



# Suitability and carrying capacity of Larearea Island marine tourism in Sembilan Island area, Sinjai District, South Sulawesi Province, Indonesia

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**Abstract.** The area of Sembilan Island, especially the Larearea Island, has natural resources of coral reefs, seagrass beds and beautiful white sands, thus, it can be developed as a marine tourism area, in order to improve the standard of living and welfare of the local community. This study aimed to determine the suitability and carrying capacity of the island of Larearea in the island of Sembilan as marine tourism. The results of this study are expected to provide useful information for policy makers and decision makers in determining the marine tourism development and can be used as a reference in the development policy of the Sembilan Island area. This research was conducted from October to November 2019 on the island of Larearea in the area of the island of Sembilan, Sinjai Regency, South Sulawesi Province, Indonesia. Sampling was carried out around the Larearea Island, at 3 stations. The observed data were the coral reefs, seagrass, current velocity, water depth, brightness, dangerous biota and diversity of coral fish species. From the results of the suitability indicator assessment, it can be seen that the suitability index value for diving tourism in the Sembilan Island area (Larearea Island) is 69.32% or in the S2 category (quite appropriate). The suitability values and categories obtained indicate that coral reefs, seagrass and other biota in the Pulau Sembilan area are still suitable for diving tourism activities. As for snorkeling, from the results of the suitability assessment it can be seen that the value of the suitability index in the Sembilan Island area was 71.11% or in the S2 category (quite appropriate). Meanwhile, the carrying capacity resulting from the data analysis for Larearea Island, in the area of Sembilan Island, suggest that the marine tourism related to the diving category supports as many as 18 persons every day and the snorkeling tours support as many as 36 persons every day.

**Key Words:** suitability, carrying capacity, marine tourism, Larearea Island, Sinjai regency.

**Introduction.** The marine sector has biological and non-biological resources, such as the marine services sector, fisheries, marine mining, the maritime industry and sea transportation. This sector can become one of the mainstays of Indonesian tourism. Based on the aspects of exploration, conservation and integrated management, the development of the tourism sector is expected to be able to implement a sustainable ecosystem management, while developing the marine tourism (Fandeli 2000; Alamsyah et al 2019). The development of the tourism industry is one of the strategies used by the government and even by the private sector to promote certain areas as tourist destinations, in order to increase the economy and job opportunities (Agung 2014). Coastal and marine areas that can be developed into tourist areas offer beautiful coastal views and authenticity of the environment, such as a diversity of life under water, as an environmental service providing benefits due to their aesthetic values (Yulisa et al 2016; Ali 2004). Advances in science and technology help people choose sustainable tourist destinations. In addition to enjoying the beauty of nature, this also involves elements of education and support for conservation efforts. Tourism activities are expected to have a positive impact on environmental sustainability and to improve the standard of living and the economy of local communities. The Sembilan islands have natural resources, like

coral reefs, seagrass beds and white sands, thus having the potential to be developed as marine tourism areas to improve the welfare of the local community. The existing ecosystem, especially the coral reef ecosystem, is still in a good category of environmental quality (Suharyanto & Utoyo 2005). The present study aimed to determine the suitability and carrying capacity of Larearea Island as marine tourism for diving and snorkeling.

## Material and Method

**The study area.** The present research was conducted on the island of Larearea, in the area of Sembilan Island, Sinjai Regency, South Sulawesi Province, Indonesia from October to November 2019. The research location is shown in Figure 1, below. Samplings were carried out at 3 observation stations, namely: Station 1 at coordinates: 05° 04' 15.88 "S and 120° 23' 36.98" E, station 2 at coordinates: 05° 04' 19.80" S and 120° 23' 26.95" E and station 3, at the coordinates: 05° 04' 16.25" S and 120° 23' 03.75" E.



Figure 1. Research location at the Larearea Island in the Sinjai District of South Sulawesi.

Observation of coral reefs was carried out by survey methods and using Landsat 8 imagery. Survey methods were carried out using the Line Intercept Transect (LIT) method or the Line Transect Method (English et al 1997). This method basically uses transect lines that are placed over the coral colonies.

**Water quality parameters.** Water quality parameters observed during the study can be seen in Table 1.

Table 1  
Types of water quality parameters observed in the study

Component data	Method of collecting data	Data source
Depth of water (m)	Depth observation	Observation
Salinity (‰)	In situ	Mensuration
Current velocity (m s <sup>-1</sup> )	In situ	Mensuration
Temperature (°C)	In situ	Mensuration
Brightness water (%)	In situ	Mensuration
Dissolved oxygen	In situ	Mensuration

**Area suitability analysis.** The analysis of the suitability of the area for marine tourism was split in two categories, namely: diving and snorkeling. The corresponding suitability matrices can be seen in Table 2 and 3 below.

Table 2

## Suitability matrix for diving tourism

<i>Parameter</i>	<i>Weight</i>	<i>Standard parameter</i>	<i>Score</i>
Live coral cover (%)	3	>75	3
		>50-75	2
		25-50	1
		<25	0
Brightness of the water (%)	3	100	3
		80-<100	2
		20-<50	1
Amount of life form types (ind)	2	< 20	0
		>12	3
		<7-12	2
Amount of types of reef fish (ind)	2	4-7	1
		<4	0
		>100	3
Depth of the coral reef (m)	2	50-100	2
		20-<50	1
		<20	0
Current speed (cm/s)	1	6-15	3
		>15-20 or 3-5	2
		>20-30	1
		>30 or <3	0
		0-15	3
		>15-30	2
		>30-50	1
		>50	0

Source: Hutabarat et al 2009.

Table 3

## Suitability matrix for snorkeling tours

<i>Parameter</i>	<i>Weight</i>	<i>Standard parameter</i>	<i>Score</i>
Live coral cover (%)	3	>75	3
		>50-75	2
		25-50	1
		<25	0
Brightnes of the water (%)	3	100	3
		80-<100	2
		20-<50	1
Amount of life form types (ind)	2	<20	0
		>12	3
		<7-12	2
Amount of types of reef fish (ind)	2	4-7	1
		<4	0
		>100	3
Depth of the coral reef (m)	2	50-100	2
		20-<50	1
		<20	0
Width of the flat reef (m)	2	6-15	3
		>15-20 or 3-5	2
		>20-30	1
		>30 or <3	0
		>500	3
		>100-500	2

<i>Parameter</i>	<i>Weight</i>	<i>Standard parameter</i>	<i>Score</i>
		20-100	1
		<20	0
Current velocity (cm s <sup>-1</sup> )	1	0-15	3
		>15-30	2
		>30-50	1
		>50	0

Source: Hutabarat et al 2009.

According to Yulianda (2007), the formula used for the suitability of beach tourism is:

$$IKW (\%) = (\sum Ni/N \text{ max}) \times 100$$

Where:

IKW - tourism suitability index;

Ni - score (weight) of the i<sup>th</sup> parameter;

N max - maximum value of a tourism category.

**Carrying capacity analysis.** Tourism carrying capacity is more related to the biophysical and social criteria resulting from the development of specific activities. The carrying capacity of tourism can be calculated with the following formulas (Hutabarat et al 2009; Yulianda 2007):

$$DDK = K \times (Lp/Lt) \times (Wt/Wp)$$

Where:

DDK - carrying capacity area;

K - the ecological potential in number of visitors per unit of area;

Lp - the maximum usable area;

Lt - area unit by category of activity;

Wt - the time per day required to visit the region and perform all the tourist activities;

Wp - time spent by visitors on each activity.

The visitor ecological potential and activity area can be seen in Table 4. It is assumed that each person needs 500 m<sup>2</sup> of the total area used for diving tourism and 250 m<sup>2</sup> of the total area used for snorkeling tours.

Table 4  
Visitor ecological potential and area of activity

<i>Type of activity</i>	<i>K (Σ visitors)</i>	<i>Required area (Lt)</i>	<i>Information</i>
Diving	2	1,000 m <sup>2</sup>	2 persons per 1,000 m <sup>2</sup>
Snorkeling	1	250 m <sup>2</sup>	1 person per 250 m <sup>2</sup>

Source: Hutabarat et al 2009.

The visitor activity time (Wp) is calculated based on the period spent by visitors to carry out a given tourism activity Table 5. The visitor time is calculated as the total time spent in the area (Wt). The area time is the period during which the area is opened in one day and the average working time is around 8 hours (8-16 hours).

Table 5  
Type of activity and time required

<i>Type of activity</i>	<i>Time taken Wp (hours)</i>	<i>The total time day<sup>-1</sup> Wt (hours)</i>
Diving	2	8
Snorkeling	3	6

Source: Hutabarat et al 2009; Yulianda 2007.

## Results

**Suitability marine tourism.** Each area that will be used for an activity should take into account the level of suitability of its utilization. It is important to know the level of suitability of the area so that any future utilization activities do not interfere or damage the present and future ecological, socio-economic and cultural systems. The research results can be seen in Table 6 and Table 7.

Table 6  
Result of land suitability assessment for Larearea Island diving tourism

<i>Parameter</i>	<i>Criteria</i>	<i>Value</i>	<i>Score</i>	<i>Amount</i>
Live corals cover (%)	8.9–24.3	3	1	3
Brightness (%)	100	3	3	9
Amount of life form types (ind)	6	2	1	2
Amount of types of reef fish (ind)	53	2	2	4
Water depth (m)	3–12	2	3	6
Current speed (cm s <sup>-1</sup> )	20-60	1	3	3
Total				27

Table 7  
Result of land suitability assessment for snorkeling tourism in Larearea Island

<i>Parameter</i>	<i>Criteria</i>	<i>Value</i>	<i>Score</i>	<i>Amount</i>
Live coral cover (%)	8.9–24	3	1	3
Brightness (%)	100	3	3	9
Amount of life form types (ind)	5	2	1	2
Amount of types of reef fish (ind)	42	2	2	4
Water depth (m)	3–12	2	3	6
Width of the flat reef (m)	100-500	2	3	6
Current velocity(cm s <sup>-1</sup> )	20-60	1	3	3
Total				33

**Carrying capacity marine tourism.** Table 8 shows the results of the calculation of the carrying capacity of tourism activities in the Pulau Sembilan area.

Table 8  
Carrying capacities by marine tourism activity on the island of Larearea

<i>Activity</i>	<i>Utilization carrying capacity (ind day<sup>-1</sup>)</i>
Diving	18
Snorkeling	36

## Discussion

**Suitability marine tourism.** In this study, analyzing the suitability of the area is limited to the designation, snorkeling and marine tourism and diving with one island, namely Larearea Island. The level of suitability of the utilization of the Sembilan island area for marine tourism activities will be adjusted to the potential resources and their current allocation. This means that there is a potential of suitability of the resources and of their environment to be exploited for marine tourism purposes, depending on several parameters and assessment criteria. Certain parameters are limiting factors for the marine tourism, namely the brightness, cover and species of live coral, the reef fish diversity, the depth and current velocity, and the width of the coral reefs. Water transparency is the main requirement that must be met in diving and snorkeling tourism activities. The brighter the waters, the higher the beauty of the marine park that tourists

can enjoy. The clear waters respond to the curiosity to see the underwater beauty. The percentage of coral community cover, types of life forms and species of reef fish are also important because they are the main attraction for tourists. Variations in coral morphology and colors are a determining factor for the beauty of the marine park. The suitability criteria results are shown in Table 6.

From the results of the assessment, it can be seen that the score of the suitability index for diving tourism in the Sembilan Island area (Larearea Island), which refers to the formula, is 69.32%, in the S2 category (quite appropriate). The suitability values and categories obtained indicate that the coral reefs in the island Sembilan area are still suitable for diving tourism activities. The referenced observation station for this activity is the southeastern part of the island of Larearea.

Among the important things that need to be considered and improved there is the percentage of coral community cover. The average percentage of live coral cover in the Sembilan Island area is only of 26.73% (bad category, below 30%), meaning that some coral reefs are damaged. Therefore, in the future it is necessary to establish a better management of coral reef ecosystems, so that the condition of coral reefs can improve, which can be done through rehabilitation and conservation activities, by creating marine protected areas. All parties need to be consistent in applying the management rules.

For the assessment of the land suitability for snorkeling marine tourism, the area analyzed for this activity has a depth level of not more than 6 meters and not less than 1 meter. The purpose of snorkeling tours is to show to the tourists the underwater beauty, from the surface of the waters. According to Hawkins & Roberts (1997) and to Barker & Roberts (2004), the coral reef waters are generally suitable for snorkeling at a depth of 1–3 m, with minimal waves. Meanwhile, areas with a depth of less than 1 m will be easily trampled by tourists. If the depth is above 6 meters, it will be not optimal in terms of visibility, making it less attractive. From the suitability criteria perspective, the results are shown above, in Table 7. The suitability index score for snorkeling tourism in Larearea Island is of 71.11%, in the S2 category (quite appropriate). The score or category obtained is influenced by the real conditions in the field. Where the advantage of the coast of island Sembilan is that it has a fairly wide stretch of flat reef (>100 m), at several points, with very bright (clear) water conditions and an average depth of 3 m, with a current speed  $<5 \text{ cm s}^{-1}$ , so it is very suitable for snorkeling activities.

The observation station that is referenced for this activity is the northern part of the island of Larearea, at the station 1. This potential and condition must be maintained, so it needs good regulations regarding the number of tourists that can be accommodated and the role of tour guides in explaining the field conditions and in implementing the regulations.

**Carrying capacity marine tourism.** Exploitation activities using natural resources as capital must consider the area able to support the activities planned or developed. In this study, the carrying capacity assesses the maximum level of exploitation of an area or an ecosystem, in terms of number and type of accommodated activities, before causing a decrease in the ecological quality of the area or ecosystem, including its environmental aesthetics or natural conditions. With a limitation on the number of tourists according to the carrying capacity of the area, it is hoped that the natural resources and the environmental quality of the area can naturally assimilate the tourism activities' impacts. The use of an area for marine tourism activities in accordance with its capacity will greatly affect the sustainability of marine tourism activities. This is in accordance with the recommendations of Davis & Tisdell (1995), Roupheal & Inglis (1997), Schleyer & Tomalin (2000), Zakai et al (2002), de Vantier & Turak (2004), Peuru (2012) and Yudasmaru (2016), related to the management efforts in area in order to reduce the pressures and to increase the local sustainability, by reducing or limiting the time for diving and snorkeling tours. In the Sembilan Island, the area of coral reefs is assumed to host the diving and snorkeling tourism activities, since they concern the coral reef ecosystem as its main attraction.

From Table 8 it can be seen that the carrying capacity of Sembilan Island for the use of marine tourism with the diving tourism category is 18 people day<sup>-1</sup> and for

snorkeling tours it is of 36 people day<sup>-1</sup>. The number of tourists that can be accommodated for snorkeling marine tourism is greater than the capacity of tourists for diving tourism, due to the limiting factor which is the area of utilization of marine tourism activities or the area of coral reef ecosystems, smaller than the beach area, including the mangroves. The level of carrying capacity per day, at each observation station, is 18 people for diving and 36 people for snorkeling. The score of the carrying capacity obtained for each tourism activity is then calculated for a whole year: 6,570 people for the diving tourism and 13,140 people year<sup>-1</sup> for the snorkeling tours. Overall, the carrying capacity of the Pulau Sembilan area is 19,710 people year<sup>-1</sup>. Meanwhile, the visitors number reported in 2018 was of 5,220 people year<sup>-1</sup>, far below the carrying capacity of the area. Davis & Tisdell 1995 stated that the ecological carrying capacity for diving and snorkeling tourism in a conservation area is around 200 000 divers year<sup>-1</sup> (300 days). Compared to the results of the carrying capacity analysis above, tourism activities in the Sembilan Island are still under carrying capacity. Hawkins & Roberts (1997) recommend 5,000–6,000 divers year<sup>-1</sup>, corresponding to a per capita required area of 500 m area<sup>-1</sup> as an estimate of the carrying capacity of marine protected areas, depending on the number of dive sites that can be used. Dixon et al (1993) suggested a limit of 4,000–6,000 divers year<sup>-1</sup>. Assuming 300 days year<sup>-1</sup> of diving at a given location, the recommended figure by Davis & Tisdell (1995), Hawkins & Roberts (1997) and Hawkins & Roberts (1997) is 13 to 20 divers dive<sup>-1</sup> site day<sup>-1</sup>. The moderate condition of the live coral cover on Larearea Island has to be also considered, since the uniqueness and beauty of coral reefs is the main source of attraction for tourism activities in the Pulau Sembilan area. The carrying capacity of marine tourism is not only related to the total number of tourists that can be accommodated in an area, but also to the availability of high-quality locations with the presence of a variety of biota (Davis & Tisdell 1995; Barker & Roberts 2004; deVantier & Turak 2004; Suharsono 2014; Deni & Milla 2017; Wahyudi et al 2017). Actions to be taken to maintain or improve the the condition of natural resources and the environmental quality status are the periodic monitoring of the ecosystem condition, the distribution of the number of visitors and visits duration among the dive spots, proportionally to their respective carrying capacities, and the rehabilitation activities within the protected areas concerned by tourism impacts (Zamani 2015; Kurniawan et al 2016; Wijaya & Furqan 2018).

**Conclusions.** From the results and discussion, it can be concluded that the suitability index value for diving tourism in Larearea Island is 69.32%, in the S2 category (quite appropriate) and the suitability index value for snorkeling tourism on Larearea Island is 71.11%, in the S2 category (quite appropriate). Meanwhile, the carrying capacity of Larearea Island for the use of marine tourism in the diving tourism category is of 18 people per day and for snorkeling tours it is of 36 people day<sup>-1</sup>. Further research related to the carrying capacity of the area should use geographic and information systems so that the data obtained will be more accurate and in accordance with the spatial designation for marine tourism.

**Conflict of interest.** The authors declare no conflict of interest.

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