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DETECTION OF CHANGING SHALLOW WATER SEABED USING REMOTE SENSING

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ABSTRACT: The manual data collection of shallow water seabed generally acquire in Indonesia. Remote sensing technology offers a new approach method to obtain the descriptive data using satellite image interpretation. However, remote sensing requires field verification to obtain a more appropriate object quantitatively. Data and materials used in this research are Landsat 7-ETM+ image, *path/row* 122/064 recorded at August 29, 1999 and Landsat 7-ETM+ image, *path/row* 122/064 recorded on March 31, 2003. Data processing uses Lyzenga Algorithm and Unsupervised Classification. Lyzenga Algorithm for 1999 is Y = ln (TM1) + 0.841049313 (TM2) and Lyzenga Algorithm for 2003 is Y = ln (TM1) + 0.867053991 (TM2). After the classification, the result indicate that the width size of coral reef increased from 671.631 to 826.728 ha (1999 to 2003), the width size of sea grass decreased from 544.076 to 48.539 ha (1999 to 2003) and the sand width increased from 475.687 to 534.2562 ha (1999 to 2003). This research suggests that the data acquired from remote sensing could be used to detect the changes of shallow water seabed.

KEY WORD: Remote Sensing, Lyzenga Algorithm, Unsupervised Classification, Shallow Water Seabed

1. Introduction

Changes in shallow water seabed are important following the need to understand the natural seabed phenomenon, especially in respect to the change in coral reef with its impact on environment degradation. Data, information and knowledge about the width change of coral reef, sea grass, and sand at shallow water seabed would be supportive to the overall national marine and fisheries development. More specifically, the local government would be enriched with such data and information for their regional development planning and development.

The technique to obtain data and information about the abovementioned changes is important in the attempt to have a more accurate and valid data. Following this method, tools to apply for analysis would be also given priority. Technique used for similar purpose may vary according to tools availability and its suitability with certain location specific as these tools could react differently. Remote sensing technique would be appropriate to use in the detection of changing shallow water seabed taking into account its flexibility, wider area coverage, and smoothness of the responded image.

Remote sensing is an art or knowledge to get some information about some objects, the area or phenomena through the data analysis obtained by tools and or without direct contact with the reviewed object, area or phenomena (Lillesand and Kiefer, 1990). There are four physical components used in the system of remote sensing, namely, (a) sun as resource energy in the form of electromagnetic radiation, (b) atmosphere as a trajectory media from electromagnetic radiation, (c) sensor as a function to detect the electromagnetic radiation and change it into signal which can process or record, and (d) object as something that detected by the satellite (Butler *et al.,* 1988).

The ability of electromagnetic radiation to penetrate the water column is very important if the objective is to have some information about the changes condition or phenomena occurred at the bottom of the water. In connection with shallow water mapping using satellite image Lillesand and Kiefer (1990) declared the best probability is using the range of wavelength from 0.48 µm – 0.60 µm. To show more about the object from the bottom of the bottom water, Siregar (1996) suggests that with the combine of natural logarithm of two canals visible light, new image that show bottom water will be obtained in a more informative response. In this research, the approach that had been applied to get the algorithm is the one developed by Lyzenga (1978), which is the Exponential Attenuation Model.

Lyzenga (1978) stated that the reflectance from the bottom water could not be observed directly from the satellite because of the affect of the absorption and scattering in the layer of water surface. It can be count, if at any point in that region known the depth and the water optical characteristics. This principal is a basic in the development of combine information technique from several canals spectral to determine depth-invariant index. Input parameter in this algorithm is a comparison between several water attenuation coefficients on several canals spectral. This algorithm taken the information of substrate in the bottom water based on the fact that the bottom reflectance signal verge linier functions from the reflectance of bottom water and exponential function from depth. As earlier mentioned, the formula used in this research is the Exponential Attenuation Model, which could be expressed as follows:

$$L_{i(H)} = L_{i\infty} + (A_i - L_{i\infty})^{-2K_iH}$$

where : $L_{i(H)}$ is the canal i reflectance with the depth H (m)
$L_{i\infty}$ is the canal i reflectance from deep sea
A_i is the canal i bottom albedo
H is the depth of the water (m)
K_i is the canal i water attenuation coefficient (m^{-1})

Smith, *et al.* in Jupp, *et al.* (1985) used remote sensing to monitor the area of shallow water and the image was taken from Landsat-MSS satellite. They mapped the biophysics region of coral reef and made an inventory of the Great Barrier Reef (Australia) natural resources. However, shallow water seabed mapping have some difficulties and limitations, based on radiative transfer theory that the penetration ability of visible light (blue) wavelength at 20 m depth is only 60% (Engman and Gurney, 1991).

Satellite image is one of the spatial data sources that used in remote sensing. There are a lot of remote sensing satellite types, and one of that many is the Satellite Landsat 7 ETM+. In this research, the remote sensing for mapping shallow water uses the characteristic electromagnetic radiation in the range of visible light. This spectrum can penetrate water column through the bottom of the water, and this is the reason that substrate in the bottom of the shallow water could be detected. To detect the substrate at the bottom of the shallow water using Landsat 7 ETM+ are the canal 1 (blue) 0.45 µm – 0.52 µm, the canal 2 (green) 0.52 µm – 0.60 µm, and the canal 4 (red) 0.61 µm – 0.73 µm.

With this description, the main objective of this research is to investigate the changes of shallow water seabed on coral reef, sand, and sea grass in the Southern Kepulauan Seribu of Jakarta Province. The result is expected to provide valuable data and information to improve policy formulation in marine and fisheries development.

2. Method

The materials used in this research are Landsat 7 ETM+ image path/row 122/064 recorded at August 29, 1999 and March 31, 2003. This is the prerequisite before moving into the next step, which is the image processing. Geometric correction is the first step to process such images. The formation of composite image is required to have the prevailing description about the data and three different canals composite (canal 421 or 542) are needed to determine the control points for geometric correction process.

Image cropping is applied for image boundary to obtain the proper area as required by this research. The proper area is taken from the large area of Landsat IFOV (Instantaneous Field Of View). The transformation used in this research is Lyzenga Algorithm developed by Siregar (1996) for Indonesian ocean which could be stated as follows:

$$Y = \ln (TM_1) + k_i / k_j \ln (TM_2) \qquad (1)$$

Y = equation for extration of water seabed
TM_1 = digital value of canal 1
TM_2 = digital value of canal 2
k_i / k_j = value of attenuation coefficient

where

$$k_i / k_j = a + \sqrt{(a^2+1)} \qquad (2)$$

with

$$a = (\text{var } TM_1 - \text{var } TM_2) / (2 * \text{covar } TM_1 TM_2) \qquad (3)$$

var = variance from digital value
covar = covariance from digital value

Image classification is a process to classify the image into several different classes. In this research, the classification used is the unsupervised classification. The image that transformed with the equation will be the basic image to cluster the result of unsupervised classification. The image is classified into 30 different classes with further cluster process to have five classes, namely coral reef, seagrass, sand, land, and sea. The result of this classification is the map of shallow water seabed.

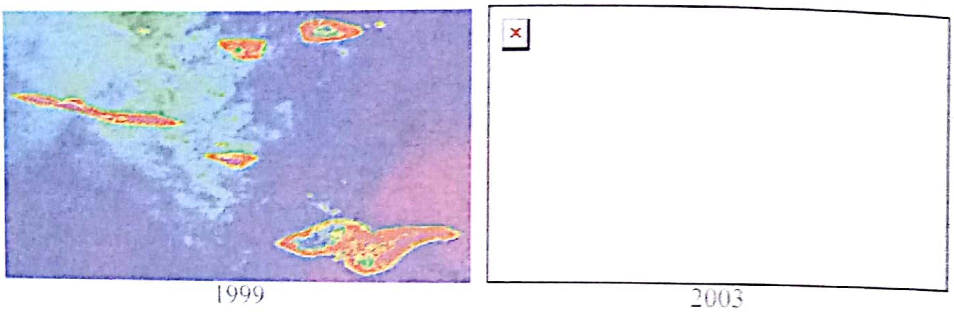
Before calculating the width of substrate (coral reef, seagrass, sand) in the research area, manipulating and editing is a must because of the cloud and unacceptable relevant of the substrate. This means that the area that unacceptable would be eliminated from calculation. Important to note that one of the weaknesses of the remote sensing for mapping in the water area could only applicable for shallow water seabed. The last step in this method is to layout the images into map.

3. Result

The result of the image data processing is the value of the Lyzenga Algorithm to be used to see the differences on the shallow water seabed. The equation result for the 1999 image is Y = ln (TM1) + 0.841049313 (TM2) and the equation for the 2003 image is Y = ln (TM1) + 0.867053991 (TM2). After the application of the equation into the image, the following images show the difference between the image without the equation and the image with the equation as illustrated in their respective figures (Figure 1 and 2).

1999 2003

Figure 1. Image 1999 and 2003 before the equation



1999 2003

Figure 2. Image 1999 and 2003 after the equation

The images above show the signature of the shallow water seabed around the islands. These two images are highly considered to differentiate shallow water seabed and could be used these images as image references for the unsupervised classification.

The unsupervised classification is a reliable method used in this research. With this classification, the 30 different classes clustered into five different classes were to remove things beyond the understanding of scientific principles of shallow water seabed, such as the remove of the clouds around the area. With this application, Figure 3 and 4 show the final layout results for 1999 and 2003.

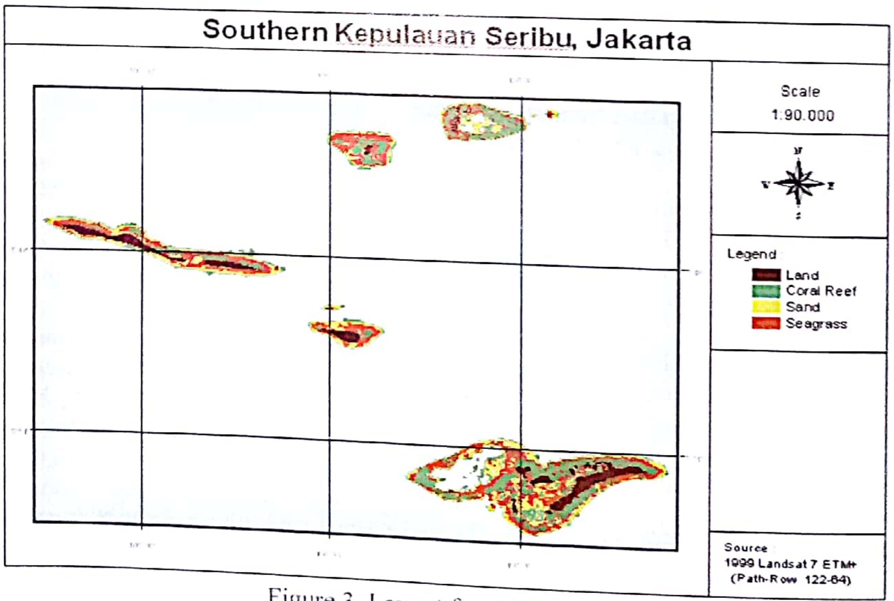


Figure 3. Layout for 1999 image

Using the images, reclassification was applied to obtain the width of each shallow water seabed class for coral reef, sand, and sea grass. The calculation results for 1999 and 2003 are provided in Table 1 below.

Table 1. The width for 1999 and 2003 images

Substrate	1999 Size/Width (ha)	2003 Size/Width (ha)
Coral Reef	671.631	826.728
Seagrass	544.076	48.539
Sand	475.687	534.2562

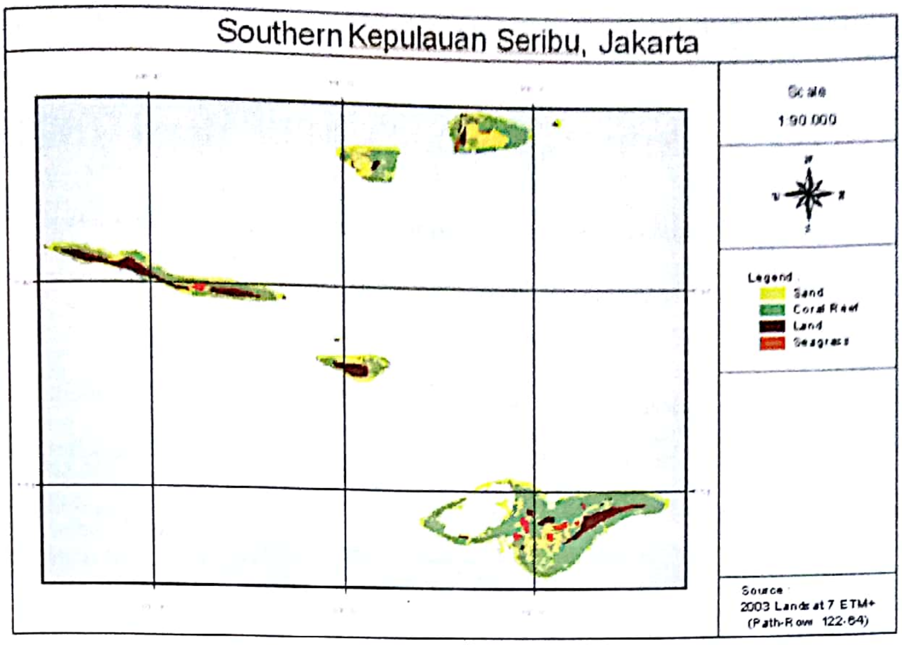


Figure 4. Layout for 2003 image

The width size of coral reef increased from 671.631 to 826.728 ha (23.09%), but the width size of sea grass decreased from 544.076 to 48.539 ha (91.07%), and the width size of sand increased from 475.687 to 534.2562 ha (12.31%) from 1999 to 2003. The calculation has successfully worked with the use of proper method and technique. The result has also proved that using remote sensing method, the changes of shallow water seabed can be detected.

4. Conclusion and Recommendation

The detection of changing shallow water seabed is important to help local government to improve marine and fisheries environment degradation. Sufficient data, information and knowledge about the changes in water seabed will also help improve the marine and fisheries development policy.

The data acquired from remote sensing could be used to detect the changes of shallow water seabed. The application of this method satisfies the objective of this research. Nonetheless, this research still need additional data for deeper accuracy, such as verification obtained from the field (ground check). This is necessary along with other supporting data (e.g. phenomena that happens at appropriate time or other oceanographic data, etc) and time series image data in order to have a proper change during the consecutive period of observation.

Further calculation is required for classification accuracy and compares its results with other methods. Ground check is needed for calculation accuracy.

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