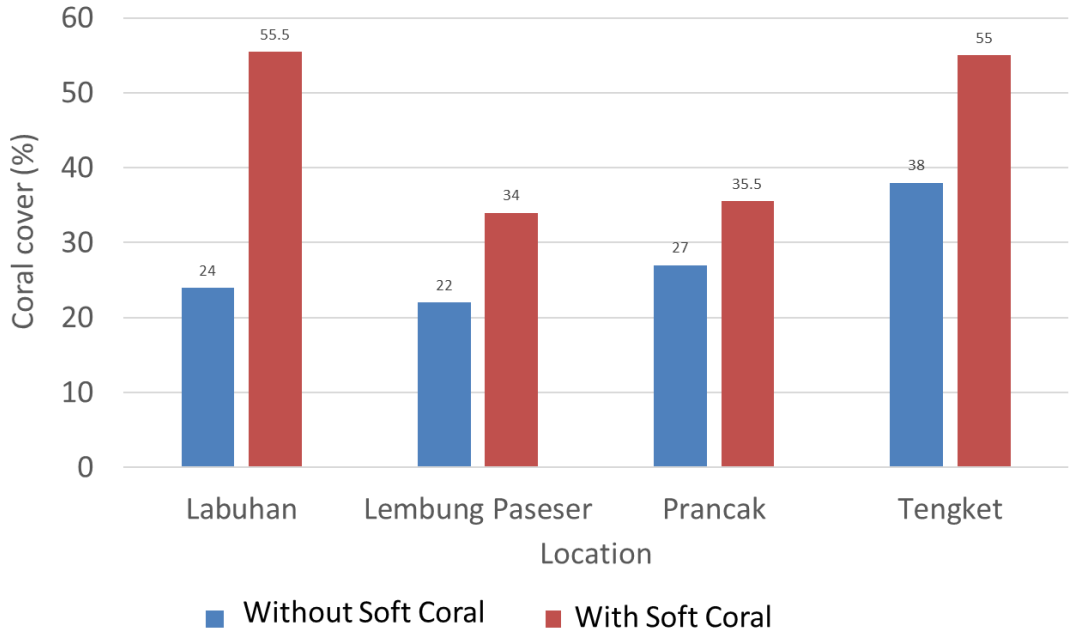

Figure 2. Percentage of coral cover at the study site

3.2. Number of Coral Lifeform

The number of coral growth forms found in Labuhan is six forms (ACS, CE, CF, CM, CMR, CS, SC), Passer Lembung found as many as seven forms (ACB, ACS, CE, CF, CM, CS, SC), Prancak waters found as many as seven forms (ACS, ACD, ACT, CE, CM, CS, SC) and Tengket waters found as many as eight forms (ACS, ACD, ACT, CE, CM, CMR, CS, SC) (Table 2). The coral growth form found in Sepulu waters is lower when compared to the coral growth form found in the waters of Gili Labak (Sumenep), which have 12 forms (Insafitri et al., 2021) [12], but similar compared to coral growth form found on Bidadari Island, Sumenep [14].

Table 2. Coral growth forms found in the waters of Sepulu, Bangkalan

Coral Lifeform	Labuhan	Lembung Paseser	Prancak	Tengket
Acropora Branching (ACB)	-	V	-	-
Acropora Submassive (ACS)	V	V	V	V
Acropora Digitate (ACD)	-	-	V	V
Acropora Tubulate (ACT)	-	-	V	V
Coral Encrusting (CE)	V	V	V	V
Coral Foliose (CF)	V	V	-	-
Coral Massive (CM)	V	V	V	V
Coral Mushroom (CMR)	-	-	-	V
Coral Submassive (CS)	V	V	V	V
Soft Coral	V	V	V	V
Total Lifeform	6	7	7	8

3.3. Reef Fish

Reef fish found in Sepulu district water were 7-12 species (Table 3), with the highest number found in Labuhan and the lowest found in Lembung Paseser. The number of reef fish found is still higher when compared to reef fish on Bidadari Island, Sumenep, which ranges from 5-6 species [14]. The difference number of reef fish found might be caused by their coral cover in the respective location. Labuhan had the highest coral cover of other locations, which may contribute to the number of reef fish, similar to those on Bangsring, Bayuwangi and other areas in East Java Waters [13].

Table 3. Reef fish and the number of reef fish species found in Sepulu District, Bangkalan.

Reef fish	Prancak	Lembung Paseser	Tengket	Labuhan
Abudefduf saxatilis	-		V	-
Abudefduf vaigiensis	V	V	-	V
Aethaloperca rogaa	-	V	-	-
Acanthurus pyropherus	V		-	-
Apogon fucata	V		-	-
Apogon semilineatus	-	-	-	V
Caseo cuning	V	V	V	V
Chaetodon vagabundus	V		V	V
Cheilodipterus artus	V		-	
Chelmon rostratus	-	V	-	-
Chrysiptera parasema	-	-		V
Chrysiptera unimaculata	-	-		V
Dascyllus trimaculatus	-	-	-	V
Hemigymnus melanopterus	-	V	V	-
Heniochus diphreuthus	-	V	V	V
Labroides dimidiatus	-	-	-	V
Letrik harak	V		-	
Lutjanus liniolatus	-		V	-
Parachaetodon ocellatus	V		-	-
Pomacentrus burroughi	V		-	V
Pomacentrus coelestis	-		V	-
Pracanthus hepatus	-		V	-
Scarus schlegeli	V	V	-	V

Thalassoma hardwickei	-	-	-	V
Number of reef fish species	10	7	8	12

3.4. Water Clarity, Current and Depth

Water clarity at the study site was 100%, where the brightness was to the bottom of the waters. The current speed in the water location ranges from 5-7 cm / s, while the depth in Sepulu waters is 3 m (Table 4).

Table 4. The value of water clarity, currents, and depth in the Sepulu waters, Bangkalan

Location	Water Clarity (%)	Current (cm/s)	Depth (m)
Labuhan	100	6	3
Lembung Paseser	100	5	3
Prancak	100	7	3
Tengket	100	6	3

3.5. Reef Area

Using satellite imagery data analysis, the area of coral reefs in Sepulu Bangkalan waters ranged from 3.8 – 12.5 ha (Figure 3). Labuhan waters have a coral reef area of 9.8 Ha (98,000 m^2), Lembung Paseser has a coral reef area of 3.8 Ha (38,000 m^2), Prancak has a coral reef area of 7.7 ha (77,000 m^2), and Tengket has a coral reef area of 12.5 Ha (125,000 m^2).

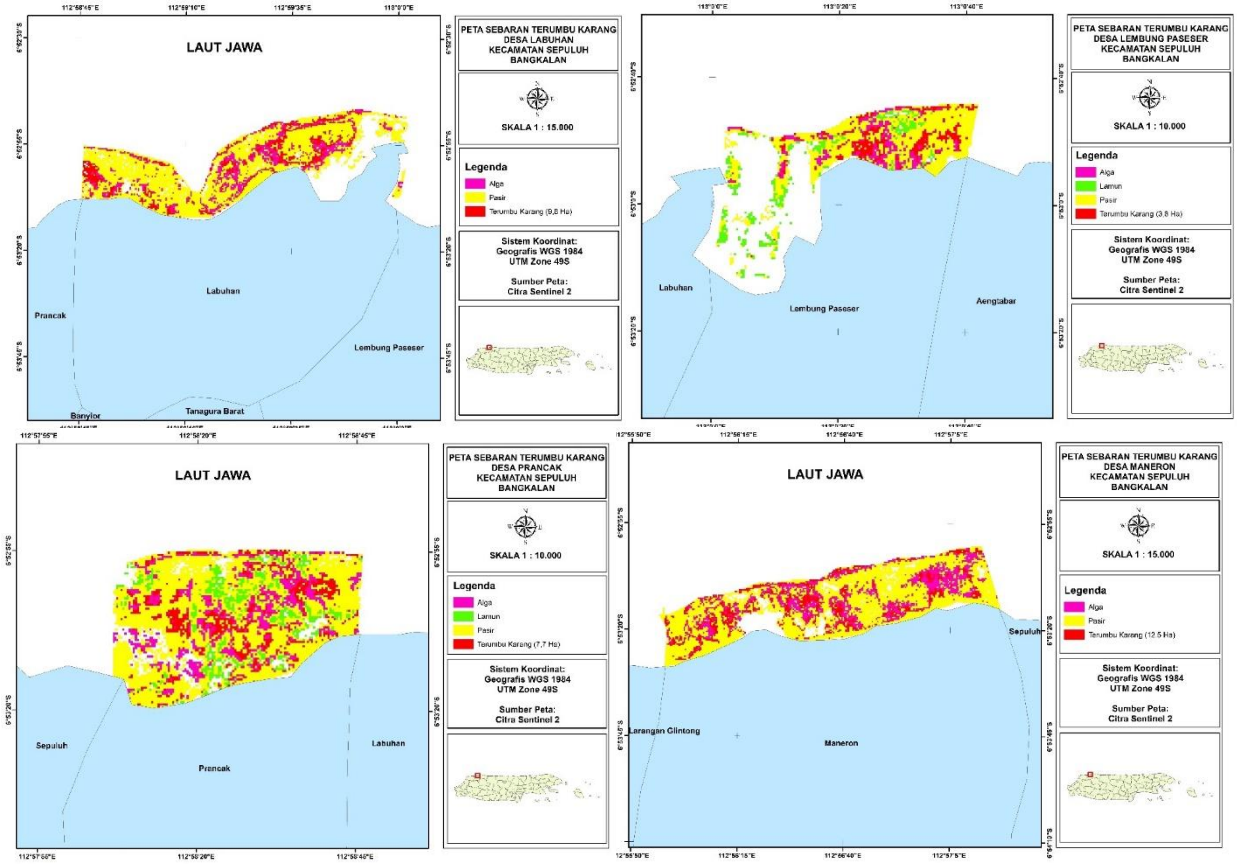

Figure 3. Map showing the extent of coral reefs in Sepulu Waters, Bangkalan, based on analysis of satellite imagery.

3.6. Snorkeling Tourism Suitability Index

The tourism suitability index of Sepulu Waters, Bangkalan, which ranges from 61.40 – 75.44% (Table 5), is included in the suitable category. The tourism suitability index in Prancak and Lembung Paseser waters has the same percentage of tourism suitability index, namely 61.40 %, which is classified as quite suitable. The similarity can be affected by the adjacent location. Meanwhile, the tourism suitability index between Tengket and Labuhan has a higher percentage value. However, both have the same quite suitable class. All locations generally belong to the same category, which is quite suitable.

Table 5. Snorkelling tourism suitability index at Sepulu waters, Bangkalan

Site	Water Clarity (%)	Coral cover (%)	Number of Coral Lifeform	Number of reef fish	Current (cm/s)	depth (m)	Reef area (m^2)	Tourism Suitability Index (%)	Category
Labuhan	100	55.5	6	12	6	3	98,000	70.18	Quite suitable
Lembung Paseser	100	34	7	7	5	3	38,000	61.40	Quite suitable
Prancak	100	35.5	7	8	7	3	77,000	61.40	Quite suitable
Tengket	100	55	8	10	6	3	125,000	75.44	Quite suitable

This value indicates that all areas are suitable for snorkelling and diving marine tourism activities [11]. However, efforts to improve coral reef ecosystems, such as through coral transplantation and the manufacture of artificial coral reefs, including several reef fish, need to be made.

Based on the results obtained, Tengket and Labuhan waters have a high potential to be used as snorkelling tourism objects. However, inadequate road access to Tengket waters requires more effort for tourism development. Meanwhile, Labuhan has become a beach tourist location that is quite popular, so it is enough to carry out management and promotion activities so that snorkelling tourism activities can run.

3.7. Area Carrying Capacity

Analysis of the area's carrying capacity is carried out to determine the maximum number of visitors that can be tolerated or handled by a tourist area to maintain comfort, sustainability and preservation. The area's carrying capacity in Prancak waters is 308 people per day. Labuhan waters with a regional carrying capacity of 392 people per day. Lembung Paseser waters with a regional carrying capacity of 152 people per day, and Tengket waters with a regional carrying capacity of 500 people per day (Table 6).

Table 6. Area carrying capacity of Sepulu waters, Bangkalan, for Snorkeling activities.

Site	K	Lp (m^2)	Lt (m^2)	Wt (Hours)	Wp (Hours)	ACC (Person)
Labuhan	1	98,000	500	6	3	392
Lembung Paseser	1	38,000	500	6	3	152
Prancak	1	77,000	500	6	3	308
Tengket	1	125,000	500	6	3	500

The area's carrying capacity is a way of management that can show or provide a picture of estimations based on objective measures and estimations needed by tourists to maintain the comfort value between tourists and the local community [15]. The area's carrying capacity can also be interpreted as the level of use of an area without exceeding the area's power [16]. Tourism activities can cause a decline in the quality of these resources, so a balance is needed to limit the number of tourists visiting and carry out further processing in the area. The area's carrying capacity greatly determines the sustainability of tourism activities in the area [17].

4. Conclusion

Sepulu Waters, Bangkalan, has a suitable snorkelling tourism suitability index; the area's carrying capacity for snorkelling tourism activities is 152-500 people daily. However, several things become limiting factors, namely a low per cent of coral cover, a small number of coral growth forms, and a small number of reef fish. For Sepulu waters to be more suitable, it is necessary to improve, especially with the addition of coral cover with transplantation and artificial reefs, as well as the introduction of new reef fish species.

5. Acknowledgement

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