Analysis of the utilization of landsat 8 oli imagery for mapping the distribution of coral reefs in Pulau Weh Sabang

by Sugiharto Dkk

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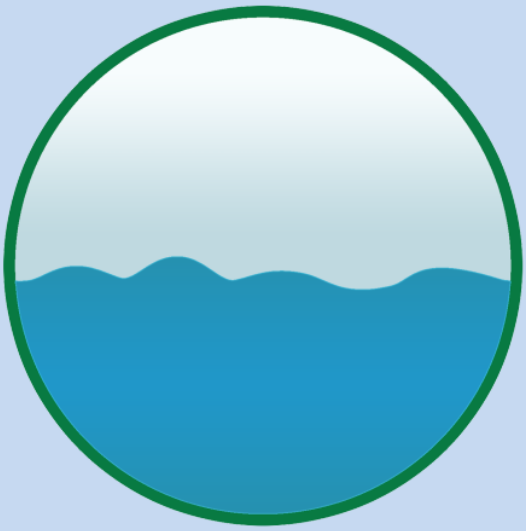

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Analysis of the utilization of landsat 8 oli imagery for mapping the distribution of coral reefs in Pulau Weh Sabang

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ABSTRACT

As one of the largest archipelagic countries globally, Indonesia has diverse natural resources, one of which is the coral reef ecosystem. Coral reef ecosystems are spread across almost all Indonesian waters, and Pulau Weh Sabang is one distribution area. This study aims to determine the distribution of coral reef ecosystems and test landsat 8 oli imagery accuracy in mapping coral reef ecosystems. The method used in this research is the nearest neighbour algorithm object-based classification method. The results showed that the coral reef ecosystem in Pulau Weh Sabang was divided into two classes: a healthy coral reef ecosystem class with 277.38 hectares and a medium condition coral reef ecosystem class with an area of 710.01 Ha.

Introduction

Indonesia is one of the countries that have abundant natural resources. As one of the largest archipelagic countries and significant natural resources, the Indonesian archipelago has various marine ecosystems, both those that live in shallow seas and those that live in the deep sea. Dahuri (2003) suggests that coastal ecosystems' characteristics can be classified into artificial ecosystems and natural ecosystems. One of the natural ecosystems located in the coastal zone is the coral reef ecosystem. Koroy (2020) argues that coral reefs have distributed throughout Indonesia's territorial waters with varying conditions, both in type and quantity. According to Tangke (2010), coastal ecosystems generally consist of three components: sea, coral reefs, and mangroves.

Nybakken (2001) suggests that coral reef ecosystems are shallow marine organisms whose organic productivity is very high compared to other organisms and is typically found in tropical areas. The increased productivity of coral reef ecosystems is because the coral reef ecosystem has various benefits for the surrounding ecosystem and human life, such as fish spawning grounds, habitat and food sources, coastal protection, and carbon sinks. The coral reef ecosystem also has economic benefits as a marine tourism attraction. The existence of coral reef ecosystems is spread across almost all coastal areas of Indonesia with various conditions and characteristics. According to Hadi *et al.* (2018), based on observations at 1067 points, Indonesia's coral reefs are divided into several conditions: poor condition by 36.18%, moderate condition by 34.3%, and good condition 22.96%, and excellent condition by 6.56%. Muhsoni (2011) stated that human activities threaten 88% of coral reefs threatening biological and economic values that are very important for human life. 50% of the endangered coral reefs are at very high threat levels, only 12% are at low threat levels. According to Lutfi and Anugrah (2017), the condition of coral reefs is currently experiencing damage and decline caused by various activities, including bombing fish, fishing using toxic materials, illegal trading of ornamental corals, and climate change. Several studies on the damage to

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coral reef ecosystems due to human activities, among others, were put forward by Uar *et al.* (2016); several human activities that damage coral reefs are fishing using fish bombs, arrows, nets, traps, taking coral for decoration and building materials. Meanwhile, research conducted by Jubaedah and Anas (2019) stated that marine tourism in the Nusa Penida marine conservation area impacted reducing the scope of coral reefs by 4%.

One of the areas in Indonesia that has a coral reef ecosystem is Pulau Weh Sabang. Pulau Weh is a marine conservation area managed by the Traditional Laot Institution system following the Sabang Mayor Number 729 of 2010 concerning the Sabang Island Coastal Marine Protected Area's Reservation. According to Hastuty (2014), the eastern coastal area of Pulau Weh is unique in its management system, namely using local wisdom (customary law), which had been implemented long before this area was designated as a conservation area.

Coral reef ecosystems must be well managed, and following the conditions of life that can be tolerated by coral reef ecosystems such as salinity levels, water temperature, pH, and human activity factors, this is because coral reef ecosystems have very little growth every year (Dahuri *et al.*, 1996). The low growth rate of coral reef ecosystems and the high human need for coral reef ecosystems today and in the future requires a method that is relevant, effective, and efficient in managing coral reef ecosystems so that that coral reef ecosystems can be managed sustainable, one of which is using remote sensing technology.

The development of remote sensing technology to manage coral reef ecosystems is inseparable from technology's rapid growth. Currently, remote sensing technology for coral reef ecosystems varies significantly with the availability of low-resolution imagery to high-resolution imagery. Coral reef management can be carried out sustainably. According to Sutanto (1992), remote sensing images have advantages, including pictures depicting objects, areas, and symptoms on the earth's surface following the shape of the original object. The use of remote sensing technology is very effective in various aspects such as cost efficiency, time, and human resources to monitor changes and management of natural resources, incredibly natural resources in shallow waters and coastal areas (Mumby *et al.* 1999; Green *et al.* 2000; Maeder *et al.* 2002; Lillesand *et al.* 2004; Zhigang *et al.* 2008; Tamondong *et al.* 2013 in Fahriansyah *et al.* 2017).

Research on the use of remote sensing images with various resolutions for shallow water ecosystems has been carried out before, including Hafizt *et al.* (2017) with the title study of the LANDSAT 8 OLI image classification method for benthic habitat mapping in the Padaido Islands, Papua with image accuracy results of 47.57% for multispectral classification and 36.17% for the object-based category. Nababan *et al.* (2018), with the title research object-based benthic habitat mapping using sentinel images in the waters of Wangi-Wangi Island, Wakatobi Regency with the accuracy of sentinel-2 images using object-based classification, which has an accuracy value of 60.4% for 12 benthic habitat classes and 64.1% for nine benthic habitat classes.

Based on previous research, this study aims to map the distribution of coral reef ecosystems on Weh Sabang Island and test the accuracy of LANDSAT 8 OLI (Operational Land Imager) imagery in mapping the distribution of coral reefs. This study produces data that can be used as a reference for the management of coral reef ecosystems on Weh Sabang Island. The condition of the coral reef ecosystem on Weh Sabang Island can be preserved and can be used for economic development in the management of sustainable marine tourism. This research must consider that coral reefs will easily change due to various natural factors and human activity factors.

Materials and Methods

Location and time of research

This research was conducted from August - October 2020. Geographically, Weh Sabang Island is located between $95^{0}12'00"$ - $95^{0}16'00"$ BT and $5^{0}51'00"$ - $5^{0}55'00"$ LU. Weh Sabang Island is part of the Sabang City administration, with a land area of 121.7 km^2 and a water area of 920.05 km^2. From a geographical perspective of Indonesia, the Weh Sabang Island region is the westernmost administrative area and directly borders neighbour countries, namely Malaysia, Thailand, and India (Badan Pusat Statistik, 2019). The coast of Pulau Weh Sabang is a Marine Conservation Area which was determined based on the decision of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 57/KEPMEN-KP/2013. For more details, the research location can be seen in Figure 1.

Research tools and materials

The tools used in this study consisted of ENVI 5.1 software, e-Cognition 9.0 software, eutech instruments, handheld reference meters, Global Positioning System (GPS), and cameras. Meanwhile, the research materials used included LANDSAT 8 OLI (Operational Land Imager) imagery recorded on

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June 25, 2020, a 1: 50,000 scale RBI map of Pulau Weh Sabang (Sheet number 0421-53 and 0421-54), and coral transect data from field surveys.

Research stages

The research stages consisted of literature studies, image data acquisition (USGS Eart Explore), digital image processing, coral reef distribution analysis, and field surveys. The field survey aims to directly see whether the condition of coral reefs follows the results of tentative map and to determine the factors of damage to coral reefs caused by natural and human factors. The biological factor in this study is the condition of the waters of Weh Island, Sabang. The image processing stages used in the study consist of (1) image correction (geometric and radiometric), (2) masking and classification, and (3) field survey (based on the tentative map). For more details, the stages of the research can be seen in Figure 2.

This study uses image data recorded in June 2020. The LANDSAT 8 OLI image is an L1-T (level one terrain corrected) image that has been free from sensor errors, so there is no need for geometric corrections anymore. Meanwhile, the radiometric corrections carried out include converting the Digital Number (DN) value to the radian spectral value, converting the radian spectral value to the reflectance spectral value, Fast Line of sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) correction, Sunglint correction, and Water Column correction. The technique used in image masking is a visual technique based on Pulau Weh Sabang's administrative area. Image classification used in this study is using the object-based segmentation and classification (OBIA) nearest neighbour algorithm. According to Simamora *et al.* (2015), OBIA classification is a classification approach with advantages over other classifications because OBIA classifies by considering the object's spatial aspects.

The field survey was conducted in August-October 2020 based on a tentative map of LANDSAT 8 OLI image data processing recorded in 2020. This research field survey used the photo transect method developed by Roelfsema and Phinn (2009). This method is effective because it records all objects at the sampling point in the form of photographs. Coral reef information will be obtained in qualitative and quantitative states, such as the percentage of cover, composition, and coral reef ecosystem conditions.

Figure 1. Research location map.

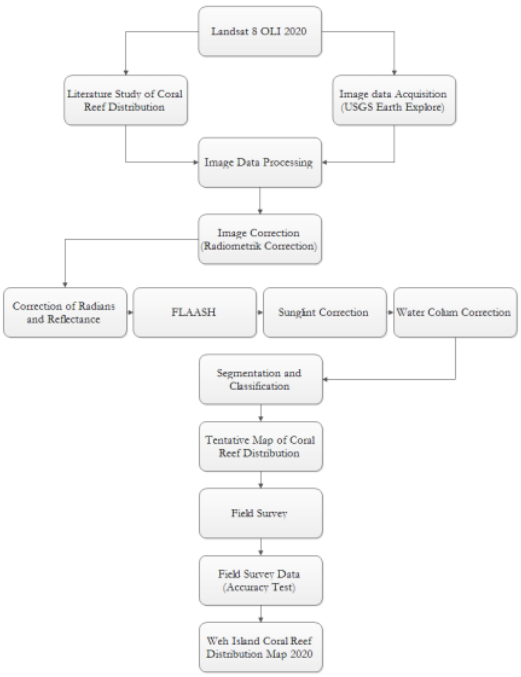

Figure 2. Framework for the stages of coral reef distribution research.

Results

Distribution of coral reefs

Mapping of coral reef ecosystem distribution is obtained based on the nearest neighbour algorithm object-based classification. The object-based classification process (OBIA) consists of image segmentation and image classification resulting from segmentation. Mapping the distribution of coral reef ecosystems in object-based classification begins with the image segmentation process and segmentation sampling for each object of the coral reef ecosystem.

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The distribution of coral reefs was obtained by analyzing the results of image classification and field surveys. For more details, the distribution of the coral reef ecosystem on Pulau Weh Sabang in 2020 can be seen in Table 1 and Figure 3.

Table 1. Distribution of coral reef ecosystem extensions in Pulau Weh Sabang.

No	Coral Reef Class	Ecosystem Area (Ha)	Percentage (%)
1.	Healthy Coral Reef Ecosystem	277,38	28,10
2.	Medium Coral Reef Ecosystem	710,01	71,90
	Amount	987, 39	100

Source: Data Processing (2020).

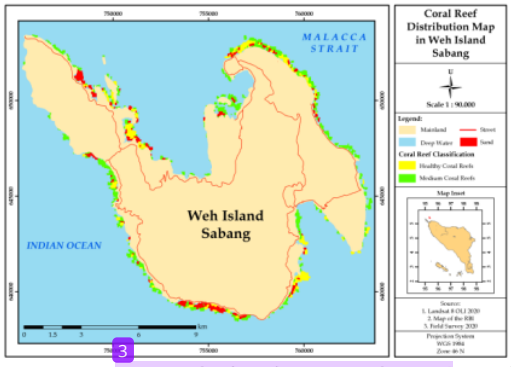

Figure 3. Map of distribution of coral reefs ecosystems in Pulau Weh Sabang 2020.

Image classification

The results of the object-based classification, the distribution of coral reef ecosystems on Weh Sabang Island, were only classified into two classes, namely the healthy condition coral reef ecosystem class with an area of 277.38 Ha (28.10%) and the coral reef ecosystem class in medium condition with an area of 710.01 Ha (71.90%). Based on image classification results, there are sand objects that dominate the distribution of coral reefs. The number of sand objects is due to damaged and dead coral reefs, so the classification results are detected as sand. For more details, the coral reefs on Pulau Weh Sabang can be seen in Figure 4 and 5.

Water conditions

Based on the Pulau Weh area's field survey data, the water temperature ranges from 29.6^{0}C-30.9^{0}C, the salinity level varies from 33.17‰-32.96‰, and the pH ranges from 8.44-8.56. Based on these data, Pulau Weh Sabang's waters have a temperature greater than 0.9^{0}C and a pH level greater than 0.6 than the tolerance value that the coral reef ecosystem can accept. Changes in the composition of benthic habitats can occur due to various sustainability factors, such as human activities and natural disasters. This is because the habitat benthic have different tolerance limits to sustainability factors. Some biological factors influence changes in the composition of the benthic habitat between temperature, salinity and other pH levels outside benthic habitat tolerance limits. While characteristics of human activity that damage in the form of underwater tourism activities that are not taking into account the conditions of benthic habitats and ship fuel disposal (Rahmadi, 2017)

Image accuracy test

The accuracy test is the final stage to determine the accuracy of the distribution map of coral reef ecosystems. The accuracy test is carried out on the corrected image using a field survey sample. In this study, the accuracy-test used an error matrix table (Confusion matrix). Based on image classification and data to the field, the accuracy-test results of the distribution mapping of coral reef ecosystems in Pulau Weh Sabang are 57%. The low accuracy of mapping the distribution of coral reef ecosystems occurs because of the low quality of images and many atmospheric disturbances.

Discussion

Based on data from the classification results of the image classification of the coral reef ecosystem class on Weh Sabang Island, the coral reef area is equal to 987.39 Ha which is divided into two categories, namely a healthy class coral reef ecosystem of 277.38 Ha and a medium-class coral reef ecosystem of 710.01 Ha. The low classification level of the coral reef ecosystem class is due to several factors, namely the quality of the image, which has many atmospheric effects, and the sunglint effect. In classifying the image, data can only detect two objects of coral reef class. According to Danoedoro (2012), the accuracy of satellite image data processing accuracy is determined by the image resolution used.

The results of previous research conducted by Souisa and Makailipessy (2017) on the waters of the Tayando District, LANDSAT 8 OLI image was only able to detect the bottom substrate of the waters consisting of fine sand, sand mixed with dead coral debris, dead coral, coral reefs, and seagrass. In another study conducted by Fadhli and Pin (2018) in the waters of Karawang in the LANDSAT 8 OLI image, there is a difference between the results of the mapping and the field survey where in the field survey there are 11 clusters of coral reefs, while the mapping results only classify nine groups of coral reefs.

Figure 4. Condition of Healthy Coral Reef in Pulau Weh Sabang

Figure 5. Condition of Medium Coral Reefs in Pulau Weh Sabang

The coral reef ecosystem on Pulau Weh Sabang is scattered in almost all of Weh Island's water areas, with different conditions for each distribution. The distribution of coral reef ecosystems in a healthy state is dominant in the regions that are the center of coral reef conservation, namely, Rubiah Island waters, Gampong Iboih waters, Gampong Gapang waters, Kasih coastal waters, elephant tread coastal waters, and the southern part of Weh Island. Meanwhile, the distribution of coral reefs is almost evenly distributed throughout the waters of Pulau Weh Sabang. The implementation of the marine conservation area (Watershed Nature Reserve) of Pulau Weh Sabang was determined based on the Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 57/KEPMEN-KP/2013.

According to Rusman *et al.* (2017), coral reefs on Weh Island, Sabang consist of 11 species, namely *Acropora Cytherea, Acropora digitifera, Acropora Humilis, Acropora Hyacinthus, Acropora Rosaria, Favites Abdita, Favites Acuticolis, Goniastrea Pectinata, Montipora SP, Pocillopora Verrucosa,* and *Porites australiensis*.

The coral reef is an ecosystem that has high productivity and is very sensitive to water conditions. Coral reef growth is determined by good water conditions and is below the tolerable limits of coral reefs. According to (Wisha *et al.* 2019), Weh Island is one of the outer islands of the Indonesian Territory, which is directly adjacent to the Indian Ocean. Water circulation that occurs in the waters of Pulau Weh is influenced by processes that occur in the Indian Ocean, such as the monsoon cycle and the Indian Ocean Dipole, thus affecting sea surface temperature that occurs in the waters of Pulau Weh. Marshall *et al.* (2012) suggest that coral reefs have acceptable tolerance limits for their survival. If they are excessive or deficient for an extended period, it will result in coral bleaching. According to the Decree of the Minister of the Environment (2014), coral reefs have temperature tolerance limits between 28^{0}C-30^{0}C, salinity ranges from 32-35‰, and pH ranges from 7-8.5. Maududi and Lutfi (2018) stated that the quality of the water parameters greatly determines the survival of biota in each marine ecosystem. Temperature changes can affect coral reefs' survival process that involves chemical, physical, and biological processes in water bodies. Changes in temperature of 1^{0}C-2^{0}C will put pressure on coral reefs to turn white for a long time.

Meanwhile, the high pH value in the waters of Pulau Weh Sabang is due to the high concentration of carbon dioxide in the atmosphere, where the carbon dioxide released by the sea returns to the atmosphere. The absorption of carbon dioxide in the oceans depends on its concentration in the atmosphere. It is closely related to sea surface temperature, currents, and the level of biological activity in the oceans (Marshall *et al.*, 2012).

The accuracy test is the final stage to determine the accuracy of the distribution map of coral reef ecosystems. The accuracy test is carried out on the corrected image using a field survey sample. In this study, the accuracy-test used an error matrix table (confusion matrix). Based on image classification and data to the field, the accuracy-test results of the distribution mapping of coral reef ecosystems in Pulau Weh Sabang are 57%. The low level of accuracy of mapping the distribution of coral reef ecosystems occurs because of the many atmospheric disturbances. Green *et al.* (2000) suggest that remote sensing image data accuracy that can be used as a reference for further research is >60%. The low level

of accuracy obtained in the final results of this study is due to several things, namely the number of coral reef classes, the number of observation points made, and the unfavourable condition of the image data.

The LANDSAT 8 OLI imagery in this study has not detected coral reefs correctly and provides maximum classification results due to several things, namely poor image quality (numerous atmospheric effects during recording) and low resolution (30 meters).

Conclusion

Based on the results of the study, it can be concluded that the distribution of coral reef ecosystems in Pulau Weh Sabang is divided into two classes, namely a healthy coral reef ecosystem class of 277.38 Ha (28.10%) and a moderate condition coral reef ecosystem class of 710.01 Ha (71.90%). The accuracy test for LANDSAT 8 OLI imagery for mapping the distribution of coral reef ecosystems in Pulau Weh Sabang is 57%.

The results of this study still need further research to determine the level of accuracy of the LANDSAT 8 OLI image data in the development of coral reefs on Weh Sabang Island by using different methods and extraction of image data so that that image capabilities can be seen and provide additional accuracy and classification results. in the coral reef

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