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ANALYSIS OF THE CONDITION AND AREA OF CORAL REEF COVER IN THE WATERS OF PANDAN ISLAND, WEST SUMATRA PROVINCE

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ABSTRACT

This research was carried out in January 2024 in the Pandan Island Conservation Area, Padang City, West Sumatra Province. The aim was to determine the condition and the extent of coral reef cover in this area. The method used in this research is a survey method with quantitative analysis using coral reef observation data. Data was collected at three stations using the UPT (Underwater Photo Transect) method, namely by diving using Scuba diving equipment and taking underwater photos using a digital camera. The percentage of coral reef cover at the three stations includes Station I (Pandan Island to the south), which has a coral cover of 67.60% categorized as good, and Station II (Pandan Island to the east), which has a cover of 69.07%, which is classified as good. Station III (Pandan Island to the north) has a cover of 63.04%, categorized as good. The types of growth of living coral reefs (life form) found at Station I are dominated by Coral Foliose (CF) at 44.13%, at Station II, it is dominated by Coral Foliose (CF) at 38.13%, and Coral Encrusting (CE) amounting to 14.73%. In comparison, Station III was dominated by Coral Encrusting (CE), amounting to 20.86%, and Coral Massive (CM), amounting to 15.90%. Based on the image classification results, it can be concluded that the area of living coral reefs in the research area is 14.65 ha.

Keywords: Coral Reef, Underwater Photo Transect, Sentinel Imagery.

1. INTRODUCTION

Coral reefs are one of the abundant marine resources in Indonesia, ranking at the top globally in terms of both area and species richness, covering over 75,000 km² or approximately 14% of the world's total coral reef area. The diversity of coral reefs in Indonesia is relatively high, with more than 480 species of hard coral identified[1]. Coral reefs are the fundamental marine ecosystems primarily inhabited by various species of hard corals. The formation process of coral reefs takes quite a long time, during which various other living creatures inhabit them. Coral reefs serve as coastal protectors from waves and currents. Coral reefs also have ecological functions such as habitats, places to find food and spawning grounds for marine organisms[2].

Coral reefs have significant conservation value due to their high biodiversity and as a source of germplasm. Other functions of coral reefs include protecting coastal ecosystems, serving as tourist attractions, and providing significant benefits to communities. To a certain extent, coral reef communities can form complex coral reef structures[3].

West Sumatra Province has a marine area exceeding two-thirds of its land area and a fairly good coral reef ecosystem. Thus, efforts are needed to protect and conserve these resources. Coral reefs scattered in the Pulau Pieh Conservation Area require data collection to facilitate future coral reef

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monitoring processes. Many methods can be used in coral reef data collection, including the Underwater Photo Transect (UPT) method. Data collection in the field involves taking underwater photos using underwater digital cameras. The resulting photographs are then analyzed using the Coral Point Count with Excel Extensions (CPCe) program to obtain quantitative data.

Previous research has shown a decrease in coral reef coverage in several areas, one of which is the waters of the Spermonde Islands, which experienced a decrease of 13.1% over ten years[4]. This research was conducted to determine the condition and extent of coral reef coverage on Pandan Island, located within the Pulau Pieh Conservation Area. In this study, quantitative analysis was conducted using coral reef observation data obtained from the field and the interpretation of satellite images presented in the form of maps, which were then analyzed descriptively.

2. RESEARCH METHOD

Time and Place

This research was conducted in January 2024 on Pandan Island within the Pulau Pieh Conservation Area and the surrounding seas of West Sumatra Province (Figure 1).

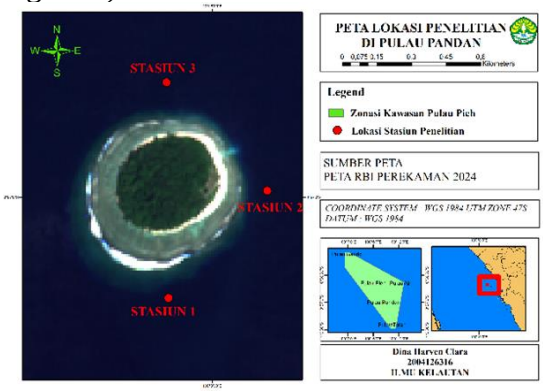

Figure 1. Map of research location

Method

The survey method was used in this research. This study collected primary data and secondary data. Primary data were obtained from direct observations in the field. Secondary data were obtained from the Copernicus website, which produces Sentinel 2A images.

Procedure

Determination of research station points was carried out using a purposive sampling method, which was considered to represent the research object in the waters. Station I is located to the South of Pandan Island in the core zone, Station II is located to the East of Pandan Island in the utilization zone, and Station III is located to the North of Pandan Island in the utilization zone. Each observation station is a permanent station designated by the Pulau Pieh Conservation Area and its Surrounding Sea.

The data collection was conducted by diving using scuba diving equipment. Data was collected using the UPT (Underwater Photo Transect) method by taking underwater photos using digital cameras. The satellite image data processing procedure using Composite imagery involves combining color images from three channels: red, green, and blue. Combining these three channels will produce a new image with a color display that combines the three basic colors. Composite images are used to identify objects in the picture. In this study, the bands used in the composite are band 4 (red), band 3 (green), and band 2 (blue).

Analysis Data

Data analysis of coral reef coverage calculations was performed using the Coral Point Count with Excel Extensions (CPCe) software[5]. Analysis of coral reef quality was conducted by calculating the percentage value of live coral cover obtained from the measurement of coral colony length using the formula:

$$L\ (\%) = Li : N \times 100$$

Description:
L = percentage of coral cover (%),
Li = Total length of live coral colonies
N = transect length (20 m).

Percentage cover refers to the percentage of area covered by live coral. The

classification of coral reef conditions based on the rate of live coral cover refers to Ministerial Decree No. 04 of 2001, which is as follows: Excellent (75- 100%), Good (50-74.9%), Fair (25- 49.9%), and Poor (0-24.9%).

In this study, the composite image used is the actual color composite. The true color composite is a band composite recommended for identifying shallow water habitats with sufficient penetration ability into clear water[6].

Grouping the reflection values of each shallow water object into certain classes is done using the supervised classification method. In the initial stage of classifying the image with the supervised method, digitization of training areas is first performed to group pixels of the same color. Supervised classification is conducted using the Maximum Likelihood Classification (MLC) method.

The principle of Maximum Likelihood Classification is to classify pixel values based on the probability of a pixel value belonging to a certain class within the pixel sample[6]. This study's classification process is conducted to distinguish four classes of shallow water bottom habitats: live coral, algae, and sand.

3. RESULT AND DISCUSSION

Water Quality

To determine the oceanographic conditions of the waters around Pandan Island, Padang City, measurements of several parameters were directly taken in the field: temperature, salinity, brightness, current velocity, and pH. Each parameter was measured at each data collection location using different instruments according to the parameter to be measured. The average values of the aquatic ecological parameters can be seen in Table 1.

Table 1. Average values of aquatic ecological parameters

Station	Temperature (°C)	Salinity (ppt)	Brightness (m)	pH	Current velocity (m/s)
I	29	27	8	7	1,3
II	29	27	8	7	1,5
III	29,8	29	8	7	1,5

Coral Reef Coverage Percentage

The calculation results of coral coverage percentage in 2023 were obtained from secondary data from the Pekanbaru LKKPN, and in 2024, were obtained from fieldwork at three stations at a depth of 5 meters. These results can be seen in Table 2.

Table 2. Coral Coverage Percentage for 2023 and 2024

Station	Year	Hard Coral (%)	Fleshy Seaweed (%)	Rubble (%)
I	2023	83,07	11,07	3,33
	2024	67,60	0,53	26,60
II	2023	46,93	29,93	7,07
	2024	69,07	0,40	13,67
III	2023	59,67	32,87	3,00
	2024	63,04	21,94	2,92

The analysis results at Station I show that the percentage of live coral coverage at Station I in 2023 was 83.07%, indicating that the coral reef condition was very good, while in 2024, it was 67.60%, indicating a good condition. The growth form of live coral in 2024 was dominated by Coral Foliose (CF) at 44.13%.

The analysis results indicate that the percentage of live coral coverage at Station II in 2023 was 46.93%, indicating a fairly good condition of the coral reef, while in

2024, it was 69.07%, indicating a good condition. The growth form of live coral in 2024 was dominated by Coral Foliose (CF) at 38.13% and Coral Encrusting (CE) at 14.73%.

The analysis results show that the percentage of live coral coverage at Station III in 2023 was 59.67%, indicating a good condition of the coral reef, while in 2024, it was 63.04%, also indicating a good condition. The growth form of live coral in 2024 was dominated by Coral Encrusting (CE) at 20.86% and Coral Massive (CM) at 15.90%.

The health of coral reefs can be determined from observations of coral coverage and categorized into coral health categories. Low or high coverage percentages can indicate the health condition of a coral island. The status of the coral reef condition on Pandan Island can be seen in Table 3.

Table 3. Status of coral reef condition of Pandan Island

Station	Year	Hard Coral	Condition
I	2020	69.80	Good
	2021	80.80	Very good
	2022	85.87	Very good
	2023	83.07	Very good
	2024	67.60	Good
II	2020	46.33	Very good
	2021	27.62	Moderate damage
	2022	40.73	Moderate damage
	2023	46.93	Moderate damage
	2024	69.07	Good
III	2020	33.67	Moderate damage
	2021	48.80	Moderate damage
	2022	53.67	Good
	2023	59.67	Good
	2024	63.04	Good

The coral reef condition is categorized as "Very good" at Station I, located in the southern part of Pandan Island. The main cause is the optimal temperature for coral growth and development. The most optimal temperature for coral growth ranges from 23°C to 32°C. Temperatures below 18°C can inhibit coral growth and even lead to death. Temperatures above 33°C can cause bleaching symptoms[7]. The temperature values obtained during the study averaged between 29-30°C.

Image Processing Results

In this study, three images from 2024 were used as material for analyzing coral reef coverage. Before reaching the stage of calculating the area of coral reef coverage, these two images were processed through various stages as follows:

Sunglint correction. Perfect sunglint reflections captured by the sensor have extreme values compared to pixels around them, causing the reflection values of the objects to be chaotic. Subsequently, a masking process is carried out. The masking process is done by displaying the near-infrared channel, where all areas covered by water have low reflection values and tend to be dark. Thus, the results of the linear relationship and the masked sunglint image from the sunglint calculation results can be seen in Table 4.

The regression results are used to reduce glint effects on Sentinel 2A images, which are highly susceptible to glint effects due to the spatial resolution of 10 x 10 meters. The higher the spatial resolution, the more precise the glint effects received by the sensor.

Table 4. Sunglint calculation results

Band	Formula	R^2	bi
Band Blue	1,1205x + 0,0032	0,9399	1,062
Band Green	0,8348x + 0,0606	0,8367	0,834
Band Red	1,0622x + 0,0334	0,8015	1,0622
Min NIR	0,105		

Table 5. Lyzenga statistical values

Var	0.028	0.03774	0.035085
Band	Cover	a	Ki/Kj
Band 12	0.032	-0.15017	0.861039
Band 13	0.03	-0.11539	0.891242
Band 23	0.035	0.037773	1.038486

Water Column correction. Water Column Correction is performed to remove disturbances within the seawater column that can affect the reflection values of shallow marine habitats/base objects. The attenuation of sunlight penetrating the water can be determined by calculating the variance and covariance values from the image data. Data collected for water column correction should have an R^2 value of >=0.8 to maintain the quality of the water column correction results (Table 5).

For this process, supervised classification is used, assuming that the processed image still does not recognize various visible objects, thus requiring the determination of object names in the image. In this study, the author uses the maximum likelihood method by taking representative samples from several areas using the color of pixel data from the image. The results of the image classification can be seen in Figure 2.

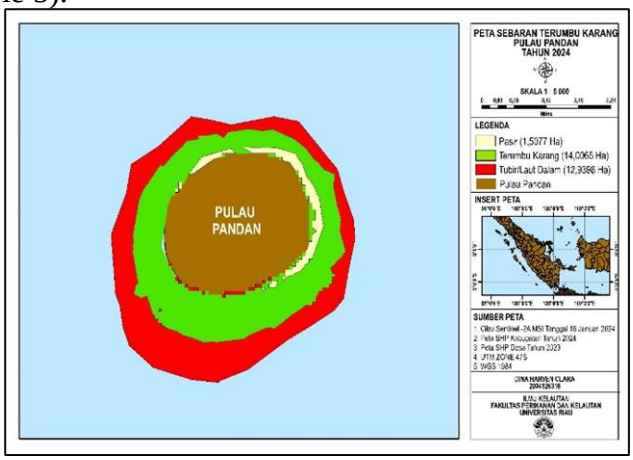

Figure 2. Coral reef distribution map 2024

Figure 2 shows the sunglint correction, water column correction, and refined multispectral classification results. In light green, it can be seen that the distribution mainly lies within the water body, representing live coral reefs at stations I, II, and III, categorized as in good condition. Meanwhile, the sandy substrate, represented by a cream color, is located between the shoreline and the water body. Furthermore, the red color represents the offshore/deep sea.

Result of Coral Reef Area Calculation

The image classification results are divided into live coral, sand, and offshore/deep sea. This classification refers to field data from direct observations at the

research site. Live corals are distributed in areas not too close to the land.

The analysis of Sentinel-2A imagery with RGB 4, 3, and 2 indicates that the coral reefs around Pandan Island cover an area of approximately 14.65 hectares. This is data from the Sentinel-2A imagery for the year 2024. Benthic habitats, especially coral reefs, are crucial ecosystems that support marine life. Moreover, coral reefs are often sought-after tourist attractions. Based on the results of multispectral correction and classification using Sentinel-2A imagery, it is evident that the waters around Pandan Island have a dominant coral reef ecosystem. Field accuracy tests have confirmed that the condition of these coral reefs is good. However, a limitation of coral reef mapping is the inability to differentiate between reefs in good condition and those already damaged, thus requiring accuracy testing.

4. CONCLUSION

At Station I (South Pandan Island), coral cover is 67.60%; at Station II (East Pandan Island), it is 69.07%; and at Station III (North Pandan Island), it is 63.04%. Based on the percentage of coral cover, the overall condition of the coral reefs at all stations is categorized as good. According to the image classification results, the area of live coral reefs in 2024 is 14.65 hectares. The types of live coral growth forms found at Station I are predominately found in coral foliose (CF) at 44.13%. At Station II, they are predominantly Coral Foliose (CF) at 38.13% and Coral Encrusting (CE) at 14.73%, and at Station III, they are predominantly Coral Encrusting (CE) at 20.86% and Coral Massive (CM) at 15.90%. Monitoring and supervising the coral reef conditions in the waters around Pandan Island and its surroundings are necessary to ensure the recovery process proceeds smoothly.

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