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Coral Reef Mapping As Areas for Diving and Snorkeling Tourism at Pari Island Kepulauan Seribu DKI Jakarta

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ABSTRACT

The research aimed to create the coral reef distribution map and determine the potential tourism areas for diving and snorkeling at Pari Island Kepulauan Seribu DKI Jakarta. This research at the computer laboratory the Faculty of Fisheries Marine Science Padjadjaran University. The Lyzenga Algorithm method was used to produce map of distribution of coral reef. Secondary data on there station to support the required parameters, brightness of water, coral cover, amount of lifeform, coral depth, flow velocity and expanse of coral. Matrix analysis and tourism suitability index were used to determine suitable for diving and snorkeling areas. The research showed that the coral reef distribution cover were 0.18 km^2. Based on the secondary data, the coral reef condition in Pari Island belong to the category of poor to moderate with the percentage coral reef cover range from 20%-45.65%. The results of suitability location analysis showed the area with the category of highly suitability for diving were located at station one and there (S1), meanwhile conditional category area at station two (S3). As for snorkeling tourism, the moderately suitable was located at stasion one and there (S2), and conditional category at station two (S3).

Key words : Diving and Snorkeling, Coral Reef Mapping, Pari Island

INTRODUCTION

Pari Island is part of the Kepulauan Seribu, which belong to the cluster constituent Pari Island. Pari Island cluster unit consists of five small islands, namely Pari Island, Kongsi Tengah Island, Kongsi Barat Island, Burung Island, and Tikus Island (Asriningrum 2005). Cluster Island here into a single entity by the growth of coral reefs. Coral reef ecosystems around the entire island with the type of growth form that is quite diverse coral reefs. Corals that grow in Pari Island waters are mostly coral.

Coral reef ecosystem is a community that is unique as it includes the diversity and abundance of marine life are very high. Tourism activities in locations such as coral reefs are underwater diving tour and snorkel. Marine tourism is a kind of tourism that involves both above and below-water activities related to the marine environment (Ermawan, 2008).

Tourism developing in Pari Island since 2011 after a hectic population-based tourism in the Kepulauan Seribu (Indah 2013). Development Pari Island towards nautical tourism has not been supported with the management of coral reef ecosystem which optimum, so we need a study of the ecological aspects in the development of nautical tourism diving and snorkeling category Pari Island. Thus the coral reef ecosystem management for development of nautical tourism is expected to create a balanced condition between diving and snorkeling with marine environmental management waters of coral reef ecosystems. Ecology also serves economic goals by providing resources and tourism attractions (Prihadi et al. 2018).

In the development of tourism activities diving and snorkeling needed some information about the environmental aspects of water coral reef ecosystems that support for these activities, so

that the expected results of the development undertaken is able to provide information about the appropriate location and minimize the negative impacts caused by the presence of tourist activities.

RESEARCH METHODS

Location and Time Research

The location of research is in the territorial waters of Pari Island is divided into 3 stations (Figure 1). Research has been conducted on July-August 2014. The implementation of this research generally includes three stages, namely the first stage of data collection, the second stage of the preparation of spatial database and non-spatial, the third stage of data processing and data analysis.

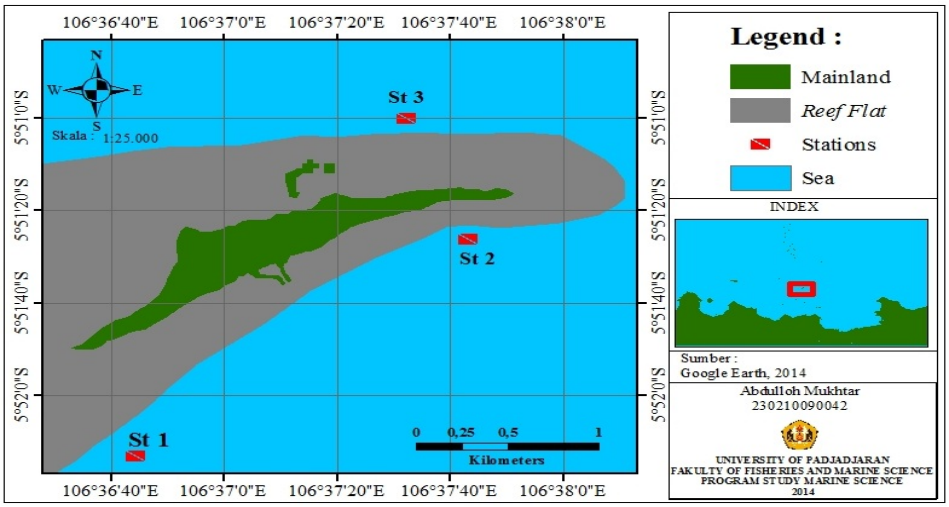

Figure 1. Map Location Research

Tools and materials

1) Hardware such as personal computers / notebooks, external hardist, and printers
2) Software used in this study were Er Mapper 7.1, ArcGIS 10.1, and Frame and Fill
3) satellite images of Landsat 7 ETM + month-August 2013
4) Map RBI Indonesia
5) Data coral reefs include coral cover and the type of lifeform coral in August 2013

Method

Research to produce a map of the distribution of coral reefs using Lyzenga Algorithm. Application method Lyzenga Algorithm in this study is intended to get a new image by combining two channels seem capable of penetrating into the body of water to a certain depth.

Data Collection

At this stage the data collected includes the cover of coral reefs, coral lifeform type, and physical data Pari Island waters. Methods for data collection using literature by searching or gathering information required in a study that can be gathered about the data and information sourced from agencies UPT Loka Pengembangan Kompetensi Sumberdaya Manusia Oseanografi, Pulau Pari, Pusat Penelitian Oseanografi-Lembaga Ilmu Pengetahuan Indonesia (LIPI) (2013) dan Alfaridzie dkk. 2013.

Preparation of database

Stages managing digital data base covering penyususunan spatial database and non-spatial.

A. Base spatial data

1) Bathymetri map to obtain depth data

2) thematic maps covering the suitability parameters diving and snorkeling waters include brightness maps, flow velocity, and distribution maps of coral reefs.

B. The non-spatial database, including:

1) The data cover the coral reefs at each station and percent cover of coral reefs

2) Data life form coral reefs at each station and the number of life form

3) oceanographic data covering current velocity, depth, water transparency, temperature and salinity.

Image Processing

Image data processing aims to improve the quality of the image is used in order to facilitate interpretation. The image used in this study is the Landsat 7 ETM + and process-processing of image data as follows:

1) Geometric Correction

2) Cutting Image (Cropping)

3) Composite Image Data

4) Algorithm Method Lyzenga

The application of this algorithm is to obtain a better visual image for an object that is under the water surface.

Steps being taken by this method are as follows:

- Preparation of training site
  Making the training site by using ER Mapper. Training site aims to look for coral reef sharpening coefficient (ki / kj)
- Transformation of image
  Mapping shallow waters to see the distribution of coral reefs can be done by using image enhancement algorithms are arranged lyzenga (1978) and developed in the waters of Indonesia (Siregar 1996 in Aitiando 2008):

$$Y = 1n\,(TM1) + ki/kj\ 1n\,(TM2)$$

Y = image of the bottom waters extract
TM1 = Digitas value channel 1 Landsat TM
TM2 = Digitas value channel 2 Landsat TM
K_i/k_j = nilai koefisien atenuasi

Where

$$K_i/K_j = a + \sqrt{(a^2 + 1)}$$

With

$$a = \frac{(varian\ TM1 - varian\ TM2)}{2\ x\ covarian\ TM1\ TM2}$$

varian = variance value of the digital value
covar = nilai koefisien keragaman dari nilai digital

- Image Classification
  Classification of coral reefs are intended to get the class section of coral reefs make it easier on the fox into a vector format. Classification used is the unsupervised classification.

Data Analysis

Analysis of Distribution Map of Coral Reefs

Data generated from Landsat 7-ETM+ processed by using statistical software (ER Mapper and ArcGIS) to produce a map of the distribution of coral reefs to determine potential sites Diving and snorkeling tour analyzed in the description.

Suitability Matrix Analysis Tourism Diving and Snorkeling

Suitability marine tourism category diving consider five parameters with four classification or valuation classes namely S1 (highly suitability), S2 (moderately), S3 (Conditional), and N (Not applicable). Suitability parameters marine tourism diving categories among which the brightness of the water, cover the coral communities (hard corals, soft corals and other organisms), the type of lifeform, current speed, and depth of coral reefs (Table 1).

Suitability marine tourism travel category snorkeling considered six parameters with four classification or valuation classes namely S1 (Very appropriate), S2 (Under), S3 (According conditional), and N (Not applicable). Suitability parameters marine tourism travel category snorkel among which the brightness waters, coral communities cover (hard corals, soft corals and other organisms), type lifefrom, current velocity, depth of coral reefs, and the width of the flat expanse of coral (Table 2).

With Travel Suitability Index values range as follows:
S1 = highly suitability, with a value of 80 to 100%
S2 = moderately, with a value of 60 to ≤ 80%
S3 = conditional, with the value of 35-≤ 60%
N = not fit, with values > 35%

Table 1. Matrix Suitability Diving Tourism

No	Parameter	Weight	Category S1	Score	Category S2	Score	Category S3	Score	Categor y N	Score
1	Water transparency (%)	5	>80	3	50-80	2	20 -<50	1	<20	0
2	Coral cover (%)	5	>75	3	>50-75	2	25-50	1	<25	0
3	Total lifeform	3	>12	3	<7-12	2	4-7	1	<4	0
4	Reef Depth (m)	2	6-15	3	>15-30	2	>30-50	1	>30	0
5	Flow velocity (cm/dt)	2	0-15	3	>15-30	2	>30-50	1	>50	0

Description: Weight x score = 54 (maximum value)
Source: Yulianda 2007

Table 2. Matrix Suitability Snorkeling Tourism

No	Parameter	Bobot	Category S1	Score	Category S2	Score	Categor y S3	Score	Categor y N	Score
1	Water transparency (%)	5	>100	3	80-<100	2	20 -<50	1	<20	0
2	Coral cover (%)	5	>75	3	>50-75	2	25 -50	1	<25	0
3	Total lifeform	3	>12	3	<7-12	2	4-7	1	<4	0
4	Reef Depth (m)	2	1-3	3	>3-6	2	>6-10	1	>10 <1	0
5	Flow velocity (cm/dt)	2	0-15	3	>15-30	2	>30-50	1	>50	0
6	Reef flat width (m)	1	>500	3	>100-500	2	20-100	1	<20	0

Description : Weight x score = 57 (Maximum value)
Source : Yulianda 2007

Each parameter, both derived from spatial data and non-spatial has a different contribution to the adjustability diving and snorkeling. Therefore in penentukan weights and scores for each parameter is adjusted to the influence of these parameters on the value of conformity. Suitability value at each location is calculated by:

$$N_i = \sum B_i \times S_i$$

Description:
Ni = total weight value in location-i
Bi = weight on each parameter-i
Si = score on each parameter-i

Tourism Suitability Index (IKW)

Analysis of tourist suitability index (IKW) is a continuation of the suitability matrix diving and snorkeling. The formula used to travel suitability index (Yulianda 2007).

$$IKW = \Sigma [Ni/Nmaks] \times 100\%$$

Description:

IKW = Tourism Suitability Index
Ni = Parameter Value to-i
Nmaks = The maximum value of a travel category

Result and Discussion

Geometric correction and image Cutting

The initial phase of image processing in this study is the geometric correction. Geometric correction is a process to reposition the image so that it matches with the actual map coordinates earth. The conduct of the geometric process for the position and orbit and attitude sensing satellite sensor when the earth shifted. As a result of the shift will be amended so that the coordinate position is not in accordance with the position (latitude and longitude) is in fact (Purwadhi and Sanjoto 2008).

Geometric Correction using GCP (Ground Control Point). GCP is a known point coordinates precisely and can be seen on satellite remote sensing imagery such as rivers, bays, headlands and others. The use of GCP for geometric correction process requires reference data having the coordinates correspond to the actual situation on earth. Reference data used are Acuan_Indopul2.alg.

Having obtained the corrected image data and the cutting of the image (cropping). Cutting this image is useful to clarify the location of research and more effective in areas that will be studied thus simplifying the process of interpretation. The image has been cropped to keperluaan study (Figure 2).

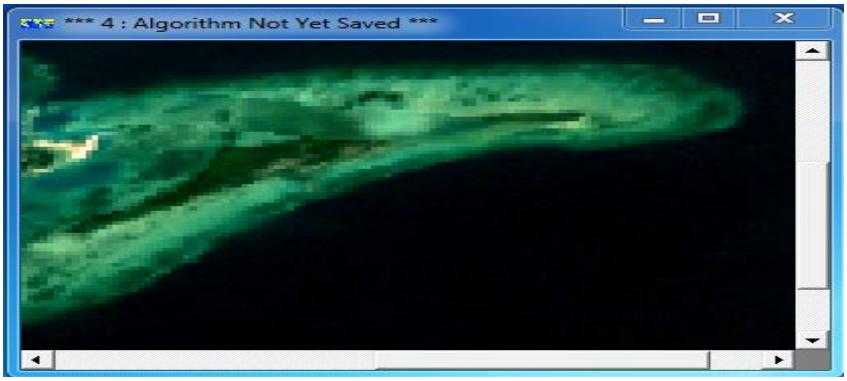

Figure 2. Image Data Pari Island Has in-Crop

Composite image and composition of Substrate Water Pari Island

Substrate bottom waters on Landsat 7-ETM + imagery obtained by combining three different bands so as to produce a composite image, ie, the composite RGB (Red Green Blue) 421 (Figure 3). Through this process, the visible difference between the inland waters and describe the base substrate spatially Pari Island waters.

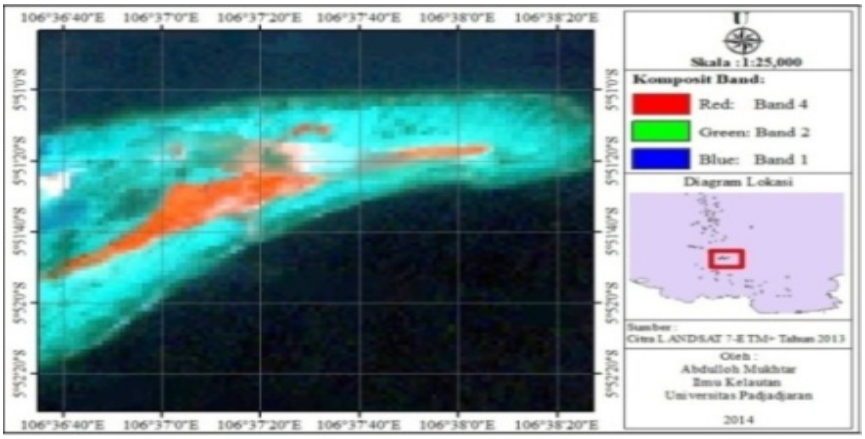

Figure 3. Image Composite RGB 421

Imaged substrate Pari Island waters because each band used to have the characteristics / different uses. The image above shows that red is the delineation of the islands and water networks, green color depicts vegetation found in the waters and sediments, blue depicts the brightness and the differences between soil and vegetation.

Based on the results of data processing of Landsat 7 ETM + using method-lyzenga algorithm then obtained a basic substrate composition waters Pari Island (Figure 4). The figure shows that the mainland Pari quite spacious compared to the outside of a stretch of land that is surrounded by the waters of the base substrate include seagrass, coral reefs and sand. Pari Island waters substrate is dominated by sand area of 0.40 km^2. Seagrass area of 0.25 km^2, only a few live coral that is an area of 0.18 km^2 compared with dead coral area of 0.26 km^2 .

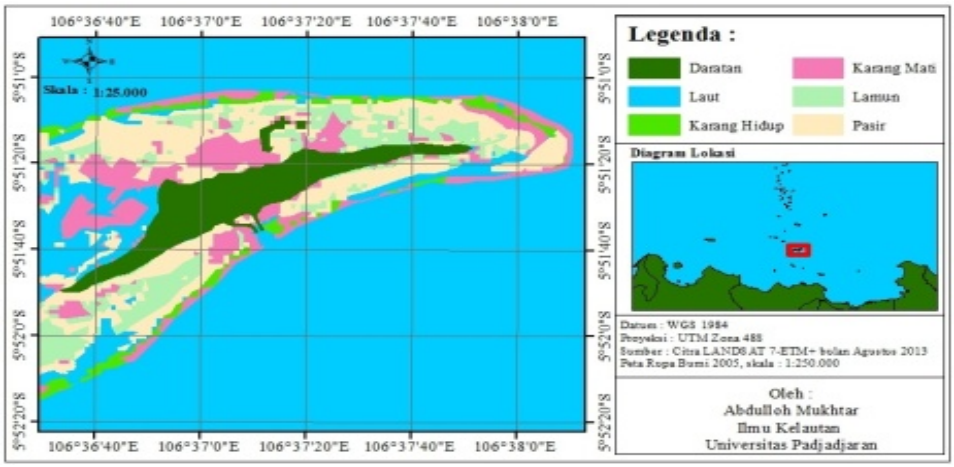

Figure 4. Composition of Substrate Water Pari Island

Condition of Coral Reefs

The condition of coral reefs in the waters of Pari Island is represented by the percentage of hard coral cover (hard coral) which includes Acropora species and non-Acropora. Percentage cover expressed in percent (%). Based on observations of UPT LPKSDMO, LIPI Pari Island (2013) and Alfaridzie et al. (2013) showed that the value of coral reefs cover Pari Island ranged between 20% - 45.67% (Table 3). Based on the decision of the Minister of State for the Environment No. 4 In 2001 the condition of coral reefs including bad criteria to moderate.

Table 3. Condition of Coral Reefs at each station

Station	Depth (m)	Live Coral (%)
1*	6	30,27
2**	6	20
3**	6	45,67

Source : * UPT LPKSDMO, Pulau Pari LIPI (2013)
**Alfaridzie dkk. (2013)

The condition of coral reefs in the waters of Pari Island belonging to poor criteria contained in station 2 is the eastern island at a depth of 6 meters Pari ie the percentage of coral cover 20%. While the first station south Pari Island at a depth of 6 meters which is the percentage of coral cover 30.27% and 3 stations north Pari Island at a depth of 6 meters which is the percentage of coral cover 45.67% belong to the middle criteria.

The poor condition of the coral reefs are an indication of the influence of the mainland because of the position of station 2 Pari Island east directly opposite the Jakarta Bay, which is where bermuaranya 19 river and there are various activities such as industry and settlements that exist around the bay Jakarta (Nugraha et al. 2010). The existence of these activities will impact the growth of coral reefs due to both direct and indirect domestic and industrial wastes such as garbage carried by currents and wave had that caused the waters east bagain affected Pari Island (water pollution).

Poor condition of coral reefs to medium can result in decreased tourist attraction. Yulianda (2007) states that cover a very conformity (S1) for a minimum of 76% of diving this condition indicates that the coral reefs in the waters of Pari Island there are very appropriate for diving activities. The condition of coral reefs there are very suitable (S1) but according conditional (S3) for these activities. The good condition of the reef is a huge potential when used for the development of diving and snorkeling.

Types of Life form

Coral growth form (Life form) that vary can be used as one of the basic dalampemenfaatan or development of diving and snorkeling. The number of life forms found in as many as 9 types of station 1, station 2 as 6 types, and station 3 of 8 types (Table 4).

Table 4. Number of Types of Life form Reefs At each station

Station	Depth (m)	Amount
1*	6	9
2**	6	6
3**	6	8

Source : *UPT LPKSDO, Pulau Pari–LIPI 2013
**Alfaridzie dkk. 2013

Based on observations of UPT LPKSDMO, LIPI Pari Island (2013) in the first station south island Pari found hard coral growth form of branching Acropora species are Acropora (ACB), Acropora submassive (ACS), tabulate Acropora (ACT), while the category of Non -Acropora namely Coral Branching (CB), Coral foliose (CF), Coral Massive (CM), Coral Heliopora (CHL), and Coral Mushroom (CMR). It was also found soft coral (Soft Coral).

Based on observations Alfaridzie et al. (2013) at stations 2 and 3 show that the form of hard coral growth at station 2 to form the growth of Acropora species found only one type of life form that tabulate Acropora (ACT), while from the category of non-Acropora as many as 5 different types of life forms that Coral Branching (CB), Coral foliose (CF), Coral Massive (CM), Coral submassive (CSM), and Coral Mushroom (CMR). At station 3, the shape of the growth of hard corals Acropora species are Acropora Branching (ACB), Acropora submassive (ACS), tabulate Acropora (ACT), while from the category of non-Acropora is Coral foliose (CF), Coral Massive (CM), Coral Heliopora (CHL), and Coral Mushroom (CMR). Besides, it was also found soft corals (Soft Coral).

Based on observations indicate that the category of Non-Acropora dominate each observation station compared with Acropora species. According to Johan (2003) is a type of coral Acropora coral-shaped group of fast-growing branches but are susceptible to a variety of pressures, while the

types of non-Acropora corals are able to adapt and be able to withstand the pressures of both natural and human environment (Suharsono 1996).

Coral growth form that is found in every station of the category of non-Acropora are foliose Coral and Coral Massive. While the growth of coral Acropora species found at each station are tabulate Acropora. Type of life form that is found in every station has different characteristics and shape into a tourist attraction diving and snorkeling. This is in line with the statement Plathong et al. (2000) in Widhianingrum et al. (2013) that in the development of marine tourism category diving and snorkeling coral life form types are needed as a variation that can be enjoyed under the sea.

Oceanographic Conditions

Depth (Bathymetry) Water

Bathymetric mapping Pari Island waters were obtained by interpolation of the 60 points depths ranging from 3 to 12 meters. Having produced bathymetric maps show some degree of depth in the waters of Pari Island vareatif enough due to the depth of the interpolated point has a relatively close distance but undergo striking changes.

Such changes indicate that increasing open water toward or away from the mainland, the island water depth increases. It is clear from the contours and shades of blue indicate the depth of 3 to> 9 meters while the dark blue color with a circular contour of> 12 meters (Figure 5).

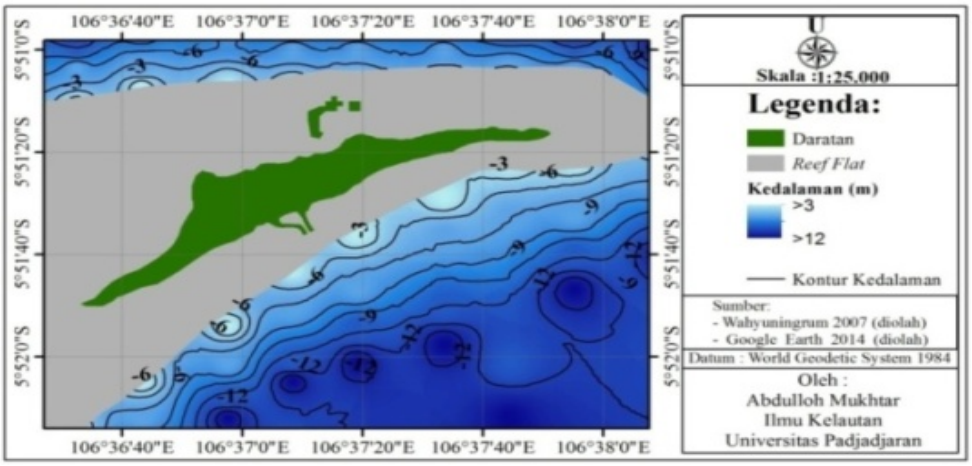

Figure 5. Contour Pari Island Water Depth

Based on the results of the processing of bathymetric map shows that there is a depth of 3-9 meters it is suitable for diving and snorkeling activities. Having obtained the grading done suitability depth for diving and snorkeling activities (Table 5).

Table 5. Results of Conformity pengkelasan Depth To Travel Activities Diving and Snorkeling at Coral Reef Region

Sutability	Locations	Depth (m)	Category
Diving Tourism	Station 1 (South Pari Island)	6-9	Very Highly (S1)
	Station 2 (East Pari Island)	3-<6	Moderatery (S2)
	Station 3 (North Pari Island)	6	Very Highly (S1)
Snorkeling Tourism	Station 1 (South Pari Island)	<6	Very Highly (S1)
	Station 2 (East Pari Island)	3-<6	Very Highly (S1)
	Station 3 (North Pari Island)	<6	Very Highly (S1)

Based on the results obtained welding depth for diving activities in station 1 at a depth of 6-9 meters (very appropriate S1), station 2 dikedalaman 3- <6 meters (according S2), and station 3 dikedalaman 6 (very appropriate S1). As for snorkeling in station 1 at a depth of> 6 meters, station 2 dikedalaman 3- <6 meters, and station 3 at a depth of 6 meters. Depth for snorkeling tourist activities at each station included into the category of very fit.

The depth of water is not only related to diving and snorkeling. The depth of water is one of the limiting factors for coral life. Increasingly in an increasingly unproductive waters for coral growth. According to (Kordi 2010) The maximum sea depth for the growth of coral reefs is 40 m and the most reefs grow well at a depth of 25 m or less.

Brightness Water

Water transparency is the most important parameters and have the greatest weight in determining the suitability level diving and snorkeling (Hertikawati 2011 in Prihadi et al. 2012). Based on the results of measurements of the brightness level of the waters in Pari Island by UPT LPKSDMO, LIPI Pari Island (2013) and Alfaridzie et al. (2013) ranged between 79-100%, the lowest brightness are at station 2 is 79%, while the stations 1 and 3 brightness reaches 100%.

Water transparency to be important in determining the diving and snorkeling because of the brightness will provide added value for the underwater lovers. In addition to adding value for connoisseurs of beauty beneath the sea, water transparency is important for the growth of coral reef habitat conditions because its waters should be clear and free from contamination either from river water and domestic waste (Prihadi et al. 2012).

Flow velocity

Based on the results of observations made by the UPT LPKSDMO, LIPI Pari Island (2013) and Alfaridzie et al. (2013) the flow velocity in Pari Island relatively weak and moderate currents, it is suitable for diving and snorkeling in the range between 0.19 to .133 flow velocity (m / s) with the current movement from east to west, the lowest station there at station 1, while the highest current is 0.133 m / sec are on station 3. The strong currents at station 3 is suspected because of the influence of the density of sea water. According to Arifin et al. (2000) in Johan et al. (2011) that the current speed is relatively weak is the ideal conditions for marine tourism category of diving and snorkeling.

Flow velocity has an important role for tourism diving and snorkeling because it is associated with keselamata tourists. Besides having an important role in determining the location of diving and snorkeling flows have a role for the growth of coral reefs. Current movement is required for the availability of food and oxygen supply flow or for avoiding a pile reef sediments (Sukarno et al. 1981).

Temperature

Pari Island water temperature based on measurements by UPT LPKSDMO, LIPI Pari Island (2013) at station 1 (South Island of Pari) 30,6^{0}C temperature value and Alfaridzie et al. (2013) at stations 2 and 3 (North East and Pari Island) measurement result is 290C. Permissible temperature range changes to <2^{0}C of natural temperature (KepMenLH 2004). The temperature range allowed for diving and snorkeling activities.

Water temperature conditions of the research location slightly higher than the optimum temperature for the growth of coral reefs ranging from 23-25^{0}C, but the reef can tolerate changes in temperature 36-40^{0}C (Nybakken 1992). According Kordi (2010) the temperature required for the growth of coral reefs is 25-30^{0}C.

Salinity

The results of measurements of salinity in the waters of Pari Island conducted by UPT LPKSDMO, LIPI Pari Island (2013) at station 1 (South Pari Island) 30 $^{0}/_{00}$ salinity values and Alfaridzie et al. (2013) at stations 2 and 3 (North East and Pari Island) produced 30.6 $^{0}/_{00}$ salinity values for stations 2 and 33 $^{0}/_{00}$ at station 3. From these results show relatively little variation in salinity.

The highest salinity at station 3 is 33 $^{0}/_{00}$. While there are low salinity at station 1 is 30 $^{0}/_{00}$. Salinity range for the suitability of marine tourism diving and snorkeling category that allowed a change to the $<5^{0}/_{00}$ salinity seasonal average (KepMenLH 2004). Salinity giving role for the growth of coral reefs. According Kordi (2010) salinity suitable for growth and reef formation is 27-35 $^{0}/_{00}$. Based on the measurement results obtained show that the salinity of the waters of Pari Island is good for the growth of.

Sutability Tourism Diving and Snorkeling

Based on the results of the calculation of matrix analysis of the obtained tourist suitability index value (IKW) for diving tourism activities at stations 1 and 3 by 81.48% and 55.55% at station 2. While the results of the calculation of matrix analysis suitability snorkel tours and travel suitability index (IKW) for tourist activities snorkeling at station 1 and 3 by 78.94% and station 2 by 52%.

The results of the analysis matrix calculation of all subsequent parameters in the form of maps dioverlay suitability diving area (Figure 6) and snorkleing (Figure 7). These results indicate that the stations 1 and 3 very sesuia (S1) is represented in blue and 2 corresponding conditional station (S3) is represented by the color yellow for diving.

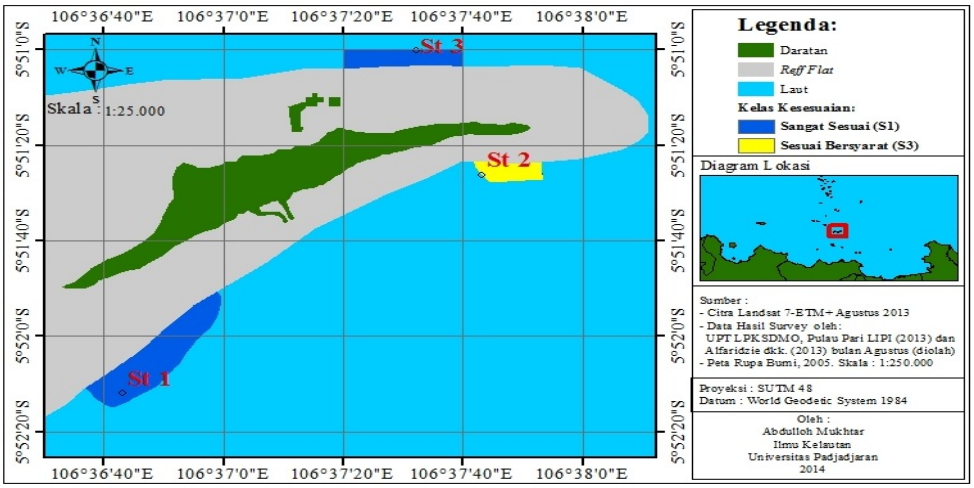

Figure 6. Map of Sutability for Diving Tourism Pari Island

The results of calculations for snorkeling tourist activity stations 1 and 3 are reasonably fit (S2) is represented by a light green color and station 2 corresponding conditional (S3) is represented by the color yellow. The difference from the calculation of the matrix analysis shows that in every category of tourist have needs that are not the same because diving activities carried out in the waters while snorkleing activities carried out on the surface of the ocean waters. Category diving absence width parameter while snorkeling the reef flat width parameters for a wide expanse of coral reef beds become important for snorkeling activities because these activities enjoy the panoramic beauty of the coral reefs of the surface waters. In addition to conserving the natural flora and tree species, the original appearance and unique qualities of the site are also preserved (Fang, 2020).

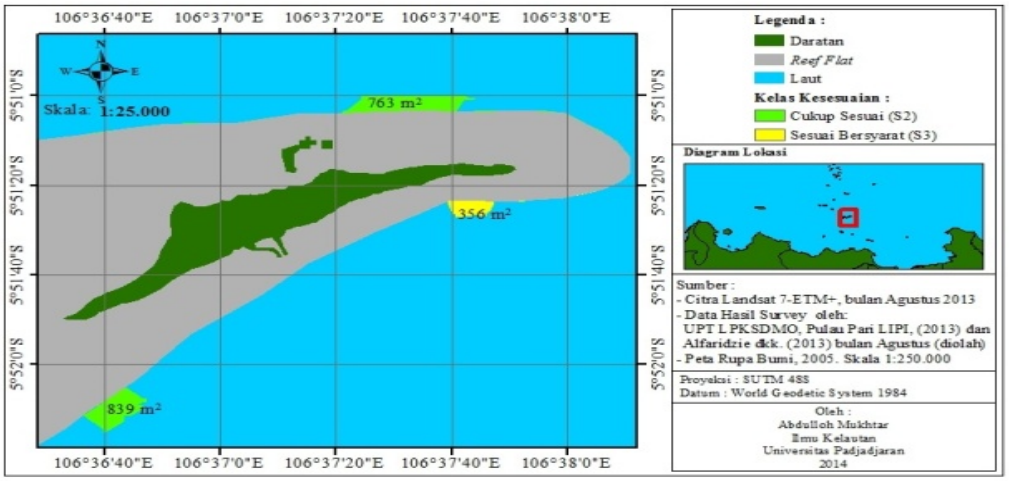

Figure 7. Map of Sutability for Snorkeling in Pari Island Tourism

Conclusion

Based on the results of data processing of Landsat 7 ETM +-in August 2013 identified extensive living coral reef that is 0.18 km2 and death of coral reefs is 0.26 km2. The results of the analysis of the suitability of potential areas for diving has been done obtained a very appropriate location (S1) is at station 1 and 3 while the second station included into the category corresponding conditional (S3). Snorkeling tour at stations 1 and 3 are reasonably fit (S2) and station 2 corresponding conditional (S3).

Biography

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