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Coral Reef Zone Analysis in Development of Segmentation Ecotourism in Karimunjawa National Park

Aramita Livia Ardis[1*], Mega Laksmini Syamsudin[1], Herman Hamdani[1] and Lantun Paradhita Dewanti[1]

[1]Faculty of Fisheries and Marine Science, University of Padjadjaran, P.O.Box 45363, Jatinangor, Indonesia.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Karimunjawa is one of the main destinations that present underwater beauty that is quite popular. But due to increased tourism activities provide economic benefits but also have a negative impact on coral reef ecosystems so that prudent and sustainable management is needed, these characteristics are felt capable of being helped by remote sensing technology. The purpose of this research is to analyze the coral reef zoning for the development of ecotourism segmentation and the carrying capacity of coral reef ecosystems and to map the condition of coral reef ecosystems in the Karimunjawa National Park area through remote sensing technology. The method used in data collection uses a survey method which is divided into 2 types in-situ conducted on 19th April 2019 to 2nd May 2019 and ex-situ taken for 4 years for coral cover and 1 year for sea surface temperature. By using quantitative descriptive analysis, land suitability results are obtained based on the land suitability index approach and the percentage of coral cover in determining the mapping of ecotourism segmentation areas. The results of this research show that through in-situ

**Corresponding author: Email: aramital18@gmail.com;*

approach, data collection in three stations on Sintok and Menjangan Kecil Islands has good coral cover while Cemara Besar is damaged. The appropriate Tourism Conformity Index value is on Menjangan Kecil Island while the other two stations are not so that the carrying capacity calculation is only done on the appropriate and very appropriate island. Inversely proportional through the analysis of the Scenic Beauty Estimation value, Cemara Besar Island which shows a high value while on the Menjangan Kecil Island the lowest. Spatial analysis shows that the fluctuation in sea surface temperature during one year is not too significant and is still limited to the optimum temperature range for coral growth so that it does not affect the conditions causing damage to coral reefs, called bleaching. Looking at the distribution of coral reefs via satellite, over the past 4 years shows an increase in dead coral cover leaving 6,752,802 m^2 in 2019.

Keywords: Cemara Besar; island; map; Menjangan Kecil; tourism; sea; Sintok.

1. INTRODUCTION

Coral reefs are shallow-water ecosystems that consist of reefs made of calcium carbonate which is mostly secreted by reef-building corals and encrusting macroalgae. They occupy less than 0.1% of the ocean floor yet play multiple important roles throughout the tropics, housing high levels of biological diversity as well as providing key ecosystem goods and services such as habitat for fisheries, coastal protection, and appealing environments for tourism [1,2]. The form of coral growth is also strongly influenced by environmental conditions. Corals will respond to the forms of environmental stress they receive. Coral reefs are very sensitive to environmental influences, both physical in nature (dynamics of the sea and coastal waters), damage due to human activities, chemical pollution and damage due to biological activities [3,4].

Karimunjawa becomes one of the main destinations that present underwater beauty that is quite popular. With the development of the era of population growth and increased development on the Karimunjawa Islands, have positive and negative implications. Increased tourism activities provide economic benefits but also have a negative impact on coral reef ecosystems [5,6]. Some tourist behaviours have the potential to damage coral reefs such as kicking corals, holding corals, walking on corals, and anchoring anchors on corals. Snorkelling and diving tourism has a number of physical and ecological limitations/vulnerabilities with relatively limited location, so it needs to be considered in the suitability and carrying capacity of the environment for tourism development.

According to Irawan [7], these characteristics require the use of technology that is able to overcome these problems. Remote sensing technology is considered capable of being used as a tool for mapping the area of coral reef areas. The mapping obtained is expected to be a zone quality standard for tourists who will dive or snorkelling in certain zone areas.

Based on UU Number 1 of 2014 concerning Management of Coastal Areas and Small Islands, wise and sustainable management is needed so that it can be utilized as well as possible and stated in Article 1 Number 14 that talks about zoning management plans in determining spatial structures and patterns in conducting management plan referred to in Article 1 Number 15.

Based on this, further review is needed on the impact of tourism in snorkelling and diving activities on coral reefs through the extent of coral reef area cover to see the extent to which these activities have an influence on the coral reef ecosystem in Karimunjawa with remote sensing technology.

2. METHODOLOGY

2.1 Location and Time of Research

To collect data, two sets of data taken were conducted consisting of 2 types, namely: (1) Primary data collection in the Karimunjawa Marine Park-Conservation Area by in-situ includes observing physical parameters that affect the condition of coral reefs and distribution of coral cover as well as conducted in May 2019 and conducted a questionnaire to several tourists, (2) Secondary data by downloading of coral cover imagery from Landsat 8 satellite and distribution of sea surface temperature from Aqua MODIS satellite on June 2019. Geographically Karimunjawa Islands are located at the coordinate of 5°40' – 5°57 S dan 110°4' – 110°40 E (Fig. 1).

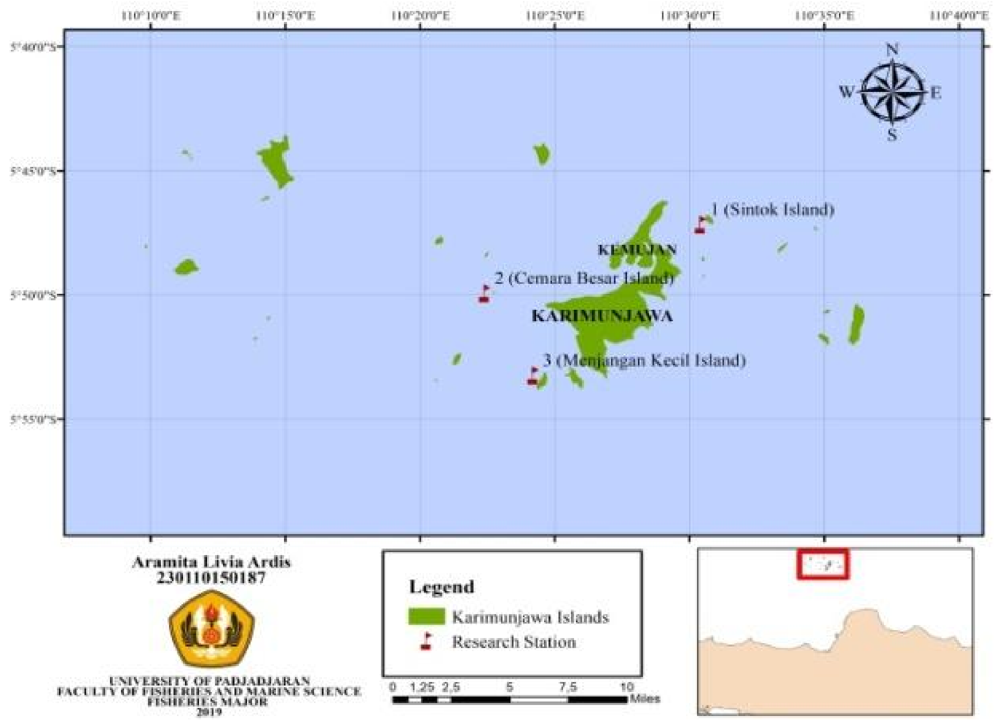

Fig. 1. Research location

2.2 Data Collection Methods

In-situ data collection was carried out using a survey method conducted in May 2019 by taking samples and went to the field to collect coral cover distribution data using the LIT (Line Intercept Transect) method once for each station without replication using a rolling meter along 50 meters and using SCUBA equipment sets, and each point was carried out at a depth of 10 meters [8] along with physical tests of water such as surface water temperature, visibility, current speed, and salinity. Ex-situ data retrieval is done by taking secondary data that has been downloaded through NASA's official website regarding coral cover image with a resolution of 30-meter data obtained using Landsat 8 Satellite. The other dependent variables such as SST image data. Whereas the SST image was obtained from the Aqua MODIS lvl 3 satellite with a resolution of 4 km.

Other primary data taken is the implementation of SBE data with an approach in which 20 respondents will be given an online questionnaire against the data that has been taken then the respondent will give a score on a scale of 1-10. The criteria of the participants are must have a SCUBA licence at least Open Water level and more than that. The data collection procedure diagram that was carried out during the preparation of the report in this research is shown in Fig. 2.

In processing satellite images using two software, first the software used for the satellite image correction process are SeaDAS and ErMapper 7.1, the classification of substrate waters until a coral reef is obtained. The second software is ArcGIS 10.3, a software used to display image data that has been processed in the form of maps, making it easy for users to understand (Fig. 3).

2.3 Measuring Parameters

2.3.1 Percentage of coral cover

The per cent data of live coral cover was obtained based on the Line Intersect Transect (LIT) method. The condition of coral cover that was obtained then categorized based on Gomez & Yap [9] in Table 1, namely:

$$\text{Li} = \frac{ni}{L}\, x\ 100\%$$

Information:

Li: Percentage of coral cover
ni: Total length of the i-th group of coral cover
L: The total length of the line transect

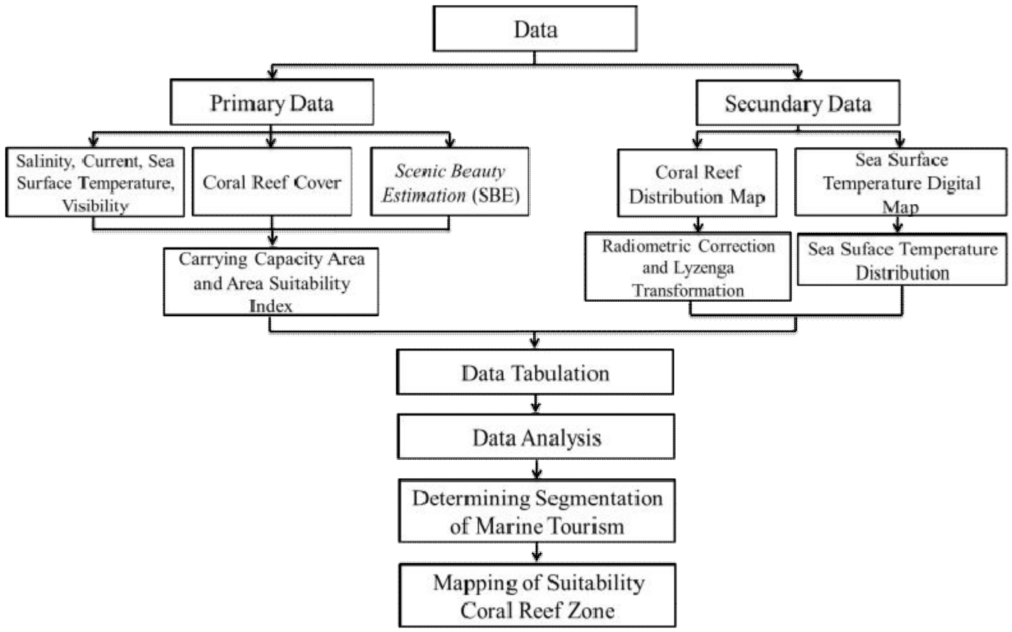

Fig. 2. Flowchart of research procedure

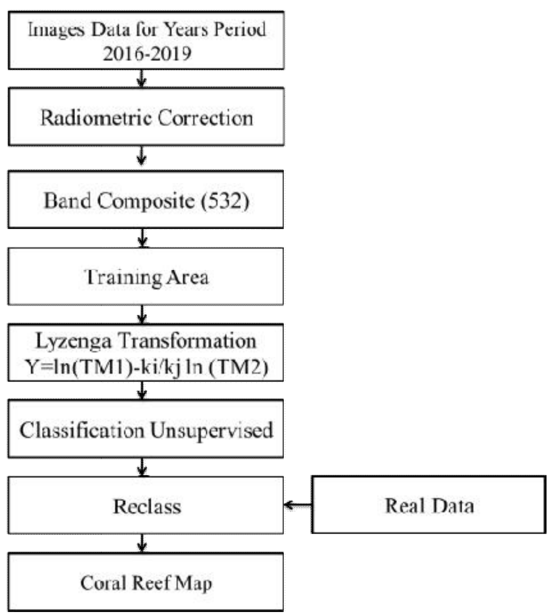

Fig. 3. Flowchart of secondary data processing procedure

Table 1. Percentage categories of coral reef cover

Percentage	Condition
75-100%	Very good
50-74,9%	Good
25-49,9%	Average
0-24,9%	Damaged

2.3.2 The suitability of marine tourism utilization matrix

According to Lumbantoruan [10], there is an index in determining the suitability of utilization for Snorkeling/diving tourism formulated as follows:

$$\text{TSI} = \sum_{i=1}^{n} \left(\frac{Ni}{Nmaks}\right) x100\%$$

Information:

ASI: Area Suitability Index
Ni: i-th parameter value (Weight x Score)
Nmax: The maximum value of area category

Provisions for the suitability class of Snorkeling/diving tourism activities are as follows (Table 2).

2.3.3 Regional carrying capacity (DDK)

According to Yulianda (2007), the concept of carrying capacity of ecotourism considers two things, namely (1) the ability of nature to tolerate disturbances or pressures from humans or natural conditions, and (2) the standard of the authenticity of natural resources.

$$CCA = K\ x \left(\frac{Ap}{At}\right) x \left(\frac{Tt}{Tp}\right)$$

Information:

CCA: Carrying capacity of tourist areas (people/day)
K: Ecological potential of visitors per unit area
Ap: Area or length of the area that can be utilized
At: a Unit area for certain categories
Tt: Time provided by the region for tourism activities in one day
Tp: Time spent by visitors for each particular activity.

2.3.4 Scenic Beauty Estimation (SBE)

According to Hadi (2001) to determine the visual value of the development of marine tourism that is using the Scenic Beauty Estimation (SBE) method. The SBE formula was formulated by Daniel and Boster [11] as follows:

SBEx = (Zx-Zo) x 100

Information:

SBEx: Estimator value of the beauty of the x-landscape
Zx: Average value of z for the x-th landscape
Zo: The average value of a particular landscape as a standard

The distribution of SBE valuation is then classified into three parts, namely high, medium and low SBE values.

2.3.5 Lyzenga transformation

Image processing was also carried out to determine the distribution of coral reefs at the study site by Lyzenga Algorithm method. The Lyzenga Algorithm calculation process includes [12]:

a) Finding the *variance* and *covariance* values of each band to get the attenuation coefficient

$$a_{12} = \frac{variance_1 - variance_2}{2\ x\ covariance_2}$$

b) Find the value of the attenuation coefficient with the formula:

$$:\frac{ki}{kj} = a + \sqrt{a^2 + 1}$$

c) Finding the value of a new image with the Lyzenga equation:

$$\text{Y} = \ln a1 + \frac{ki}{kj} \ln a2$$

Information:

ki / kj is the ratio between the attenuation of the i-th band ormos-j.

2.4 Data Analysis

Quantitative descriptive analysis is done by looking at areas suitable for marine ecotourism areas based on the results of the analysis of the measuring parameters. This is done by calculating the suitability of the area and the value of coral cover compared to the total area of cover as well as supported by the analysis of the Scenic Beauty Estimation value. The calculation of the dependent variables are then analyzed and the data collected has been entered into the segmentation region suitability matrix which is seen from the suitable and very suitable area for suitability category, good and very good for coral cover and literature studies that will be developed into the map in segmentation zoning area. The carrying capacity area approach is the maximum number of visitors that can be physically accommodated in the area provided at a certain time without causing disturbance to nature and humans in the suitable and very suitable area for suitability category.

Table 2. Conformity category marine tourism activities

Class	Information
S1	Very suitable, with IKW value 83 – 100 %
S2	Suitable, with IKW value 50 - < 83 %
S3	Not suitable, with IKW value < 50%

Source: Lumbantoruan (2017)

3. RESULTS AND DISCUSSION

3.1 Oceanographic Conditions

3.1.1 *In-situ* physical parameters

Physical parameters examined at each station include Sea Surface Temperature, Visibility, Salinity, and Current.

The results of the water parameters at the three stations (Table 3) show that the water temperature ranges from 28.9 to 29.9^{0}C. This is consistent with the statement of Nybakken [13], that the optimal temperature for coral growth is 23-30^{0}C, especially for shallow reefs which have the potential to increase in temperature which can cause coral death. The minimum temperature limit for coral growth is 18^{0}C and even coral animals can still live up to 15^{0}C, but there will be a decrease in growth, reproduction, metabolism and productivity of calcium carbonate. So that the temperatures at the three research stations can still be tolerated because they are still vulnerable to optimal temperatures for coral growth.

The salinity of the waters at the three stations during the observation ranged from 28.9 to 30‰. Salinity is classified below the optimal standard of optimal salinity for coral growth because according to Dahuri [4], optimal salinity ranges from 30-35‰ but not too far from the optimum salinity limit. Current at the three stations ranges from 12.2-14.7 cm/s. The current can clean polyps from dirt that clings or enters into it [13]. The visibility of the waters at the study site is around 4-21 meters. The intensity of the incoming light at stations 2 and 3 are still in good condition, different at station 1 which is quite turbid due to the data retrieval in a small rain condition which gives the effect of sedimentation on the seabed.

3.1.2 Distribution of Sea Surface Temperature (SST)

Observation of the maximum value in each month is carried out to determine the maximum limit that occurs if the sea surface temperature rise is far above the optimum temperature range for the life of a coral reef. Through analysis of satellite imagery in identifying the distribution of Sea Surface Temperature (SST) in the Karimunjawa Islands, it can find fluctuations in changes in Sea Surface Temperature every month in last year. Fluctuations in changes in sea surface temperature from June 2018 to May 2019 have an impact on coral reefs health (Fig. 3).

Fluctuation sea surface temperature of the three stations in a period of 1 year, from June 2018 to May 2019 (Fig. 3) shows a graph of the maximum SPL value per month at each station. The highest temperature occurred in December 2018 in the waters of Menjangan Kecil Island at 32.14^{0}C and the lowest temperature occurred on August 2018 in the waters of Cemara Besar Island at 28.44^{0}C. The temperature in May 2018 until November 2018 still shows below 30^{0}C while from December 2018 to May 2019 the average is above 30^{0}C.

Table 3. Observation stations water parameters on May 2019 in Karimunjawa Islands

Location		SST (^{0}C)	Visibility (meter)	Salinity (ppt)	Currents (cm/s)
Station	Island				
1	Sintok 110^{0}31'21" E; 5^{0}50'06" S	28,9	4	28,9	9,5
2	Cemara Besar 110^{0}22'05" E; 5^{0}48'34" S	28,9	22	29	12,2
3	Menjangan 110^{0}24'29" E; 5^{0}53'10" S	29,9	21	30	14,4
Standard Optimized		23-30 ^{0}C [13]	> 5 meter (KEPMEN LH 2004)	32 – 35 $^O/_{OO}$ [13]	< 20 cm/s (Haruddin 2011)

Fluctuations in the graph are caused by differences in seasonal influences. Rising sea surface temperatures and air temperatures also affect marine organisms. If the condition of coral reefs has been degraded by human and natural factors, it is feared that the zone will become a dead zone or a zone where marine life can no longer play a role. Sea surface temperature is a concern because an increase of 1^0C surface temperature from the optimum temperature susceptibility will cause corals to experience bleaching [14-16].

According to Putra's research [17], the SPL movement pattern in the Karimunjawa Islands follows the wind season pattern occurring in the Java Sea, namely the west, east and transition seasons. SPL Java Sea spatially in time series can be seen in Figs. 4-7 with the temperature value represented by blue to red which is a sign for warm to highest temperatures in the sea of the Karimunjawa Islands.

Monsoon wind motions cause variations in the surface temperature of the Java Sea, in the east monsoon it is seen that warm sea surface temperatures are in the east and higher in the west are marked with a more dominant red in the east than in the west which is dominated by blue (Fig. 4), this is because, during the southeast monsoon period (east monsoon), winds, and currents in the Java Sea move from east to west carrying relatively cooler masses of water coming west. This can be caused by the pressure centre in the East is higher than in the West. According to Fadika [18] East season sea surface temperature values tend to decrease compared to the West season and Transition season I.

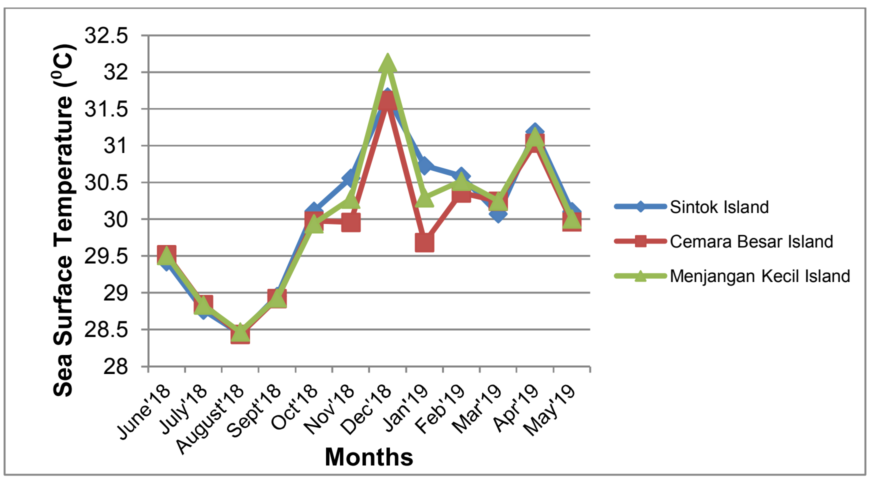

Fig. 3. Fluctuations in Sea Surface Temperature (SST) change at 3 site stations in Karimunjawa Islands from June 2018 to May 2019

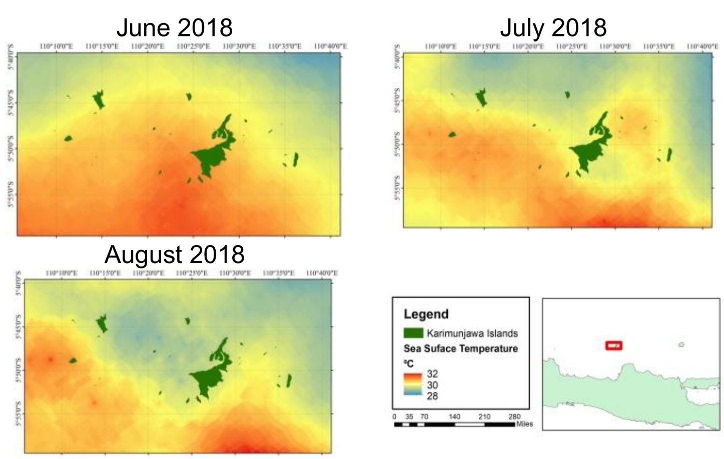

Fig. 4. Distribution of SST in the East Season in Karimunjawa Islands

After the east monsoon, there is a transition season II which becomes the transition of the east monsoon to the west monsoon. In the transition season II an increase in temperature but more homogeneous. Marked by the widespread blue on the map (Fig. 5).

In climatology, the highest sea surface temperature values occur during the west and transition season I while the lowest values occur during the east and transition season II. In this season entering the Second Transition season, the dominant wind blows from the Southeast. In this season, there is a remnant from the East season, which is a wind that moves from the east, marked by the widening of the red indicator on the map (Fig. 5), which is more dominant in the southeast and south. As for the effect of currents on temperature, in this season the pattern of movement of currents moving towards the Northeast carries the mass of water that has a lower temperature towards the Northeast. In this season is still affected by the East season, water needs time to release heat. After the transition season II, there is a West monsoon which show the east monsoon truly end (Fig. 6).

Transition of the transition season II to the West Season shows the entry of low value SSTs from the South China Sea through the Java Sea to the Makassar Strait and the Flores Sea (Fig. 6), shown by the warmer water masses of the northeast due to winds blowing from the South China Sea towards Australia. In December to February, the temperature decreases again which is the influence of the northwest monsoon which causes the mass water of the South China Sea with lower temperatures to mix and push the Java Sea water mass from west to east [10]. In the West season surface currents move towards the East. Whereas the distribution of sea surface temperature in this season is lower water mass in southern waters.

During the Transition I season (Fig. 7), there is no correlation between the distribution of sea surface temperature and the direction of motion of surface currents. Transitional Season I sea surface temperature values tend to be higher than during the Western monsoon. This season has a red distribution because it still carries winds from the western monsoon which is dominated by high temperatures despite experiencing temperatures.

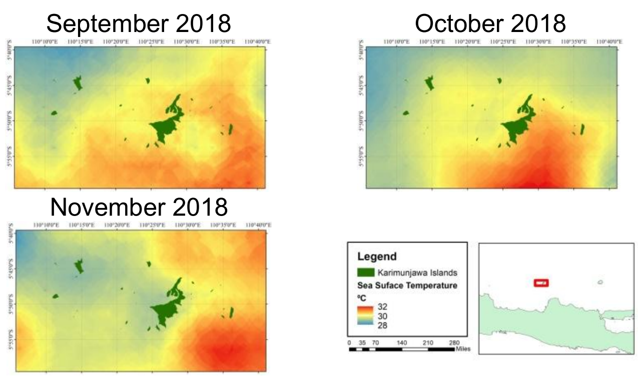

Fig. 5. Distribution of SST in transition season II in Karimunjawa Islands

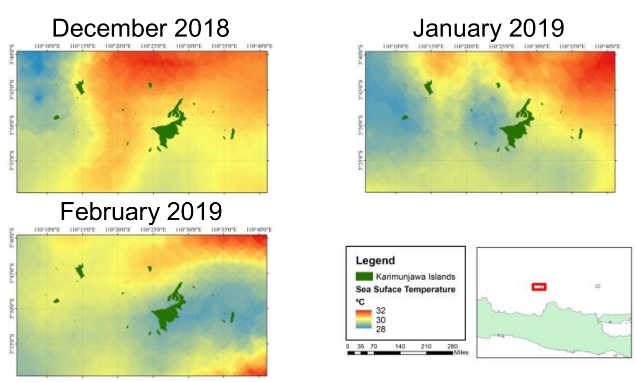

Fig. 6. Distribution of SST in the Western season in Karimunjawa Islands

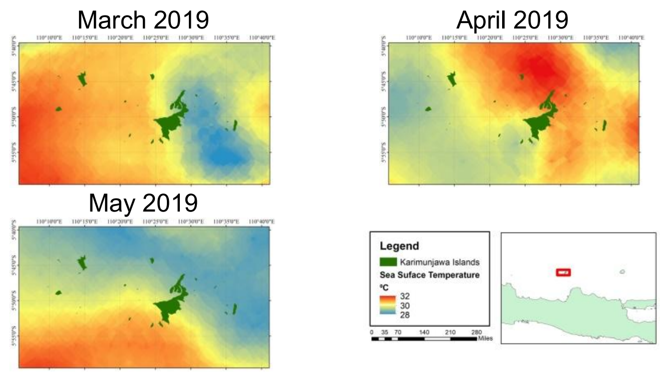

Fig. 7. Distribution of SST in transition season I in Karimunjawa Islands

Fluctuations in sea surface temperature changes in the 1 year period from June 2018 to May 2019 indicate that the maximum temperature that occurred did not have an impact on coral bleaching because it was still within the optimum temperature range for coral growth. In contrast to the mid-2015 case studies between 2016 and 2016, there was an *El Nino* event that led to rising sea surface temperatures centred in the Pacific Ocean, so that water temperatures in Indonesia became warmer. This resulted in the whitening of corals at most of the observatory locations in Karimunjawa National Park (Pardede et al. 2016).

3.2 Condition of Coral Reefs

3.2.1 Distribution and condition of coral cover in Sintok Island, Cemara Besar Island and Menjangan Kecil Island

The results of the study on Sintok Island taken along 50 m, using the LIT method with coordinates 110°31'21" E and 5°50'06" S, stated that the percentage of live coral cover was 50.82%, while the percentage of dead coral cover was 31.72%. The percentage of live coral consists of 9.4% of the genus Acropora and 41.42% Non-Acropora (Fig. 8).

The results of the LIT method study on the Cemara Besar Island taken along 50 m with coordinates 110°22'05" E and 5°48'34" S, stated that the percentage of live coral cover was 21.2%, while the percentage of dead coral cover was 3%. The percentage of live coral consists of 0.8% of the genus Acropora and 20.4% Non-Acropora (Fig. 9). The island is an observation station that is classified as damaged and dominated by Abiotic by 73.8% of which 51% is coral fragments.

The results of the LIT method study on the Menjangan Kecil Island taken along 50 m with coordinates 110°24'29" E and 5°53'10" S, stated that the percentage of live coral cover was 73.8%, while the percentage of dead coral cover was 15.2% (Fig. 10). The station has a category of good coral cover perhaps the best among 3 stations that observed almost ¾ is live coral cover.

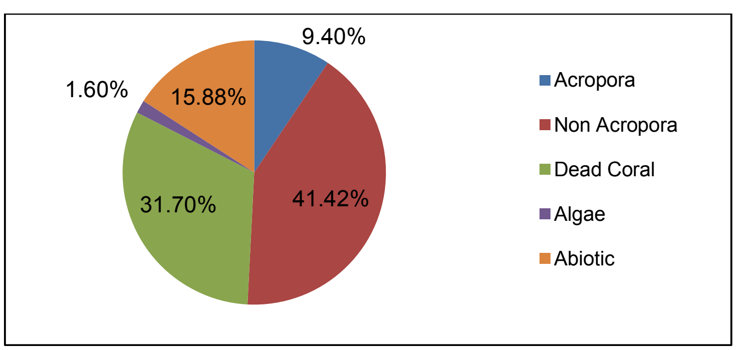

Fig. 8. Coral cover of Sintok Island In Karimunjawa Islands on May 2019

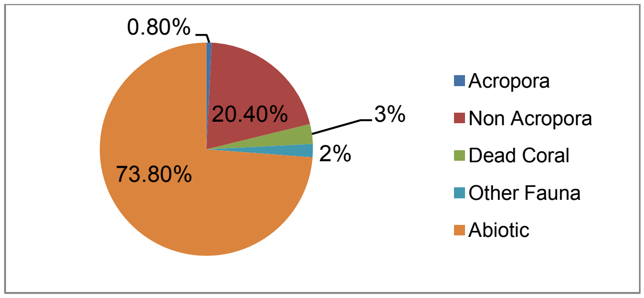

Fig. 9. Coral cover of Pulau Cemara Besar In Karimunjawa Islands on May 2019

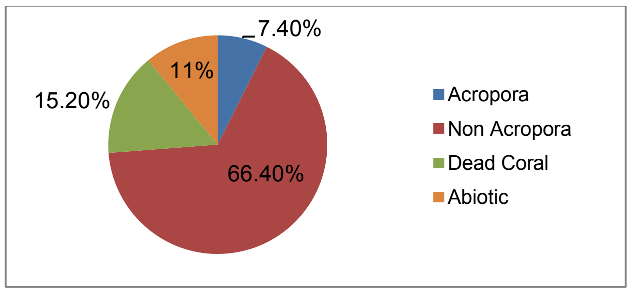

Fig. 10. Coral cover of the Menjangan Kecil Island In Karimunjawa Islands on May 2019

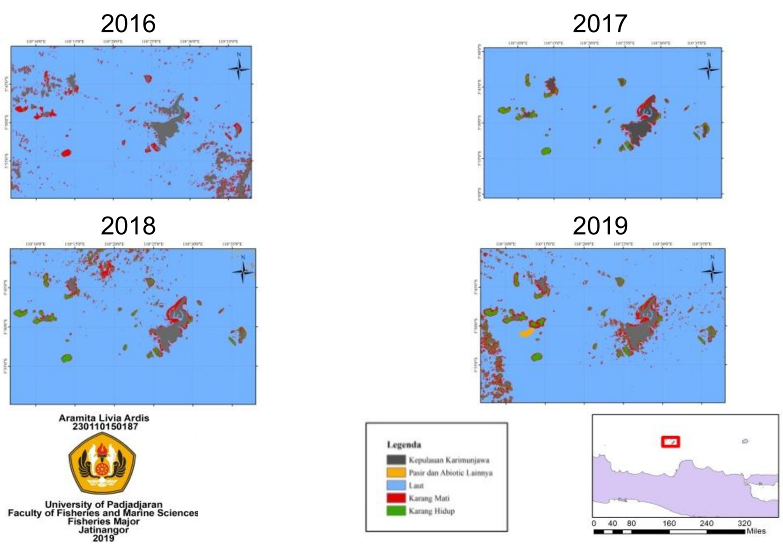

Fig. 11. Distribution of coral cover in 4 years from 2016 to 2019 in Karimunjawa Islands

Dead coral (HCD) and Rubble (RB) is thought to be a result of the hectic underwater tourism activities in the water area, seen from the number of fragments/fragments of coral reefs that are still new, the scratches found on living coral reefs due to friction from fins and also a large amount of coral reef fracture suspected from laying anchor vessels that are not in accordance with procedures.

3.2.2 Spatial distribution of coral reefs

Based on the results that have been obtained from the estimated area of coral reefs in the last 4 years through satellite imagery, it can be seen that the amount of coral cover is decreasing every year (Fig. 11).

Based on the calculation results, the calculation value of the water attenuation coefficient is obtained value (ki / kj) which is equal to 0.3033 in 2019 and 0 in 2016-2018. Thus the logarithmic equation used to extract the substrate of the waters becomes Y = ln Band 3 + ki / kj * ln Band 2. From the image of the alogarithmic transformation then using a rainbow colour palette it can be visually clearly distinguished dead coral reefs (red), live coral is green, yellow is mixed sand with broken coral with a gradation of greenish-yellow colour.

Analysis based on the logarithm value of lyzenga is known that the area of dead and living coral cover in the last 4 years shown in Table 4 shows the increase in the area of dead coral and likewise the reverse in live coral cover has decreased.

The decline in the coral area in the Karimunjawa Islands shows that tourist activity and other factors have a negative impact on the survival of coral animals. Through spatial analysis only gives an overview of areas that are not as specific as dead corals classified as Dead Coral classified as dying or dead is not detected.

3.3 Analysis of Marine Tourism Suitability

3.3.1 Area suitability index

The Area Suitability Index (ASI) of the three stations is obtained from 5 observed parameters, namely the visibility of the waters, the cover of the coral community, the number of types of life-forms, the depth of the coral reefs, and the speed of the currents.

By the total of Nmax of 45, station 3 is the only station classified as S2 or suitable because it has an ASI value of 60%. At stations 1 and 2 have ASI values of 48.89 and 37.78% so that both are classified as S3 or not suitable.

3.3.2 Regional carrying capacity area

The concept of carrying capacity of tourism in the coral reef ecosystem has not been able to produce a numerical value that determines the number of tourists and divers but is assessed through criteria that can affect capacity and cause a decrease in capacity.

The Regional Carrying Capacity Area (CCA) for suitable marine activities from the three stations is only on Menjangan Kecil Island. With area 76,320 m^2 provided, 18 persons that suit for a good capacity. CCA assessment is carried out only at station 3 because it is a station classified as ASI S2 or suitable. With the information on the amount of coral cover available, the Area Suitability Index and the Regional Carrying Capacity in supporting zoning segmentation.

3.3.3 Estimated visual value of coral reef ecosystems

A visual assessment of the quality of a coral seascape is done by involving divers who have a minimum diving certificate of A1 / Open Water as a respondent. The total number of respondents selected was 20 people, 5% were respondents with Basic level certificates, 55% Open Water levels, and 40% Advance level certificates.

Table 4. Extensive reefs in the Karimunjawa Islands in the past 4 years from 2016 to 2019

No	Class	Area (m^2)			
		2016	2017	2018	2019
1	Living Coral	8.451.105	7.669.132	7.062.144	6.752.802
2	Dead Coral	7.615.980	7.799.324	8.142.073	8.831.927

Table 5. ASI values at each station in Karimunjawa Islands on May 2019

No	Parameter	Sintok Island		Cemara Besar Island		Menjangan Kecil Island	
		N	ASI (%)	N	ASI (%)	N	ASI (%)
1	Water Visibility (m)	0	48,8889	5	37,7778	5	60
2	Coral cover community (%)	10		0		10	
3	Number of types life-form coral	6		6		6	
4	Depth of coral reefs (m)	3		3		3	
5	Current speed (cm/s)	3		3		3	

Table 6. CCA values at suitable and very suitable station on May 2019

Location	Area (Ha)	CCA (person)
Stasiun 3, Menjangan Kecil Island	7,632	18

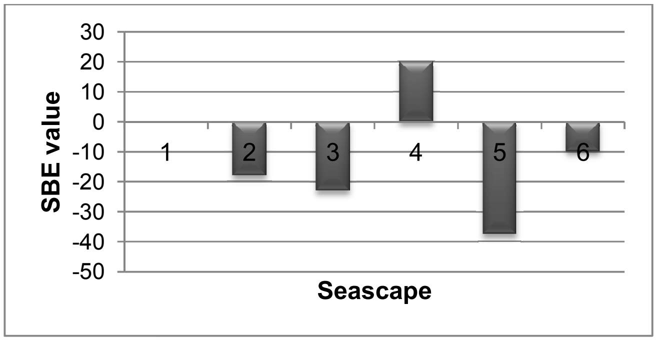

Fig. 12. Seascape SBE value chart for 3 stations in Karimunjawa Islands on May 2019

Based on Fig. 12, it can be seen that shows the SBE values for each seascapenya. Seascape 1 and 2 is taken on Sintok Island. Seascape 3 and 4 on Pulau Cemara Besar, and Seascape 5 and 6 on Menjangan Kecil Island.

Taking the observation point is based on the diversity of vegetation living coral reefs that are the best from the overlay analyzed, this shows that the Area Suitability Index (ASI) of lifeform cover affects the attractiveness of tourists, especially to respondent divers who already have certificates. This can be supported by the lack of diversity of coral cover types that are felt to have a boring effect on tourists and also the diversity of reef fish species themselves. When compared to the observed coral cover conditions, Cemara Besar Island has a coral cover that is classified as having the highest SBE value and vice versa on the Menjangan Kecil Island which is the best coral cover among the three stations having the lowest SBE value. This shows that not all points on the island indicate the condition of coral reefs as observed.

Based on Table 7, seascape 5 and 3 are in a low category, *seascape* 1, 2 and 6 are in the medium category and seascape 4 is in the high category. This shows that respondents tend to be more interested in good conditions and dense coral cover. These SBE results make that even though station 2 has damaged coral cover and unsuitable IKW (S3) there are still good coral reef conditions and offers beautiful and healthy reefs.

3.4 Zoning Plan for Marine Ecotourism for Segmentation Development

A zoning plan for segmentation development is needed to minimize damage to coral reef ecosystems that occur through community and ecological approaches. Through the Integrated Education-Based Marine Ecotourism Model (EBBPT), this helps in developing small islands to make the best use of them.

Based on Fig. 13, the three categories have a different function. In the core and rehabilitation zones, according to Sulisyati et al. [19] the core zones are based on the potential and representation of important ecosystems in the form of mangrove ecosystems, habitats of various protected bird species, coral reef ecosystems, coastal vegetation, turtle nesting beaches, ecosystems of various types of protected marine life such as clams and turtles, places or locations that are considered as forbidden by the community. The location design

Table 7. Classification of SBE classes for 3 stations research site in Karimunjawa Islands in May 2019

Category	SBE values		
Low	(-37,4)	-	(-18,23)
Middle	(-18,22)	-	0,94
High	0,95	-	20,12

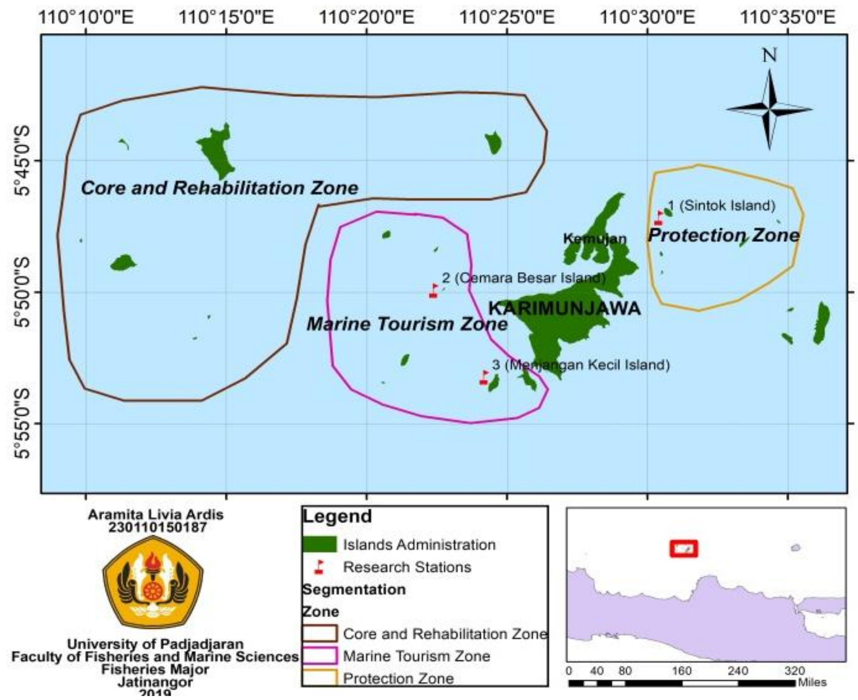

Fig. 13. Ecotourism zoning segmentation in Karimunjawa National Park on May 2019

includes the waters of Burung Island, Kumbang Island, Taka Menyawakan, Gosong, Menjangan Kecil Island, Karang Besi, Taka Malang and Tanjung Bomang. However, some islands can be utilized as tourism uses such as Menjangan Besar, Menjangan Kecil, and Menyawakan, Kembar Islands. The utilization zone was chosen because it has the potential and representation of important resources such as coral reef ecosystems, habitats for various types of marine life. Rehabilitation zones for restoration of damaged areas so that they can return to their original function, which can later be converted into other zones such as marine tourism zones or other zones. So that the core and rehabilitation zones should be closed in conducting marine tourism.

Different in the utilization zone, in this zone marine tourism can still be carried out but tourist policies and information about the area are needed in order to maintain underwater preservation such as installing tourism information boards, using lifejacket if can't swim, not touching corals, etc. This is due to reduce damage to corals that become more severe due to human activities. In addition, the utilization zone was chosen because it has the potential and representation of important resources such as coral reef ecosystems, habitats for various types of marine life. This zone includes Menjangan Besar, Menjangan Kecil, Menyawakan, Kembar, Tengah, East of Kumbang, Bengkoang, Indonor and Karang Kapal Islands.

And the protection zone has the potential and representation of important resources such as coral reef ecosystems, fish spawning areas, habitats of various types of marine animals that must be protected to maintain the integrity and preservation of representation of native ecosystems and their ecological functions and to support the core zone. The island includes the waters of Geleang Island, Bird, Tanjung Gelam, Sintok, Cemara Kecil, Katang, Gosong Selikur, and Gosong Tengah Islands. Particularly in the eastern part such as Cilik Island, Tengah Island and Sintok Island, a marine tourism ban is needed due to the deterioration of coral reefs which is getting worse due to the barge lining which has a major impact on the degradation of coral reef damage.

4. CONCLUSION

- Through the ecological approach of Menjangan Kecil Island, it is the most suitable station to be utilized in the development of marine ecotourism while in

Cemara Besar Island it is not suitable. Through a social approach even though Cemara Besar Island is classified as damaged there is still a good coral cover available and is in demand by marine tourists especially divers. Through the Integrated Education-Based Marine Ecotourism Model, the degradation of live coral cover has decreased every year in the last 4 years.

- Zoning of coral reefs for marine ecotourism namely:

  1) Sintok Island with a good coral cover category and IKW value does not fit into the protection zone, this zone needs to be temporarily closed to carry out conservation efforts.
  2) Cemara Besar Island in the category of damaged coral cover and IKW value does not fit into the tourism utilization zone, this zone can still be used for marine tourism activities.
  3) Menjangan Kecil Island with good coral cover category and IKW value according to the utilization zone, this zone can be used for marine tourism activities.

Besides that, outside the observation station, there are still core and rehabilitated zones that are considered to be forbidden and no marine activities should be carried out only as conservation areas.

5. RECOMMENDATION

1) This research can be developed in determining the suitability of an area in developing ecotourism segmentation so that the sustainability of coral reef ecosystems can last long.
2) Pay attention to the area by making written information that can be seen by tourists.
3) Conducting studies on the use of coastal resources for local inhabitant, while maintaining the preservation of the area to the surrounding community.
4) Utilizing satellite imagery in tourist development. Satellite imagery is a technology that is considered capable of helping the maritime community in exploring the survival of coral reefs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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