GIS Application and Remote Sensing for Monitoring the Changing of Coral Reefs in Belitung Regency

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Abstract. Coral reefs are one of the most important and the most vulnerable marine ecosystem in the world. The coral reefs can be damaged, because of environmental factors and human activities, such as overfishing and polluted activities. Bangka Belitung islands are one of the provinces in Indonesia that have a huge potential of coral reefs, which are likely being damaged. This study aims to analyze the changing of coral reefs that occurred in the islands of tourist destinations in Belitung Regency from 2005 to 2018. This study used Landsat satellite imageries such as Landsat 5 TM for 2005, Landsat 7 ETM+ for 2011, and Landsat 8 OLI/TIRS for 2018. In this study, the changes of coral reefs will be determined by image data processing. Then, overlay methods are used to analyze the changes. In 2005, the coral reefs had an area of 4.68 km², but in 2011, the coral reefs area changed to 2.45 km². Then, in 2018, coral reefs have changed to 2.04 km². In the year of 2005 and 2011, the area of coral reefs has decreased around 2.23 km². While in 2011 and 2018, the area of coral reefs has decreased around 0.41 km².

1. Introduction
Coral reef ecosystem is one of the most beautiful, ancient, and the most complex ecosystem that exists on this planet. Coral reefs are a shallow-water ecosystem that consist of reefs made of calcium carbonate which is mostly secreted by reef-building corals and encrusting macroalgae [1]. This ecosystem is located between 30° North and South of the Equator [2]. The total area of tropical and subtropical coral reefs in the world around 617,000 km² [3]. One of the countries in the world with the most extensive coral reef area is Indonesia. Indonesia has the most extensive coral reefs in the world, with percentage of 12-15% [3].

Coral reefs in Indonesia marine ecosystem have the highest marine biodiversity and the most beautiful in the world. With the richest and most extensive coral reefs in the world, Indonesia might have more species than other countries [4]. Indonesia has the most extensive coral reefs in Southeast Asia with the area between 17,500 km² to 85,707 km² depends on various criteria used by the scientists [5]. The total area of the coral reefs in Indonesia is 2.5 million acres [6].

Bangka Belitung is one of the provinces in Indonesia which has the potential of coral reefs and is one of the favorite tourist destinations that is easily accessible. Based on the results of the interpretation of Landsat Imagery, coral reefs in islands of Bangka Belitung covering an area of

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29,662.11 ha in six regencies [7]. Belitung Regency has the most extensive coral reefs area in Bangka Belitung Province [7]. It has 14,750.43 ha of coral reefs. Followed with East Belitung Regency with 8,749.97 ha, South Bangka Regency with 2,170.43 ha, Central Bangka Regency with 1,960.77 ha, West Bangka Regency 1,952.05 ha, and Bangka Belitung Regency with 78.48 ha. Belitung as the regency with the most extensive coral reefs in Bangka Belitung Islands, making it as a tourist attraction for snorkeling and diving that located in area near Lengkuas Island. However, the beauty of the coral reefs are already damaged. The coral reefs can be damaged, because of environmental factors and human activities, such as overfishing and polluted activities. Thus, this research aims to analyse the changing of coral reefs that occurred in the islands of tourist destination in Belitung Regency from 2005 to 2018.

2. Materials and Methods

The research area is located in Belitung Tourism Destination in Belitung Regency. Belitung Regency lies between 107°08’E to 107°58’E and 02°30’S until 03°15’S with total area 229,369 ha or approximately 2,293.69 km². Geographically, the north of Belitung Regency has boundaries with the South China Sea, the east is bordered with East Belitung Regency, the south is bordered with Java Sea, and the west has boundaries with Gaspar Strait. Belitung Tourism Destination that exists in Belitung Regency consists of several islands. The islands that frequently visited by tourists are Batu Garuda Island, Pasir Island, Batu Berlayar Island, Lengkuas Island, Burung Island, Kepayang Island, and Kelayang Island.

Data that used in this study is Landsat 5 TM for 2005, Landsat 7 ETM+ for 2011, and Landsat 8 OLI for 2018. The images were downloaded from the United States Geological Survey (USGS) of path 122 and row 62. All imageries were geo-referenced to Universal Transverse Mercator (UTM) map coordinate system.

In this study, lyzenga’s water column correction algorithm is used to classify undersea object surface such as coral reefs, sand, and deep sea. Lyzenga’s method still the best option to be applied in the area with lack water optical data [8]. The composite image that uses in this study is 3-2-1 for landsat 5 TM and landsat 7 ETM+, and 4-3-2 for landsat 8 OLI. To analyze the changes of the coral reefs area, overlay methods are used.

3. Result and Discussion

3.1 Coral Reefs in Belitung in 2005-2018

Based on digital image data processing and interpretation of Landsat-5 TM path 122 row 062 years 2005, Landsat 7 ETM year 2011, and Landsat 8 OLI year 2018, the area of each class can be known in table 1.

| No. | Class      | 2005       | Percentage | 2011       | Percentage | 2018       | Percentage |
|-----|------------|------------|------------|------------|------------|------------|------------|
| 1   | Coral Reefs| 4.68       | 11.56      | 2.45       | 6.06       | 2.04       | 5.05       |
| 2   | Sand       | 1.26       | 3.11       | 2.51       | 6.21       | 2.59       | 6.41       |
| 3   | Land       | 7.52       | 18.59      | 7.52       | 18.59      | 7.52       | 18.59      |
| 4   | Sea        | 26.99      | 66.73      | 27.96      | 69.14      | 28.29      | 69.95      |
|     | Total      | 40.44      | 100        | 40.44      | 100        | 40.44      | 100        |

Source: Data Processing, 2018
The results of classification illustrate that in the islands of tourist destination is dominated by the sea with an average percentage of 68.61%. Mainland and islands have only an average percentage of 18.59%, while an average percentage of sand is 5.24%. The coral reefs area have changed for years. In 2005, the coral reefs had an area of 4.68 km$^2$, or about 11.56% but in 2011, the coral reefs area changed into 2.45 km$^2$ or about 6.06%. Then, in 2018, coral reefs have changed into 2.04 km$^2$ or 5.05%. The distribution of coral reefs spread around mainland, Lengkuas Island, Burung Island, Kepayang Island, Pegadoran Island and Batu Garuda Island. The distribution of coral reefs each year can be seen in the map of coral reefs in Belitung Tourism Destination in Belitung Regency in figure 1, 2, and 3.
3.2 Coral Reefs Changing in Belitung in 2005-2018

Based on overlay analysis, in the year of 2005 and 2011, the area of coral reefs has decreased around 2.23 km$^2$ or 47.59%. While in 2011 and 2018, the area of coral reefs has decreased around 1.26 km$^2$ or 16.70%. It is inferred that there is a slow down in the decreasing of the coral reefs that can be seen in table 2. as shown in figure 4 and figure 5, it can be seen that the changes in the decrease area, marked in red color, shows greater decreasing in figure 4 compared to figure 5.

| Table 2. Coral Reefs Changes in Belitung in 2005-2018 |
|-----------------------------------------------------|
| No. | Class       | Area Changing |
|     |             | Area (Km$^2$) | Decreasing Percentage |
| 1   | 2005-2011   | 2.23          | 47.59                  |
| 2   | 2011-2018   | 0.41          | 16.70                  |

For details, in years, there is an increased, decreased, and the unchanged coral reefs. In the year of 2005 and 2011, the unchanged area of coral reefs is 1.26 km$^2$, while the increased area is 1.19 km$^2$ and the decreased area around 3.41 km$^2$. In 2011 and 2018, the unchanged area of coral reefs is 1.09 km$^2$, while the increased area is 0.95 km$^2$ and the decreased area around 1.36 km$^2$.

| Table 3. Coral Reefs Changes in Belitung in 2005-2018 |
|-----------------------------------------------------|
| No. | Category | 2005-2011 | 2011-2018 |
|     |          | Area (Km$^2$) | Area (Km$^2$) |
| 1   | Unchanged | 1.26          | 1.09        |
| 2   | Increased | 1.19          | 0.95        |
| 3   | Decreased | 3.41          | 1.36        |

**Figure 4.** Map of Coral Reefs Changing in 2005 and 2011

**Figure 5.** Map of Coral Reefs Changing in 2011 and 2018

3.3 Field Survey

Based on verification in the field, it is proved that the coral reefs in figure 3 have the same condition in the field. If the condition of coral reefs in figure 3 are in good condition, then they will be in the good
condition or unchanged or increase in figure 5. However, if the condition of coral reefs are in damaged condition, then it will be in damaged condition or decreased in figure 5. To make it clear, the condition of the coral reefs in the field can be seen in figure 6, figure 7, figure 8, and figure 9. These figures showed the sample points in every island. These points indicate the locations of coral reefs that have physically damaged or bleached shown by the color changing of the coral reefs that have turned into white.

4 Conclusion
Based on result and discussion, the coral reefs area has changed for years. In 2005, the coral reefs had an area of 4.68 km², or about 11.56%, but in 2011, the coral reefs area changed into 2.45 km² or about 6.06%. Then, in 2018, coral reefs have changed into 2.04 km² or 5.05%. In other words, in the year of 2005 and 2011, the area of coral reefs has decreased around 2.23 km² or 47.59%. While in 2011 and 2018, the area of coral reefs has decreased around 0.41 km² or 16.70%.
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