Coral reef monitoring in Panjang Island, Central Bangka

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Abstract. Bangka Island is the largest tin producer in Indonesia and since the granting of tin mining freedom in 2000, unconventional tin mining (TI) is increasingly prevalent. The existence of mining activities will directly or indirectly damage the environment both on land and at sea. Especially the high biodiversity of coral reef ecosystem. The purpose of this research was to analyze a map of the distribution of coral reef based on Sentinel 2A satellite imagery data. Analyze the extent of the coral reefs in shallow waters of Putri Island, and analyze of the condition coral reefs (percentage cover, mortality index and genus diversity) with using collaboration between the coral diving data and remote sensing data. Studies of changes in coral reef ecosystems have been ongoing since several decades ago. The combination of satellite imagery and aerial photographs is capable of making long-term and continuous observations on mapping and change detection. Remote sensing technology has several advantages over conventional sampling to monitor a large area in time almost simultaneously and continuously including the difficult to explore areas. This research was conducted with visual interpretation by using standard true color composite band (483) and false color composite band (843) of Sentinel 2A and also using lyzenga transformation. Estimation of coral reefs area based on result is 475,96 ha (2016) and decreased to 475 ha (2021). The condition of coral reefs at the research location is a good condition.

1. Introduction

Coral reef is one of ecosystem that has productivity and the high biodiversity of species at the coastal area. Ecologically, coral reefs which has a role to keep homeostatis ecosystems and it’s can be support productivity marine organism. Beside that coral reefs able to bioindicator marine environment quality. In recent decades, coral reef ecosystems have undergone changes on a global scale as a result climate change and damage by human activities. Based on data published by the Global Coral Reef Monitoring Network (GCMRN) in 2008, approximately 54% of the world’s coral reefs are in a globally threatened condition [1]. The number of activities in exploiting coastal resources excessively will cause disruption of ecosystems and damage to the environment [2]. For this reason, it is necessary to carry out real monitoring activities for any symptoms that lead to environmental damage. This is very necessary in order to obtain accurate and actual data for problems of coastal and marine resources currently being faced.

Bangka Island is the largest tin producer in Indonesia. Therefore, the government has always been in the spotlight, especially in the tin mining in 2000 to the public, unconventional tin mining (TI) has become increasingly widespread and uncontrollably in the land area until the location for TI was getting less. Therefore many peoples started looting coastal areas to carry out tin mining which is often called floating unconventional mining (TI Apung). The existence of these mining activities,
directly or indirectly will damage land area and environmental seas, especially for marine life that has coral reef ecosystem [3].

One of areas in Bangka Belitung Province which has the potential for three angle ecosystem with good condition is Panjang Island Central Bangka. Panjang Island is unique island which has shape long. Panjang Island is an uninhabited island. There is only one halfway house as a stopover for fishermen. Local people say the mangroves on the island are very thick up to 200 m and have wider seagrass beds as well as coral reefs [4]. However, information related to the percentage of damage to coral reefs in the waters of Panjang Island is still very minimal and has not been published properly and is very difficult to obtain. Therefore, special attention is needed through periodic monitoring at least once every 5 years to find out trends in real time changes and status of coral reef conditions as a result of human activities in coastal areas (especially tin mining). The use of remote sensing technology is a conventional method for mapping coral reefs. By using the Sentinel 2A satellite image with a spatial resolution of 10 m, this study will provide very good information about the condition of the coral reefs in Panjang Island. Studies on changes in coral reef ecosystems have been going on for decades. The combination of satellite imagery and aerial photography is capable of conducting longterm and continous observations for coral reef mapping change detection [5]. One method that can be used for monitoring coral reefs is combination remote sensing and Geographic Information Syatems (GIS) [6].

2. Methodology
2.1 Place and Time
This research was conducted Juny 2021 to Juli 2021 at Panjang Island, Kebintik Village, Pangkalan Baru District, Central Bangka. Map location This research showed in Figure 1.
This research divided to 2 step: Image Processing with using Sentinel 2A imagery and coral reef ecology survei (ground check). Interpretation of Satellite Imagery conducted in the Remote Sensing and Modelling laboratory at faculty of Agriculture, Fishery and Biologi, University of Bangka Belitung. Panjang Island is located in Central Bangka, on of regency in Bangka Belitung Province. Panjang Island is located geographically in 02°09’14” S and 106°16’24” E. The Coverage area Panjang Island has approximately 125 Ha (Mangrove area: 39,6 ha). Administratively, Panjang Island is bordered with Java Sea at north, bordered with Semujur Island at East, bordered with Bangka Main Island at South and West.

2.2 Tools and Materials

The tools and materials used in this study consists of Global Positioning System (GPS), water quality checker, underwater camera, identification book, bottle sample, roll meter, transect size 50 cm x 50 cm. Multitemporal imagery, reference map. In this research, multitemporal imagery used Data of Sentinel 2A imagery date acquisition Juny 6th 2021 and March 21st. Image processing Sentinel 2A and layouting map was processed using Qgis Software.

| Acronym | Band | Wavelength (nm) | Spatial Resolution (m) | Fuction |
|---------|------|-----------------|------------------------|---------|
| B1      | Violet | 443            | 60                  | Coastal and aerosol study |
| B2      | Blue  | 490            | 10                   | Features the surface water, bathymetry |
| B3      | Green | 560            | 10                   | Study of vegetation, land, sea, & sediment |
| B4      | Red   | 665            | 10                   | Comparing minerals, soil, vegetation slope |
| B5      | Red Edge | 705      | 20                   | Vegetation spectral to assess vegetation status |
| B6      | Red Edge | 740      | 20                   | Vegetation spectral to assess vegetation status |
| B7      | Red Edge | 783      | 20                   | Vegetation spectral to assess vegetation status |
| B8      | NIR   | 842            | 10                   | Biomass content and shoreline studies |
| B8b     | Red Edge | 865      | 20                   | Vegetation spectral to assess vegetation status |
| B9      | WaterVapour | 945    | 60                   | Water vapour studies |
| B10     | SWIR-Cirrus | 1380  | 60                   | Improved detection cirrus cloud contamination |
| B11     | SWIR 1 | 1610           | 20                  | Study detection soil water content & vegetation |
| B12     | SWIR 2 | 2190           | 20                  | Study detection soil water content & vegetation |

Source: USGS (ESA, 2012).

2.3 Method

This research use purposive sampling method. This research divided into 2 stage: 1) Image processing Sentinel 2A Imagery and coral reef ecology survei. Field sampling was carried out by measuring the physico – chemical parameters of sea water. Sampling of coral reefs used the line transect method. While the stages of image data processing could be explained as follows:

2.3.1. Stacking Band

Stacking band is a combination band become one layer data through overlay processing. Channel selection is based on a consideration of simplicity and easy operation, especially in image processing and classification [7].

2.3.2. Image Rectification (Geometric Correction)

According Lillesand and Kiefer (1990), Image Rectification is a process of transforming data from a grid system using a geometric transformation. The data of Sentinel 2A image was projected to Universal Transverse Mercator (UTM) coordinate system, Datum WGS 1984, Zone 48 South, Path/Row: 123/062. However, Sentinel 2A image data were compared with topographic map of Badan Informasi Geospasial with scale 1:50000. Geometric corrections were carried out to associate pixels in satellite images with their actual locations on the earth’s [5]. In its application, the location is usually
denoted by points that are measured directly on certain objects that are easily recognizable in the image, such as road junctions, river branches and others. This correction point is known as the ground control point (GCP) [8].

2.3.3. Radiometric Correction
Radiometric correction is a process to eliminate interference (noise) that occurs due to the influence of the atmosphere or due to the systematic influence of image recording [5]. Radiometric correction aims to improve the pixel value to match it as it should be, taking into account the atmospheric disturbance factor as the main source of error. Atmospheric effects cause the reflected value of objects on the earth’s surface recorded by the sensor to be not the original value, but to be larger due to scattering or smaller due to the absorption process [7]. To make corrections at this stage, a histogram adjustment method is used which is based on digital value processing by the sensor. The object that gives the lowest spectral response should have a value of 0, if this value exceeds the number 0 then that value is calculated as bias and correction is made by subtracting all values in the channel with the bias. The bias value in question is an assumption of the influence of the atmosphere on the propagation of electromagnetic waves [9].

2.3.4. Cropping Image
Cropping image is a one process in image processing with aims to crop layer data based on AOI (Area of Interest) Cropping the study area is intended to limit the study area. Cropping is in the pre-processing stage of digital images known as the image cropping process [10].

2.3.5. Band Composite and Image Sharpening
Composite band is a combination of several channels in one layer file, with the aim of facilitating image interpretation. The process of merging (composite) this band can be done for the classification process. The selection of the band to be used must be adjusted to the purpose of the classification. The selection of band combinations for observing coral reefs uses false color composites with a combination of RGB 421 atau 843. True color composites can use a combination of RGB 432 [5]. Image sharpening includes contrast enhancement, namely improving the appearance of the image by maximizing the contrast between lighting and darkening. Filtering is improving the appearance of the image by transforming the digital values of the image such as sharpening the boundaries of areas that have the same digital value [11].

2.3.6. Training Area
In this process, 30 training areas were created. Determination of the training area is carried out on objects that are visually suspected to be coral reefs. Furthermore, the calculation of variance and covariance from bands 1 and 2. This calculation is carried out to obtain the value of ki/kj which will be used in the Lyzenga transformation [11].

2.3.7. Lyzenga Transformation
This processing is intended to obtain information on basic water objects (water column correction), because the information obtained from the initial image is still mixed with other information such as water depth, turbidity, and movement of the water surface. This processing includes removing the effect of water, extracting information on seabed objects using a method based on the “Exponential Attenuation Model” by Lyzenga (1978) [12].

\[ Y = \ln (\text{Band 1}) + (ki/kj * \ln (\text{Band 2})) \] (1)

Information: Y is a Lyzenga algorithm results, Ln (band 1) is a natural logarithm of blue band, ki/kj is a varian and covarian value for blue band and green band. Ln (Band 2) is a natural logarithm of green band.

2.3.8. Masking
Masking is done to take the research area to be carried out by limiting the research area and other areas. Masking is also done to limit land and sea so that the classification process is easier to do [12].
2.3.9. **Unsupervised Classification**

Classification is a process to obtain images that have been grouped into certain classes based on the reflectance value of each object, making it easier for analysis and checking in the field [13]. The classification used is Unsupervised Classification.

2.3.10. **Ground Check and Image Rectification**

Ground check is carried out to equalize the results of primary and secondary data collection. To carry out a ground check, an accuracy test is carried out to determine the accuracy obtained from the interpretation of the image in the field. In this step also did coral reef ecology survey with using LIT (Line Intersept Transect). LIT is a method which can estimated coral reef condition based on Decree Minister of Environment No.04/2001-Criteria & Guidelines for Determining Coral Reef Damage) [14].

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**Figure 2. Flow chart Research**
2.4 Data Analysis

Accuracy Test of Imagery

The accuracy test of the interpretation results is a fairly effective method used to determine the accuracy obtained from the interpretation of images or aerial photographs with the actual conditions in the field. Mathematically, the accuracy formula can be formulated as follows [5]:

$$\text{Accuracy Test} = \frac{\text{Pixel of Correct Interpretation}}{\text{Total Observed Pixel}} \times 100 \quad (2)$$

Information of Coral Reef Changes

The calculation of the estimated area of coral reefs according to Akhrianti (2018), uses the following formula [5]:

$$L = \sum p \times r \times 0.0001 \quad (3)$$

Where: L is a coverage area (ha), \(\sum p\) is a pixel quantity, r is a spatial resolution Sentinel 2A imagery (10m x 10m), and 0.0001 (conversion value from m\(^2\) in ha). From the analysis, classification, and cross tabulation, we then carried out so that the changes in the area of the multitemporal data were known. The trend of mangrove changes that occur in each year of observation is used following the formula [5]:

$$\Delta L = \frac{(L_{t2} - L_{t1})}{L_{t1}} \times 100\% \quad (4)$$

Where: \(\Delta L\) : rate of changes area (%), \(L_{t1}\) : Area in the first year of observation (ha), \(L_{t2}\) : Area in the next year of observation.

3. Results and Discussion

Analyzing multitemporal satellite data using remote sensing and GIS Technology is very helpful for monitoring coral reef condition in Panjang Island. Further monitoring by time series satellite images is still needed to identify the changes of coral reef coverage area. Through analyzing Sentinel 2A Satellite data, this study able to know spatial distribution and coverage area from coral reef ecosystems (2016-2021). The results of the digital image accuracy test with field checks showed an accuracy value of 85%. From the results of the accuracy test that has been carried out, it can be said that by using a Lyzenga water column correction, it can improve image accuracy in mapping benthic habitats. The results of the Sentinel-2A image accuracy test using the Lyzenga water column correction as a whole are 80.73% [15]. Darmayanti (2012) added, there is some literature that states that the accuracy test can be said to be representative if the value is at least 80% [16].

Sentinel-2A satellite imagery is a high-resolution satellite image with a spatial resolution of 10 meters with a wavelength of 0.490 – 0.665 m. Detection of coral reefs using satellite imagery is by utilizing the reflectance value which is then recorded by the sensor [9]. The results of the classification of sentinel 2A images using the Lyzenga Algorithm are divided into 3 classes, namely Sea water, Coral reefs, Sand mixed with seagrass. Sentinel 2A imagery data has been classified with unsupervised classification. The classification images were followed by the field verification and accuracy assessment. The area of each coverage class is presented by Table 2.

| Years | Coral Reef (ha) | Mix Sand + Seagrass + algae (ha) | Amount |
|-------|----------------|----------------------------------|--------|
| 2016  | 475.96         | 573.04                           | 1049   |
| 2021  | 475            | 548                              | 1023   |

Based on Interpretation Result of Landsat TM 2017 by Marine Science Department [17]. Coral Reef area in Panjang Island is 475.96 Ha, it is same result from Image Processing with Sentinel 2A imagery.
imagery in 2016. There are wide changes of coral reef area in Panjang Island, and there are decreased coral reef area for 5 years (2016-2021). This result showed that people have good vision and highly supportive mindset to the coral reef conservation. Many people understand and realize that coral reef is very important to be protected and maintained because of their function to absorb abrasion and a place for coastal biota to live. Coral reef condition in Panjang Island (2016-2021) based on LIT result is presented by Table 3 (Secondary data: Document of Monitoring Organism in Bangka).

Table 3. LIT Result of Coral Reef Ecosystem in Panjang Island

| Life Form                                        | Coral Reef Condition (%) |
|-------------------------------------------------|--------------------------|
| Hard Coral: Acropora Branching (ACB)             | 1,00 0                   |
| Hard Coral: Acropora Digitate (ACD), Coral Foliose (CF), Coral Massive (CM), Coral Massive Rubber (CMR), Coral Sub massive (CS) | 74,43 66,01 |
| Hard Coral: Acropora Encrusting (ACE), Acropora Sub massive (ACS), Coral Encrusting (CE) | 0,00 23,29 |
| Algae: Halimeda (HA), Turf Algae (TA)           | 13,80 5,90               |
| Algae: Dead Coral with Algae (DCA)              | 0,00 1,80                |
| Other fauna: Zoantids (ZO), Sea Cucumber (SC), Other (OT) | 2,70 0,00 |
| Abiotik: Rubber (R)                             | 8,00 0,00                |
| Abiotik: Silt (SI) and Sand (S)                 | 0,00 3,30                |
| Amount                                          | 100,00 100,00            |

Information: % Life Form: 75,43% (2016), 89,33% (2021)  
Coral Reef Mortality : 0 (2016), 0,054% (2021)

Tin (Sn) mining activity in Panjang Island was not found. But surrounded area in Panjang Island such as the coastal area of Pangkalpinang and coastal area of Central Bangka (Kurau, Pangkalan Baru Tanjung Gunung, Baskara Bakti, etc) which is a lot of floating Tin Mining found. Formerly, the coral reef coverage area was decreased by the higher anthropogenic activities. But the coral reef condition could be visually observed in good status with life form 75,43% (good) in years 2016 tends to increase in years 2021 approximately 89,33%. The condition of the coral reef ecosystem is in a good category, high sand cover and Dead Coral Algae in some places indicate the need for more intensive management efforts, in order to preserve the existing coral reef ecosystem [19]. In general the value of the Mortality Index in 2 years of observation still shows environmental conditions that support coral life so that the coral mortality ratio is relatively low [20], and this is also supported by the standard criteria for coral reef damage which are classified as good category based on Decree of the Minister of Environment No.04/2001-Criteria and Guidelines for Determining Coral Reef Damage (Figure 3).

Based on interview in research location, the result showed that alot of people have to good perception and open minded about Marine Protect Area in Panjang Island. There are so many human activities such as Tin Mining where operated at surrounded Panjang Island, it’ show that a little influence significantly for coral reef changes [21]. Local people espeicaly Batu Belubang people who highly support the coral reef conservation to protect Island. Beside that there are fish shelter and coral reef transplantation had done by CSR can be support to repairing poor coral reef in Panjang Island [22].
Figure 3. (a) RGB:432 (Lyzenga transform – 2016); (b) RGB:432 (Lyzenga transform – 2021)

4. Conclusion
Coral reef area in 2016 is amount of 475,96 ha and coral reef area in 2021 is amount of 475 ha. The coverage area of coral reef in 2016-2021 decreased by 0.96 ha. This research concludes that coral reef distribution could be well classified using Sentinel 2A with accuracy of approximately 85%. The condition of coral reef ecosystems in Panjang Island in 2016 is 75.43% (Good), whereas in 2021 is 89.3% (Good).

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