Study on suitability of Derawan Island as marine tourism destination towards development of sustainable tourism in the new capital city candidate of Indonesia

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Abstract. Derawan Island is one of the leading tourist destinations in Kalimantan Timur Province which is a candidate for the new capital city of Indonesia. Marine tourism on Derawan Island relies on the potential of marine resources so that a suitability study is needed for the development of sustainable tourism. This study aims to determine the suitability of marine tourism, especially the interest in diving and snorkeling in sites of Derawan Island. Data collection was carried out by surveying in December 2020 at five snorkeling and six popular dive sites in Derawan Island. Data on coral community, the number of coral fish species, and the water quality parameters are used to analyze the suitability of marine tourism. Line Intercept Transect (LIT) method was used to collecting coral community data, Underwater Visual Census (UVC) method was used to collect data on the abundance of reef fish species, and in situ water quality parameters. Tourism suitability index formula (IKW) using the four classification marine tourism suitability matrix was used to analyze the data. The results of the analysis show the suitability index for diving tourism as a whole is in suitable to very suitable category, while the snorkeling tourism suitability index is in the suitable category.

1. Introduction

Derawan Island and its surroundings are also included in the Berau Tourism Development Area (KPP3) with the themes of marine tourism, special interests, nature/ecotourism and culture (RIPPARDA Berau 2016-2023) [1]. In addition, Derawan Island is included in limited use zone of the Marine, Coastal and Small Islands Conservation Area (KKP3K) of the Derawan Islands and its surroundings. The opportunity for economic development in Derawan Island tourism is to prioritize environmental services, namely the underwater biodiversity on Derawan Island which is the main attraction for tourists.

Ecotourism is currently one of the options in promoting a unique environment and maintaining its authenticity as well as becoming an area for tourist visits. Ecotourism potential is a concept of
environmental development based on the approach of nature conservation and maintenance. The application of marine ecotourism is not only in the sense of enjoying environmental services but must also pay attention to the suitability of the area so that the resources used can be sustainable.

Currently Derawan Island is used as a marine tourism area. Marine tourism is one of the leading destinations in East Kalimantan Province. The Indonesian government appointed Kalimantan Timur Province as a candidate for the new capital city of Indonesia, thus in the future the number of tourist visits will increase. Ecologically, the use of this area for marine tourism can cause damage to marine ecosystems if not managed properly, thus in line with the concept of marine ecotourism, namely the need for a study of the suitability of natural resource areas so that their designation can be utilized in accordance with the availability and characteristics of resources. This study aims to determine and assess the suitability of marine tourism in the waters of Derawan Island as a sustainable marine tourism area so that it can be used as input and consideration for the government or interested parties and developers.

2. Methods

2.1. Time and location
This research was conducted in December 2021 - March 2021 on Derawan Island, Berau Regency, Kalimantan Timur. The primary data was taken in December 2020 at several dive sites in the waters of Derawan Island, while the secondary data used came from the Department of Fisheries and Marine Affairs Kalimantan Timur Province (DKP Prov. Kaltim).

2.2. Survey of primary data and secondary data
Ecological data used in the study of the suitability of marine tourism in Derawan Island are primary data and secondary data. Secondary data in the form of coral cover and reef fish at the Coral Garden and Dharma Point sites were obtained from DKP Prov. Kalimantan Timur [2]. The suitability of diving tourism is calculated from 6 sites, while the suitability of snorkeling tourism is calculated from 5 sites scattered in the waters of Derawan Island. The determination of the site was based on information from diving and snorkeling guides on Derawan Island, namely popular sites and development sites for the use of diving and snorkeling tours specifically in Derawan waters.

Before conducting a study on the suitability of marine tourism, it is necessary to know the condition of coral reefs and water quality. The parameters of suitability for diving tourism are the brightness of the waters, the cover of the coral community, the type of life form, the type of reef fish, the speed of the current, and the depth of the coral reef. The parameters of the suitability of snorkeling tourism are the brightness of the waters, the cover of the coral community, the type of life form, the type of reef fish, the speed of the current, the depth of the coral reef, and the width of the flat expanse of coral.

Coral reef data collection uses the line intercept transect (LIT) method, which is to record coral reef cover based on life forms along a 50 m transect line per site which is installed parallel to the shoreline. Reef fish data collection uses the underwater visual census (UVC) method, which is to record types of reef fish in an imaginary tunnel measuring 50 x 5 x 5 m along the same transect as coral reefs. Water quality data collection was carried out in situ at the same location as the coral reef and reef fish collection.

2.3. Data analysis
Analysis of coral reefs using the formula for percentage cover English et al., 1994 [3] and determining the category of coral reef conditions refers to KEPMEN LH No. 04. 2001 [4] concerning the standard criteria for coral reef damage.

Percentage of coral cover formula [3]:

\[
\text{Percentage of coral cover} = \left( \frac{\text{Total area of coral cover}}{\text{Total area of transect}} \right) \times 100
\]
\[ L = \frac{L_i}{N} \times 100\% \]

Notes: \( L \) = Percentage of coral cover (%), \( L_i \) = Length of life form (colony intercept) of category \( i \), \( N \) = Transect length (50 m)

Based on KEPMENLH No.4/MENLH/02/2001 concerning the standard criteria for coral reef damage, the condition of coral reefs based on the percentage of live coral cover is divided into four categories, namely:

1. Poor Condition = 0 – 24.90%
2. Moderate Condition = 25 – 49.90%
3. Good Condition = 50 – 74.90%
4. Very Good Condition = 75 – 100%

Analysis of the suitability of diving and snorkeling tourism using the Yulianda (2019) Tourism Suitability Index (IKW) [5]:

\[ IKW = \sum_{i=1}^{n} (Bi \times Si) \]

Notes: \( n \) = Number of suitability parameters, \( Bi \) = Quality of parameter \( i \), \( Si \) = Score parameter \( i \)

The IKW result is compared to the diving and snorkeling suitability matrix (Table 1 and 2) uses four categories.

### Table 1. Resource suitability matrix for diving tourism [5].

| No | Parameter                          | Quality | Category         | Score |
|----|------------------------------------|---------|------------------|-------|
| 1  | Coral Community Cover (%)          | 0.375   | >75              | 3     |
|    |                                    |         | >50-75           | 2     |
|    |                                    |         | 25-50            | 1     |
|    |                                    |         | <25              | 0     |
| 2  | Water Brightness (%)               | 0.150   | >80              | 3     |
|    |                                    |         | 50-80            | 2     |
|    |                                    |         | 20-50            | 1     |
|    |                                    |         | <20              | 0     |
| 3  | Coral Reef Depth (m)               | 0.150   | 6-15             | 3     |
|    |                                    |         | >15-20; 3-<6     | 2     |
|    |                                    |         | >20-30           | 1     |
|    |                                    |         | >30; <3          | 0     |
| 4  | Life Form Type                     | 0.135   | >12              | 3     |
|    |                                    |         | <7-12            | 2     |
|    |                                    |         | 4-7              | 1     |
|    |                                    |         | <4               | 0     |
| 5  | Reef Fish Type                     | 0.120   | >100             | 3     |
|    |                                    |         | 50-100           | 2     |
|    |                                    |         | 20-50            | 1     |
|    |                                    |         | <20              | 0     |
| 6  | Current Speed (cm/sec)             | 0.070   | 0-15             | 3     |
|    |                                    |         | >15-30           | 2     |
|    |                                    |         | >30-50           | 1     |
|    |                                    |         | >50              | 0     |

IKW Categories:
- \( IKW \geq 2.5 \): Very Suitable
- \( 2.0 \leq IKW < 2.5 \): Suitable
- \( 1 \leq IKW < 2.0 \): Not Suitable
- \( IKW < 1 \): Very Unsuitable
Table 2. Resource suitability matrix for snorkling [5].

| No | Parameter                        | Quality | Category | Score |
|----|----------------------------------|---------|----------|-------|
| 1  | Coral Community Cover (%)        | 0.375   | >75      | 3     |
|    |                                  |         | >50-75   | 2     |
|    |                                  |         | 25-50    | 1     |
|    |                                  |         | <25      | 0     |
| 2  | Life Form Type                   | 0.145   | >12      | 3     |
|    |                                  |         | <7-12    | 2     |
|    |                                  |         | 4-7      | 1     |
|    |                                  |         | <4       | 0     |
| 3  | Reef Fish Type                   | 0.140   | >50      | 3     |
|    |                                  |         | 30-50    | 2     |
|    |                                  |         | 10-30    | 1     |
|    |                                  |         | <10      | 0     |
| 4  | Water Brightness (%)             | 0.100   | 100      | 3     |
|    |                                  |         | 80-<100  | 2     |
|    |                                  |         | 20-<80   | 1     |
|    |                                  |         | <20      | 0     |
| 5  | Coral Reef Depth (m)             | 0.100   | 1-3      | 3     |
|    |                                  |         | >3-6     | 2     |
|    |                                  |         | >6-10    | 1     |
|    |                                  |         | >10; <1  | 0     |
| 6  | Current Speed (cm/sec)           | 0.070   | 0-15     | 3     |
|    |                                  |         | >15-30   | 2     |
|    |                                  |         | 30-50    | 1     |
|    |                                  |         | >50      | 0     |
| 7  | Coral Flat Expanse Width         | 0.070   | >500     | 3     |
|    |                                  |         | >100-500 | 2     |
|    |                                  |         | 20-100   | 1     |
|    |                                  |         | <20      | 0     |

IKW Categories:
- IKW ≥ 2.5 : Very Suitable
- 2.0 ≤ IKW < 2.5 : Suitable
- 1 ≤ IKW < 2.0 : Not Suitable
- IKW <1 : Very Unsuitable

3. Result and discussion

3.1. Condition of coral reefs and water quality
One of the functions of the coral reef ecosystem for humans is as a marine tourism object. Communities found in coral reef ecosystems with a variety of distinctive morphological variations and colors that are displayed are the main attraction for tourists. However, these tourism activities can affect the condition of coral reefs [6]. The condition of coral reefs is also influenced by water quality as a limiting factor for the growth and life of coral reefs.
The condition of coral reefs in Derawan waters was analyzed from eleven data collection sites. The percentage of live hard coral cover at diving and snorkeling sites in Derawan Island waters was in range of 26.10 – 67.26% with an average value of 49.59%. The percentage of coral cover at the diving and snorkeling sites can be seen in Figures 2 and 3. The highest live hard coral cover was found at the Bumphead Point site, which was 67.26%, while at the Jetty Derawan Café snorkeling site it was 61.14%. The lowest live hard coral cover was found at the Coral Garden dive site at 26.10%, while at the Jetty BMI snorkeling site at 40.60%.

The highest live hard coral cover was found at the Bumphead Point site at 67.26%. This site is a dive tourism development site, which is a site that is still rarely used for diving tourism, thus allowing the condition of coral reefs to be relatively maintained compared to other sites due to the lack of
pressure from tourism activities. The Bumphead Point site has an additional attraction, namely the discovery of ±20 Bumphead Parrotfish (*Bolbometopon muricatum*). The lowest live hard coral cover was found at the Coral Garden dive site at 26.10%. This site is the site that is most often used for diving tourism so that it experiences greater pressure from tourist activities than other sites, especially the use of anchors for divers that destroy coral reefs into rubble.

Table 3. Water quality parameters at each data collection site.

| Site                  | DO (mg/l) | Current Speed (m/sec) | Brightness (%) | pH  | Salinity (ppm) | Temp (°C) |
|-----------------------|-----------|-----------------------|----------------|-----|----------------|-----------|
| **Diving Site**       |           |                       |                |     |                |           |
| Bumphead Point        | 7,10      | 0,10                  | 100            | 8,20| 33             | 28,20     |
| Coral Garden          | 7,10      | 0,15                  | 100            | 8,19| 31             | 28,90     |
| Dharma Point          | 7,40      | 0,14                  | 100            | 8,19| 31             | 28,60     |
| Jetty BMI             | 6,50      | 0,15                  | 100            | 8,08| 31             | 29,90     |
| Snapper Point         | 7,20      | 0,31                  | 100            | 8,14| 31             | 30,20     |
| Taman Sibili          | 10,10     | 0,17                  | 100            | 8,03| 31             | 30,30     |
| **Snorkeling Site**   |           |                       |                |     |                |           |
| Coral Garden          | 7,10      | 0,15                  | 100            | 8,19| 31             | 28,90     |
| Dharma Point          | 7,40      | 0,14                  | 100            | 8,18| 31             | 28,60     |
| Jetty BMI             | 6,50      | 0,08                  | 100            | 8,16| 31             | 30,70     |
| Jetty Derawan Cafe    | 6,50      | 0,10                  | 100            | 8,19| 31             | 30,50     |
| Taman Kima            | 10        | 0,17                  | 100            | 8,04| 31             | 30,20     |

The condition of the coral reefs is supported by the condition of water quality which is still within the tolerance range for coral growth as listed in Table 3. The waters at all data collection sites are odorless, so that the overall water quality parameters measured also show that the quality of Derawan Island waters is suitable for marine tourism activities.

Based on the results of the study, it is known that the condition of coral reefs in the waters of Derawan Island is in the moderate category (49.59%). The condition of the coral reefs is supported by the quality of the waters which are still in the range of sea water quality standards for marine biota. In addition, the measured water quality parameters (Table 3) are suitable for marine tourism activities, which are in the range of sea water quality standards for marine tourism KEPMENLH No. 51 of 2004 [7].

3.2. Marine tourism suitability

The concept of marine ecotourism that has been running on Derawan Island is understood as a tourist activity related to nature. Ecotourism is not only limited to tourism that interacts with nature or the main service offered is the environment, but ecotourism is a responsible trip to natural areas by preserving the environment, improving the welfare of local communities and providing educational value [8]. One of the efforts to preserve the environment in tourism activities is to pay attention to the suitability for the sustainability of resources. Moreover, in the future it is likely that the number of tourist visits will increase if the new capital city of Indonesia has been moved to Kalimantan Timur Province. The suitability map for diving tourism on Derawan Island is presented in Figure 4, while the suitability map for snorkeling tourism is presented in Figure 5.
The tourism suitability index (IKW) for diving tourism can be seen in Table 4, while the IKW for snorkeling tourism can be seen in Table 5.

### Table 4. Suitability of marine tourism resources for diving tourism.

| Sites            | IKW | Categories  |
|------------------|-----|-------------|
| Bumphead Point   | 2.64| Very Suitable |
| Coral Garden     | 2.01| Suitable    |
| Dharma Point     | 2.39| Suitable    |
| Jetty BMI        | 2.39| Suitable    |
| Snapper Point    | 2.13| Suitable    |
| Taman Sibili     | 2.32| Suitable    |

### Table 5. Suitability of marine tourism resources for snorkeling tourism.

| Sites                  | IKW | Categories |
|------------------------|-----|------------|
| Coral Garden           | 2.21| Suitable   |
| Dharma Point           | 2.35| Suitable   |
| Jetty BMI              | 2.21| Suitable   |
| Jetty Derawan Cafe     | 2.44| Suitable   |
| Taman Kima             | 2.41| Suitable   |

The potential of coral reefs that can be utilized for the development of marine tourism in the diving category consists of hard corals, soft corals and other biota associated with corals so as to produce their own charm with morphological variations and attractive colors [5]. Utilization of resources must be adjusted to the conditions so that they can be managed optimally, thus a suitability study is needed. The suitability of marine tourism for all recorded diving and snorkeling sites is in suitable to very suitable category.

The suitability analysis of diving tourism was carried out in deep waters (<12 m). The parameters of suitability for diving tourism are the brightness of the waters, the cover of the coral community, the type of life form, the type of reef fish, the speed of the current, and the depth of the coral reef. The suitability of diving tourism in the waters of Derawan Island is in suitable to very suitable category with an area of 402,704.29 m². The analysis of the suitability of snorkeling tourism was carried out in...
shallow waters (<5 m). The parameters of the suitability of snorkeling tourism are the brightness of the waters, the cover of the coral community, the type of life form, the type of reef fish, the speed of the current, the depth of the coral reef, and the width of the flat expanse of coral. The suitability of snorkeling tourism in the waters of Derawan Island is in the category according to the area of 281,453.29 m². Snorkeling is an activity that is mostly done by tourists than diving. This is because diving activities can only be carried out by licensed divers with national/international standards. Diving tourism activities are mostly carried out by foreign tourists than domestic tourists.

Utilization of potential for the development of marine tourism can be sustainable by taking into account the suitability index. Natural restoration of coral reefs can be done by reducing local pressures [9]. The existence of educational value in the concept of ecotourism requires diving and snorkeling guides to provide information that is educating the tourists so that they participate in conserving coral reefs. Considering that Derawan Island is part of the Marine, Coastal and Small Islands Conservation Area (KKP3K) of the Derawan Islands and its surroundings, to strengthen the application of the ecotourism concept, it is necessary to regulate area management (utilization, control and protection) taking into account the suitability value.

4. Conclusion
Conclusions based on the above analysis are as follows: the condition of coral reefs in the waters of Derawan Island is in the moderate category; the suitability index for diving and snorkeling is in suitable to very suitable category. Development of ecotourism analysis to the stage of carrying capacity of marine tourism in the next publication so that it can be considered by related parties to develop sustainable tourism on Derawan Island.

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References
[1] Peraturan Daerah Kabupaten Berau No 3 Tahun 2018 Tentang Rencana Induk Pembangunan Kepariwisataan Daerah Tahun 2016 – 2031.
[2] DKP Prov Kaltim 2020 Laporan Akhir Penyediaan Data Series Keanekaragaman Hayati dan Sumber Daya Ikan. DKP Prov Kaltim: Samarinda.
[3] English S, Wilkinson C, Baker V 1994 Survey Manual for Tropical Marine Resources. Australian Institute of Marine Science: Australia.
[4] Keputusan Menteri Negara Lingkungan Hidup No 4 Tahun 2001 Tentang Kriteria Baku Kerusakan Terumbu Karang.
[5] Yulianda F 2019 Ekowisata Perairan: Suatu Konsep Kesesuaian dan Daya Dukung Wisata Bahari dan Wisata Air Tawar. IPB Press: Bogor.
[6] Zaakai D, Chadwick-Furman N E 2002 Impacts of intensive recreational diving on reef corals at Eilat, Northern Red Sea. J. Biol. Conserv 105: 179-187.
[7] Keputusan Menteri Negara Lingkungan Hidup No 51 Tahun 2004 Tentang Baku Mutu Air Laut.
[8] https://ecotourism.org/news/ties-announces-ecotourism-principles-revision.
[9] Simarangkir O R, Yulianda F, Boer M 2015 Pemulihan Komunitas Karang Keras Pasca Pemutihan Karang di Amed Bali. JIPI 20 (2): 158-163.