Proceeding of the International Conference on Hospitality and Tourism Management
Vol. 6, Issue 1, 2021, pp. 82-99
ISSN 2357-2612 online
DOI: https://doi.org/10.17501/23572612.2021.6106

ANALYSIS OF ENVIRONMENTAL ASPECTS AND CARRYING CAPACITY OF DIVING AND SNORKELING IN SUSTAINABLE TOURISM DEVELOPMENT ON KARIMUNJAWA

Wibowo MS[1], Priyambodo TK[2]* and Fandeli C[3]

[1]*Graduate School, Universitas Gadjah Mada, Indonesia*
[2]*Center for Tourism Studies, Universitas Gadjah Mada, Indonesia*
[3]*Institute Technology of Yogyakarta, Indonesia*

Abstract: Sintok and Cilik islands of Karimunjawa are located in an area with potentials for SCUBA diving and snorkeling tourism. While these areas are developed into tourist destinations, efforts to preserve the environment need to be carried out. As a consequence, assessment of diving and snorkeling tourism management needs to be conducted by referring to indicators pertaining to the environmental aspects specified by the United Nations World Tourism Organization (UNWTO). The carrying capacity of the diving and snorkeling tourism sites needs to be measured so that the area can be a sustainable tourism destination. The objective of the study is to conduct an assessment of environmental aspects as an effort in implementing sustainable tourism development. Another objective is to identify the Tourism Suitability Index (TSI) and carrying capacity of the SCUBA diving and snorkeling tourism sites in Sintok and Cilik islands. The research methods employed were in-depth interviews and field observations. Study results indicate that Sintok island and Cilik island scored 23 and 24, respectively, for the environmental aspects in sustainable tourism development, with an average value of 3 for both islands. Based on these scores, they are categorized as "fairly suitable" with sustainable tourism development. The TSI scores obtained for SCUBA diving and snorkeling tourism in Sintok and Cilik islands are categorized as "highly suitable" (S1) and "fairly suitable" (S2). The tourism area's carrying capacity of the SCUBA diving and snorkeling tourism sites in Sintok island is 2,406 persons/day, while Cilik island's carrying capacity is 510 persons/day.

Keywords: Tourism Environmental Aspect, Sustainable Tourism, Tourism Sustainability Index, Tourism Carrying Capacity

Introduction

According to UNWTO (United Nations World Tourism Organization) (2004), sustainable tourism is defined as tourism that considers current and future economic, socio-cultural, and environmental impacts while fulfilling the needs of visitors, the industry, the environment, and local communities. The development of sustainable tourism is expected to bring about environment-friendly development criteria, local community empowerment, more developed and stronger economic growth and local culture (Fandeli dan Muhammad, 2019).

One of the indicators of sustainable tourism management is environmental carrying capacity. Environmental carrying capacity refers to nature's capacity or ability to accommodate tourism activities that would not result in the destruction of nature's existence and sustainability (Nikijuluw *et*

Corresponding Author's Email: *mastri@ugm.ac.id

al., 2017). Based on this definition, the concept of carrying capacity as an indicator for sustainable tourism can be established as performance indicator and target.

Karimunjawa Islands is an area that has significant tourism potentials with its SCUBA diving and snorkeling attractions. Administratively speaking, Karimunjawa Islands is incorporated in Jepara Regency of Central Java Province. This Islands is located approximately 45 nautical miles or equivalent to 83 kilometers northwest off the coast of Jepara (Yusuf, 2013). Based on the Decree of the Minister of Forestry No. 74/Kpts-II/2001 dated 15 March 2001 on the Establishment of National Park Area, Karimunjawa has a tropical rainforest ecosystem with a total land area of 1,285.50 hectares and marine area of 110,117.30 hectares, which have been designated as a nature conservation area. There are 2 villages found on Karimunjawa, namely Karimunjawa Village and Kemujan Village. The potential natural wealth Karimunjawa Islands have is further emphasized with the discovery of 20-30 coral reef genus and an average stocking fish density of 1.14 fish/m^3 (Yusuf, 2013). Such conditions have significantly attracted tourists to visit Karimunjawa. This can be seen from the data on tourist visits which consistently increase every year. The Table 1 presents the data on tourists visited Karimunjawa in the 2014-2018 period.

Tabel 1. Karimunjawa visitors

No	Year	Domestic Tourist	Foreign Tourist	Total
1	2014	71.081	8.669	79.750
2	2015	84.536	7.579	92.115
3	2016	110.984	7.317	118.301
4	2017	69.237	7.819	77.056
5	2018	129.679	8.156	137.835
TOTAL		465.517	39.540	505.057

Source: Tourism Information Centre Jepara (2019)

The carrying capacity of the coral reef ecosystem for SCUBA diving and snorkeling tourism is affected by the coral cover percentage, extent of coral reefs, and conducted activities. Calculation of coral reef carrying capacity can be applied to various conditions according to the tourism activity (Sulisyati, *et al*., 2016). Therefore, area carrying capacity can be prioritized for conducting assessment of every tourism destination that has an environment with tourism potentials.

The current study used indicators of sustainable tourism development that refer to the environmental aspect. This was conducted to see the extent of environmental conditions in Sintok and Cilik islands in terms of sustainable tourism development. Subsequently, the carrying capacities of the SCUBA diving and snorkeling tourism area found in both islands, which are located in Kemujan Village, were calculated.

The objective of this research is to carry out assessment and evaluation of sustainable tourism in Sintok and Cilik islands. Furthermore, the study aims to identify the tourism suitability index (TSI) score for SCUBA diving and snorkeling tourism in Sintok and Cilik islands, as well as understand the area's carrying capacity for SCUBA diving and snorkeling tourism attraction in Sintok and Cilik islands.

This research employed the qualitative approach. The research data comprises primary and secondary data. Primary data refers to results of interviews with various informants to gain better understanding about the environmental conditions in Sintok and Cilik islands and to fill in the environmental aspect indicators according to UNWTO's guideline for sustainable tourism development.

The primary data acquired include, among others, water turbidity, coral life form types and density, types of fish, coral reef depth, and extent of coral cover. Water turbidity data were taken by using a Secchi disk. Data on coral life form types and density as well as types of coral fish were obtained using the line intercept transect (LIT) method. LIT method was employed by laying out a 50 meters long roll meter parallel with the shoreline at a specified depth. Then, the types of coral reefs observed in every centimeter were recorded as data.

Secondary data were used to obtain data on current speed. The current speed condition is the result of numerical simulation modelling (Indrayanti *et al*., 2019). In terms of current speed, there are two conditions, i.e., high to low tide and low to high tide. The highest average value was, subsequently, used.

The percentage of live coral cover acquired from the coral reef (life form) data, and the percentage of live coral reef acquired from the using the line intercept transect (LIT) method were then calculated using the equation introduced by English *et al*. (1994):

$$P = \frac{Li}{L} \times 100$$

Notes:

P: percentage of coral cover (%)

Li: total length of life form types i (m)

L: length of transect observed (m)

Reef fish data were collected using the underwater visual census method (English *et al*., 1994). Fish abundance is defined as the amount or number of fish per given area of data collection. The analysis of reef fish abundance in Cilik and Sintok islands was done by using the equation introduced by Odum (1993) :

$$Kelimpahan\ ikan = \frac{\Sigma\ Xi}{L}\ ind/m^2$$

Notes:

Σ Xi: number of individual reef fish in point i (ind)

L: extent of coral reef area observed (m^2)

The water parameter data obtained include water turbidity and current at the location of study. Secondary data were acquired from other parties in the form of documents and data collected on the field, such as number of visits, geographical map, organization structure and program. Other data were collected from past studies that were conducted in the same location.

Suitability was determined by multiplying every acquired parameter. Tourism suitability was obtained by adding up all the specified parameters, for SCUBA diving tourism there are 6 pre-determined parameters, which are turbidity, coral reef cover, current, types of reef fish, number of coral life form, and depth of coral reef (Yulianda, 2007).

Table 2. SCUBA diving tourism suitability matrix

Parameters	Weigh	S1	Scor	S2	Scor	S3	Score	N	Score
Water turbidity(%)	5	>80	3	50-80	2	20-<50	1	<20	0
Coral cover (%)	5	>75	3	>50-75	2	25-50	1	<25	0
Number of life form	3	>12	3	>7-12	2	4-7	1	<4	0
Types of Reef fish	3	>100	3	>50-100	2	20-50	1	<20	0
Current speed (cm/s)	1	0-15	3	15-30	2	>30-50	1	>50	0
Depth of coral reef (m)	1	6-15	3	>15-20	2	>20-30	1	<3	0

Source: Yulianda (2007)

The suitability specifications for SCUBA diving activities are as follows:

Nmax : 54

S1 : Highly suitable, with TSI value >75-100 %

S2 : Fairly suitable, with TSI value of 50-75 %

S3 : Conditional compliance, with TSI value of 25-50 %

N : Unsuitable, with TSI value <25 %

Suitability for snorkeling tourism activities was determined by using 7 parameters and 4 assessment classifications (Table 3). According to Yulianda (2007), the parameters used for snorkeling tourism activities include, among others, coral reef cover, water turbidity, types of life form, current speed, types of reef fish, depth of coral reef, and extent of coral reef spread. The extent of coral spread was calculated by using spatial analysis method through ArcGis. Coral reef cover was calculated using Landsat 8.0 image interpretation and Lyzenga approach method.

Table 3. Snorkeling tourism suitability matrix

Parameters	Wei	S1	Score	S2	Score	S3	Scor	N	Score
Water turbidity (%)	5	100	3	80-<100	2	20-<80	1	<20	0
Coral cover (%)	5	>75	3	>50-75	2	25-50	1	<25	0
Number of life form	3	>12	3	>7-12	2	4-7	1	<4	0
Types of reef fish	3	>50	3	30-50	2	10-<30	1	<10	0
Current speed (cm/s)	1	0-15	3	>15-30	2	>30-50	1	>50	0
Coral depth (m)	1	1-3	3	>3-6	2	>6-10	1	>10	0
Extent of coral spread (m)	1	>500	3	>100-	2	20-100	1	<20	0

Source: Yulianda (2007).

The suitability specifications for snorkeling tourism activities are as follows:

Nmax : 57

S1 : Highly suitable, with TSI value >75-100 %

S2 : Fairly suitable, with TSI value of 50-75 %

S3 : Conditional compliance, with TSI value of 25-50 %

N : Unsuitable, with TSI value <25 %

According to Yulianda (2007), tourism activities that will be developed should be aligned with the existing natural resource and their intended purposes. The equation used to determine SCUBA diving and snorkeling tourism suitability is:

$$\mathbf{IKW} = \sum \left[\frac{\boldsymbol{Ni}}{\boldsymbol{Nmaks}} \right] \times \mathbf{100\ \%}$$

Notes:

IKW : Indeks Kesesuaian Wisata (Tourism Suitability Index)

Ni : Parameter value of i (Weight × Score)

Nmaks : Maximum score of the tourism category

Analysis on the carrying capacity for marine tourism development by making use of natural resource potentials in coastal areas, shores, and small islands. Calculating the usable environmental capacity requires a calculation method for ecotourism development, this is achieved by using the carrying capacity of tourism area (daya dukung kawasan – DDK) concept. According to Yulianda (2007), the equation applied to identify DDK is:

$$\boldsymbol{DDK = K \times \frac{Lp}{Lt} \times \frac{Wt}{Wp}}$$

Notes:

DDK : Carrying capacity of tourism area (person)

K : Ecological potential of visitors per area unit (person)

Lp : Span of usable area (meters)

Lt : Span of reachable area for every activity (meters)

Wt : Time for tourist activities carried out within a day in the area (hours)

Wp : Time spent by visitors for each tourist activity (hours)

Visitors' ecological potential is determined by the conditions of the resources and the types of tourism activities that will be developed (Table 4). The area of the ecotourism sites needs to be considered by taking into account nature's capacity in tolerating visitors presence so that environmental sustainability can be maintained. Visitors require ample space to move around while engaging in tourism activities like SCUBA diving and snorkeling so they can optimally enjoy the underwater beauty at the ecotourism sites, and as a consequence, time estimates for each tourism activity (i.e., SCUBA diving and snorkeling) are necessary.

Table 4. Ecological potential of visitors (K) and span of activity area (Lt) (Yulianda, 2007)

Type of Activity	∑ Visitors (person)	Area unit (Lt)	Annotations
Snorkeling	1	500 m2	1 person in area of 100 m x 5 m
SCUBA diving	2	2000 m2	2 persons in area of 200 m x 10 m

Table 5. Estimation of time required for each tourism activity (Yulianda, 2007)

Type of Activity	Required time (Wp) (hours)	Total time in 1 day (Wt) (hours)
Snorkeling	3	6
SCUBA diving	2	8

The Management capacity (MC) is the capacity of area management, which refers to the capacity of managers in the tourism area (Fandeli and Muhammad, 2019). This can be calculated using the following equation:

$$MC = \frac{Rn}{Rt} \times 100\%$$

Notes:

Rn: number of existing managers

Rt: number of managers required

Discussion

Assessment of the Environmental Aspect of Sustainable Tourism Development in Sintok and Cilik Islands

The first location of data collection was Sintok island. This island is located in the eastern part of Karimunjawa islands. According to the map from Esri, Digital Globe (2018) with a scale of 1:15,000 and Geo Eye satellite images (2017) that were subsequently processed using ArcGis 10.3 for area calculation, Sintok island was specified to have an area of 229,927.3 m^2.

Provided below are the results of an interview conducted with Sintok island's manager, Mr. Susanto. The average score for the environmental protection indicator is 3, which means fairly suitable category. However, based on the interview, it can be concluded that the managers/caretakers do not have a strategy for dealing with a surge in visitors. Accordingly, the score for the variable of manager/caretaker's strategy to cope with a surge in visitors during long holidays or weekends was 1 (unsuitable). The indicator with the best score was contamination with a score of 5, which means that Sintok island still remained clean without any contamination from air, noise, and water pollutions.

The total assessment score of the environmental aspects in sustainable tourism development in Sintok island is 23 with an average of 3. This indicates that the environmental aspect is considered to be fairly suitable with the indicators of sustainable tourism development. Responses given by the informants were subsequently converted into figures based on UNWTO's assessment table. The assessment result of Sintok island's environmental aspects is provided below:

Table 6. Assessment of Sintok Island's Environmental Aspects

Environmental Aspects		Assessment					
Indicators	Variables	1	2 (KS)	3 (AS)	4 (S)	5 (SS)	Score
Environmental Protection	Commitment of managers/caretakers to maintain Sintok island's sustainability				4		3
	Sustainable planning and management for developing Sintok island as a tourist destination			3			
	Managers/caretakers' strategy in dealing with rise in number of visitors during long holidays or weekends	1					
Water and energy consumption	Use of water and energy in Sintok island		2				2
Waste management	Waste management and waste materials		2				3
	Use of recycled goods			3			
Land change and attention to life cycle	Setting up zones in the tourism area			3			4
	Arrangement of land provided for visitors' parking				4		
Purchasing	Use of locally produced materials		2				2

Contamination	Air pollution					5	5
	Noise pollution					5	
	Water pollution					5	
Information on the environment	Education about environmental sustainability to visitors			3			4
	Training or information dissemination				4		
Total Score	23						
Average	3						

The second study location is Cilik island. This island is also located in the eastern part of Karimunjawa waters. In the distribution zones specified by the Karimunjawa National Park Office, this island is included in the marine tourism utilization zone. Based on the map of Esri, Digital Globe (2018) with a scale of 1:15,000 and Geo Eye satellite images (2017) that were subsequently processed using ArcGis 10.3 for area calculation, Cilik island was specified to have a total area of 28,506.7 m^2.

The assessment below is a summary of the results of an interview conducted with the manager/caretaker of Cilik island, Mr. Toha. Responses given by the informant were subsequently converted into figures based on UNWTO's assessment table. The total assessment score of the environmental aspects in sustainable tourism development in Cilik island is 24 with an average of 3. This indicates that the environmental aspect is considered to be fairly suitable with the indicators of sustainable tourism development. The assessment result of Cilik island's environmental aspects is provided in Table 7.

Table 7. Assessment of Cilik Island's Environmental Aspects

Environmental Aspects		Assessment					
Indicators	Variables	1(TS)	2(KS)	3(AS)	4(S)	5(SS)	Score
Environmental Protection	Commitment of managers/caretakers to maintain Cilik island's sustainability					5	4
	Sustainable planning and management for developing Cilik island as a tourist destination				4		

	Managers/caretakers' strategy in dealing with rise in number of visitors during long holidays or weekends		2				
Water and energy consumption	Use of water and energy in Cilik island			3			3
Waste management	Waste management and waste materials		2				3
	Use of recycled goods				4		
Land change and attention to life cycle	Setting up zones in the tourism area			3			4
	Arrangement of land provided for visitors' parking				4		
Purchasing	Use of locally produced materials	1					1
Contamination	Air pollution					5	5
	Noise pollution					5	
	Water pollution					5	
Information on the environment	Education about environmental sustainability to visitors				4		4
	Training or information dissemination				4		
Total Score	24						
Average	3						

In total, both islands' assessment scores for the environmental aspects in sustainable tourism development have an average of 3 and are categorized as fairly suitable. However, Qodriyatun (2018) states that tourism development in Karimunjawa cannot yet be considered sustainable. Although, economically speaking, the residents gain positive impact with the advent of job opportunities as well as an increase in their income. Issues relating to waste, clean water, destruction of coral reefs, and socio-cultural change have emerged as a result of tourism development in Karimunjawa.

Sustainable tourism development requires collaboration among stakeholders in the field of tourism. Five components that need to be given due attention include, among others: (1) preservation efforts to protect the environment; (2) community engagement; (3) use of local culture for education and entertainment; (4) positive assistance to local government; and (5) strict control to avoid negative impacts (Isdarmanto, 2017).

Assessment Parameters for SCUBA Diving and Snorkeling Tourism Suitability Index

The Tourism Suitability Index (TSI) for SCUBA diving was calculated by using 6 parameters, namely: water turbidity, percentage of coral cover, number of coral life form, types of reef fish, current speed, and depth for SCUBA diving at 10 meters. Moreover, the TSI for snorkeling specified a depth of 5 meters with an additional parameter, which is the extent of coral spread.

Results of the calculation are shown in Table 8 and Table 9.

Table 8. Calculation Results of SCUBA Diving TSI Parameters

Island	Research Sites	Parameters					
		Turbidity (%)	Coral Cover (%)	Number of Coral Life Form	Types of Reef Fish	Current Speed (cm/s)	Depth
Sintok	1	100	48,6	7	901	15	10
	2	100	51,6	8	228	25	10
	3	100	49,3	10	733	19	10
	4	100	43,2	8	249	25	10
Cilik	5	100	65	7	269	17	10
	6	100	61,4	7	679	5	10
	7	100	2,4	1	164	17	10
	8	100	71,4	8	309	3	10

Table 9. Calculation Results of Snorkeling TSI Parameters

Island	Research Sites	Parameters						
		Turbidity (%)	Coral Cover (%)	Number of Coral Life Form	Types of Reef Fish	Current Speed (cm/s)	Depth	Extent of Coral Spread (m)
Sintok	1	100	35	8	209	15	5	331
	2	100	53,4	8	806	25	5	236
	3	100	53,2	6	278	19	5	243
	4	100	86,2	8	702	25	5	169
Cilik	5	100	63,6	8	802	17	5	157
	6	100	56,2	6	321	5	5	69
	7	100	31	4	297	17	5	110
	8	100	83,6	7	702	3	5	80

According to Yulianda's (2007) TSI assessment a turbidity of 100% is categorized as highly suitable. Water turbidity is essential in SCUBA diving and snorkeling tourism because good visibility allows visitors to clearly see coral reefs and fish. The greater the coral reef cover, the greater the tourism potential. Supriharyono (2007) adds that coral reefs have extraordinary esthetic value making them the main feature of marine tourism that visitors can enjoy.

In addition to coral cover, the number of coral life form is also a significant part of SCUBA diving and snorkeling tourism. Plathong *et al*. (2000) state that the different types of coral life form are variations that visitors can enjoy underwater. Reef fish is one of the biota with high level of species diversity, and they exist in close association with coral reefs.

The current speed for both islands was calculated at around 3 to 25 cm/s. Juliana *et al*. (2013) argues that the current speed feasible for SCUBA diving and snorkeling tourism is between 15 and 40 cm/s. Current is a limiting factor in terms of SCUBA diving tourism suitability as it affects diver's movement to keep their balance (Wijaya *et al*., 2017).

The selected depth for snorkeling is 5 meters, while for SCUBA diving is 10 meters. Rudianto *et al*. (2020) add that the shallower the water depth for snorkeling, the more preferred it is because the visible objects are much closer and clearer. A depth of 10 meters is also suitable for a One Star (A1) beginner diver level. The maximum depth for divers capable of diving in limited environment with good, clear water conditions is 30 feet or 10 meters (Coremap Indonesia, 2020).

A distinct additional parameter for snorkeling tourism is the extent of coral spread. The more extensive the coral spread, the bigger the area for snorkeling. However, water depth is a point that should be considered because there are varying depths found in the coral reef covered areas in both islands.

SCUBA Diving and Snorkeling Tourism Suitability Index Assessment

TSI scores were calculated after identifying the values of each specified parameter (Table 8 and 9). These values are inserted in the assessment matrix for SCUBA diving (Table 2) and snorkeling (Table 3). Ultimately, the TSI scores were obtained by using the TSI equation (Yulianda, 2007).

Table 10. Calculation of SCUBA Diving TSI Scores for Sintok and Cilik Islands

Sites	Parameters												TSI Score (%)	Category
	Turbidity (%)		Coral Cover (%)		Number of Coral Life Form		Types of Reef Fish		Current Speed (cm/s)		Depth			
	W	S	W	S	W	S	W	S	W	S	W	S		
1	5	3	5	1	3	1	3	3	1	3	1	3	70,4	S2
2	5	3	5	2	3	2	3	3	1	2	1	3	83,3	S1
3	5	3	5	1	3	2	3	3	1	2	1	3	74,1	S2
4	5	3	5	1	3	2	3	3	1	2	1	3	68,5	S2
5	5	3	5	2	3	1	3	3	1	2	1	3	77,8	S1
6	5	3	5	2	3	1	3	3	1	3	1	3	79,6	S1
7	5	3	5	0	3	0	3	3	1	2	1	3	53,7	S2
8	5	3	5	2	3	2	3	3	1	3	1	3	85,2	S1

Table 11. Calculation of Snorkeling TSI Scores for Sintok and Cilik Islands

Sites	Parameters														TSI	Category
	Turbidity (%)		Cora (%)		Number of Coral Life Form		Types of Reef Fish		Current Speed (cm/s)		Depth		Extent of Coral Spread			
	W	S	W	S	W	S	W	S	W	S	W	S	W	S		
1	5	3	5	1	3	2	3	3	1	2	1	2	1	1	73,7	S2
2	5	3	5	2	3	2	3	3	1	2	1	2	1	2	80,7	S1
3	5	3	5	2	3	1	3	3	1	2	1	2	1	2	75,4	S1
4	5	3	5	3	3	2	3	3	1	2	1	2	1	2	89,5	S1
5	5	3	5	2	3	2	3	3	1	2	1	2	1	2	80,7	S1
6	5	3	5	2	3	2	3	3	1	2	1	2	1	1	78,9	S1
7	5	3	5	1	3	1	3	3	1	2	1	2	1	2	66,7	S2
8	5	3	5	3	3	2	3	3	1	3	1	2	1	1	89,5	S1

Notes:

W : Weight
S : Score
S1 : Highly Suitable
S2 : Fairly Suitable

The SCUBA diving TSI scores categorized as highly suitable (S1) for both islands were obtained at sites 2, 5, 6, and 8. Meanwhile sites categorized as fairly suitable (S2) are 1, 3, 4, and 7.

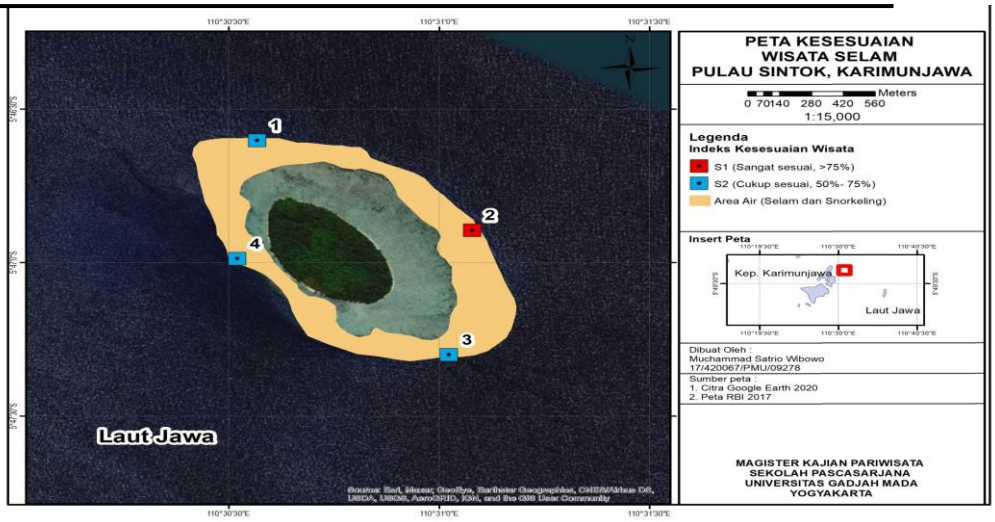

Figure 1. Sintok Island SCUBA Diving Tourism Suitability Map

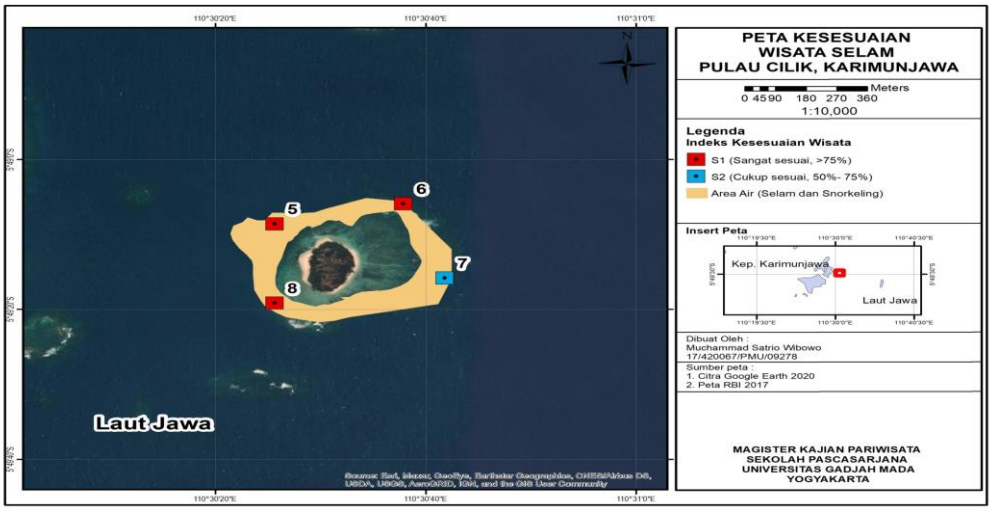

Figure 2. Cilik Island SCUBA Diving Tourism Suitability Map

As for snorkeling tourism in both islands, the sites categorized as highly suitable (S1) are sites 2, 3, 4, 5, 6, and 8. While those categorized as fairly suitable (S2) are sites 1 and 7.

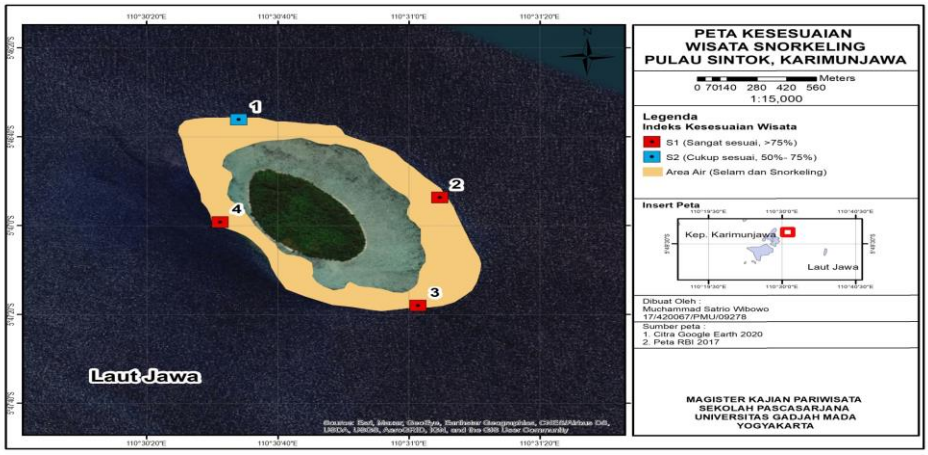

Figure 3. Sintok Island Snorkeling Tourism Suitability Map

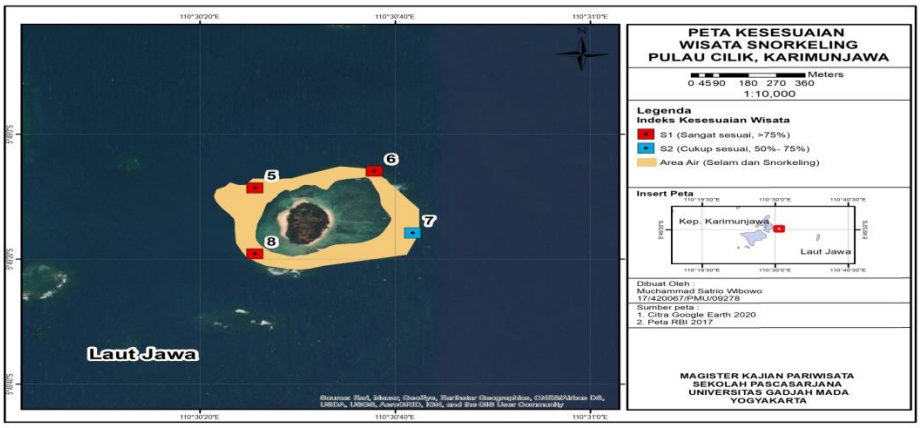

Figure 4. Cilik Island Snorkeling Tourism Suitability Map

Wijaya *et al*. (2015) add that the highly suitable (S1) TSI score in the suitability categories means that there is no limiting factor for a particular use. In other words, there are only insignificant limiting factors. The fairly suitable (S2) category means that there are reasonable limiting factors for conducting tourism activities. These limiting factors will influence the productivity of tourism activities. Given the results above, both islands have met the requirements to be considered one of the SCUBA diving and snorkeling tourist destinations in Karimunjawa islands.

Carrying Capacity of SCUBA Diving and Snorkeling Tourism Sites

The tourism area carrying capacity (Daya Dukung Kawasan – DDK) was calculated using an equation developed by Yulianda (2007). Some of the notations required include ecological potentials (Table 4), usable land area, required area unit (Table 4), required time (Table 5), and time allocation in a day (4). The areas of the coral reefs were calculated using spatial analysis method, interpretation of Landsat 8.0 images, and the Lyzenga approach. The area of coral reefs in Sintok island is 601,403 m^2 while Cilik island is 127,442 m^2. Based on these data and calculations, the SCUBA diving and snorkeling tourism carrying capacity of Sintok island is 2,406 persons/day, while Cilik island is 510 persons/day.

Identifying a tourism area's carrying capacity is paramount to ensure that the number of visitors do not exceed the threshold of the existing environmental resources. Sustainable tourism development and tourism area's carrying capacity are difficult to keep apart since carrying capacity functions as

one of the principles of sustainable tourism development (Sunarta and Arida, 2017). The coral reef environment should be utilized evenly so that all coral reef areas are enjoyed for SCUBA diving or snorkeling for the purpose of avoiding significant mass of visitors. This is supported by Fandeli and Muhammad's (2019) statement that carrying capacity also correlates with the number of visiting tourists, so that the quality of visitor's comfort and satisfaction can be ensured. Limiting the number of visitors can be part of smart measures taken to achieve balance between development and the environment. This is most crucial for a tourist destination to be able to economically survive for a long period of time (Mohan *et al*., 2007 as cited in Marsiglio, 2017).

Management Capacity

The management capacity scores for Sintok and Cilik islands are 100%. This implies that managers/caretakers are able to serve tourists well. The manager/caretaker's tasks become easier in terms of monitoring visitors due to the assistance provided by local guides while accompanying the visitors. According to the regulation, every group of 10 visitors is to be supervised by 1 local guide. Collaboration between managers/caretakers and local guides has resulted in visitors being provided proper services, and ultimately leaving them feeling satisfied when engaging in various activities in both Sintok and Cilik islands.

Conclusion

The assessment of the environmental aspects for sustainable tourism development in Sintok and Cilik islands has yielded an average score of 3. This means that the environmental aspects are categorized as fairly suitable with sustainable tourism development. The SCUBA diving and snorkeling TSI scores are categorized as highly suitable (S1) and fairly suitable (S2), which implies that they have met the requirements to be one of the SCUBA diving and snorkeling destinations in Karimunjawa islands.

The tourism area's carrying capacity (DDK) for SCUBA diving and snorkeling tourism in Sintok island is 2,406 persons/day, while in Cilik island it is 510 persons/day. Once the tourist destination development process is complete, the number of visitors is expected not to exceed the specified carrying capacity. By doing so, tourist arrivals will not cause significant damage to the ecosystem since the threshold indicating a disruption of the natural balance has been identified.

Unfortunately, in this study, there is no official data on visitors to the island of Sintok and Cilik island. This is due to the lack of popularity of the diving area. Tourists who visit the diving areas of Sintok and Cilik islands are tourists who really know Karimunjawa's tourist destinations. So that in further research it is necessary to identify ways to attract tourists to be able to explore and enjoy the beautiful coral reefs in the diving area of these two islands.

References

English, S., Wilkinson, C., and Baker, V. (1994). Survey Manual for Tropical Marine Resources. Australian Institute of Marine Seciences, Townsville: Australia.

Fandeli, C. and Muhammad. (2019). Analisis Daya Dukung Lingkungan Dalam Perpektif Pembangunan Berkelanjutan. Direktorat Jenderal Konservasi Sumber Daya Alam dan Ekosistem: Jakarta.

Goeldner, C.R., and Ricthie, J.R.B. (2009). Tourism: Principles, Practice, Philosophie. Edisi XI. John Wiley & Sons Inc: New Jersey

Hikmawati, F. (2018). Metodologi Penelitian. Rajawali Pers: Depok.

Isdarmanto. (2017). Dasar-dasar Kepariwisataan dan Pengelolaan Destinasi Pariwisata. Penerbit Gerbang Media Aksara: Yogyakarta.

Indrayanti, E., et.al. (2019). Larval Dispersal Model of Coral Acropora in the Kariumnjawa Waters, Indonesia. *Biodiversitas Journal.* 20 (7), 2068-2075.

Juliana, Sya'rani, L., and Zainuri, M. (2013). Kesesuaian dan Daya Dukung Wisata Bahari di Perairan Bandengan Kabupaten Jepara, *Jawa Tengah. Jurnal Perikanan dan Kelautan Tropis.* 9 (1), 1-7.

Marsiglio, S. (2017). On The Carrying Capacity and The Optimal Number of Visitors in Tourism Destinations. *Tourism Economics*. 23 (3), 632-646.

Nikijuluw, Victor P.H., Papilaya, Renoldy, L., and Boli, P. (2017). Daya Dukung Pariwisata Berkelanjutan Raja Ampat.

Odum, E.P. (1993). Dasar-dasar Ekologi. Tjahjono Samingan, Penerjemah; Yogyakarta: Ed ke-3. Universitas Gadjah Mada. Terjemahan dari: Fundamental of Ecology

Plathong, S., Inglis G.J., Huber M. (2000). Effects of Self-Guide Snorkeling Trails on Corals in a Tropical Marine Park. *Journal Conservation Biology*, 14 (6), 1821-1830.

Qodriyatun, S.N. (2018). Implementasi Kebijakan Pengembangan Pariwisata Berkelanjutan di Karimunjawa. Aspirasi: *Jurnal Masalah-masalah Sosial.* 9, (2). Pusat Penelitian Badan Keahlian DPR RI: Jakarta.

Rudianto, A., Dewi, YSK., Burhanuddin. (2020). Ecotourism Development of Snorkeling and Diving Activity Toward Coral Reef Habitats in The Lemukutan Island of Bengkayang Regency. Aquasains, Jurnal Ilmu Perikanan dan Sumberdaya Perairan. 8 (2).

Supriharyono, (2007). Pengelolaan Ekosistem Terumbu Karang. Djambatan. Jakarta. 129 pp.

Sulisyati, R. (2016). Daya Dukung Ekosistem Terumbu Karang Untuk Kesesuaian Wisata Bahari di Taman Nasional Karimunjawa. Unpublished Dissertation. Universitas Gadjah Mada: Yogyakarta.

Wijaya, D.N., Suryanti, and Supriharyono. (2015). Kesesuaian Ekosistem Terumbu Karang Untuk Kegiatan Wisata Bahari Kategori Selam di Pulau Kayu Angin Genteng, Kepulauan Seribu. *Diponegoro Journal of Maquares.* 4 (4), 109-118.

Wijaya, P., et.al. (2017). Suitability Analysis For Scuba Diving to Develop Marine Tourism at Saebus Island, East Java, Indonesia. *ICENIS Journal.* 5 pages.

Yulianda, F. (2007). Ekowisata Bahari Sebagai Alternatif Pemanfaatan Sumberdaya Pesisir Berbasis Konservasi. Seminar Sains Departemen Manajemen Sumberdaya Perairan. Fakultas Perikanan dan Ilmu Kelautan. IPB Bogor.

Yusuf, M. (2013). Kondisi Terumbu Karang Dan Potensi Ikan di Perairan Taman Nasional Karimunjawa, Kabupaten Jepara. *Buletin Oseanografi Marina.* 2 (2), 54-60.