BATHYMETRY EXTRACTION USING SPOT 7 SATELITTE IMAGE IN TIDUNG ISLAND, THOUSAND ISLANDS

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Abstract. The technology of remote sensing provides an opportunity for mapping shallow water bathymetry effectively and efficiently. Tidung Island is one of the islands in the Thousand Islands, Province of Jakarta which is have a shallow water and clear condition. Bathymetry extraction using satellite imagery of SPOT-7 with supported field data using echosounder is an important factor in the process of determining the resulting bathymetric information in the end. The objectivity of this research are to extract water bathymetry in Tidung Islands using SPOT-7 imagery. The method in this research using method of SDB (Satellite Derived Bathymetry) was developed by Kanno et al., 2011. The Result shows that bathymetry in Tidung Islands using SPOT-7 imagery have a value of up to 20 meters depth.

1. Introduction

Remote Sensing is the science and art contains of information about an object, area, or phenomenon through the analysis of data obtained with a device without direct contact with the object, area, or phenomenon (Lillesand et al. 2007). Technology of remote sensing begin from photographic or photogrammetry. Before 1960, remote sensing photographic known as aerial photography (Sutanto 1986). Since 1970, satellite remote sensing technology has been adopted as an alternative to minimize the mapping bathymetry (Arief 2012). The basic concept of remote sensing consists of several elements or components, including sources of energy, the atmosphere, the energy of interaction with objects on the earth's surface, sensors, processing data system, and a variety of data usage.

Technique of remote sensing implemented by photographing the earth's surface with a device we called a sensor. Sensors installed in a vehicle that was in the air in this case is a satellite with a certain height from the surface of the earth. Principles of remote sensing in fact like the principle of how the eye can see an object. When the receiver receives energy from solar light with a specific wavelength, the object can absorbs the energy, or can be reflected the energy, or dissipating the energy. The sunlight that enters the body of water in intensity continuously decreases exponentially with increasing depth Jerlov 1976). Channel look (blue, red and green) have the ability to penetrate the water up to a certain depth, although each channel has different capabilities with the blue of the channel with the ability to penetrate deeper into the water body (Jupp 1988). Multispectral sensor, especially green and blue bands, can penetrate up to 20 meters below the sea surface in a clear water condition (Sutanto 1992).

Bathymetry was generally obtained by measuring the distance between the average of sea surface to the sea floor. Preliminary technique of bathymetry measured using heavy ropes or cables lowered from the ship side. The main limitation of this technique is only able to perform one measurement in one position and is strongly influenced by the movement of the vessel and flow that is considered inefficient. The use of remote sensing images in coastal and shallow water bathymetric mapping is considerably cost effective (Mumby et al. 1999). Sea depth measurement method is currently widely used method commonly referred to an acoustic sounding. An acoustic wave is effectively used in the determination of the depth of seawater for optimal acoustic waves propagating in water medium than air medium. Calculating the value of the relative depth of seawater acoustic method uses simple physics concepts expressed by the following formula:

$$Z = \frac{1}{2} v \Delta t$$

where Z is the depth of the measure, v is stating the value of velocity of sound waves in the sea water medium, and Δt is the time between the delivery and reception of sound waves.

At the time of sounding using echosounder, transducer sensor (beam) sends a sound wave that propagates through the medium of water and reflected the wave after touching the bottom of the water. The main parameters in the process of bathymetric measurements using acoustic method are the time difference between when the sound waves emitted and received back. Each beam will get one point a depth so that when each point is connected will result in a depth profile. And when the ship moves will produce images that depict the surface of the seabed.

Depth measurement using remote sensing technology can be done by analyzing the spectral value of each channel on the satellite image. Depth measurements with remote sensing data had a principle that light through weakened interaction with the water column called attenuation and light that penetrates into the depth of the water depends on the wavelength of the light. Shorter wavelengths penetrate deeper waters than the longer wavelength (Hutomo 2010). This principle is based on the law of Beer that the absorption of sunlight by water increases exponentially with increasing concentrations of water. Lambert law also explained that the light absorption increases exponentially with increasing distance from the waters which must be passed by the light (Bukata et al. 1995). Thus the intensity of light entering the water column will decrease opposite with increasing depth, so that the attenuation values will grow as the depth increases. So the attenuation values were calculated and extracted into the depth value.

The objectivity of this study is to extract water bathymetry in Tidung Island using SPOT-7 imagery. SPOT -7 had four channels such as spectral blue,l green, red, and near infra red. Blue spectral channels are channels that are more sensitive to the identification in the territorial waters when compared with other spectral channels. The choice of location on the Tidung Island of Thousand Islands in Province of Jakarta because the island had a clear waters which is also one of the areas of nautical tourism in the Thousand Islands are much in demand by tourists so the results of this study can be used to support marine tourism in the Thousand Islands Jakarta especially for bathymetric mapping information.

2. Metodology

This research was conducted in the Tidung Island, Thousand Islands, Province of Jakarta who are geographically located at coordinates 5º44'38.21 "- 5º49'46.73" LS and 106º25'4.36 "- 106º34'11.47" BT (Figure 1). The data used in this study is the SPOT-7 imagery acquisition date of April 4, 2015 with 3 channels of four channels owned by SPOT 7, which channels in the visible wavelengths (channels 1,2, and 3). Three channels selection was based on the ability of each the visible channel for the extraction of objects that reside in shallow waters (Lyzenga 1978). Other data used is the Sea map scale of 1: 50,000 Tidung Island waters from the agency Hydro-Oceanographic Office (TNI-AL) and field measurement data.

The method used in this research is the SDB method was developed by Kanno et al. 2011. Processing with SDB methods was conducted with the support of software R i386 3.2.2. Such software is a mathematical programming that is used to extraction depth of image processing, the regression between the depth and the depth insitu extraction, and display the raster image extracted from the image. Stages of the research conducted is summarized in the flow diagram in Figure 2.

Figure 1. Area of Study

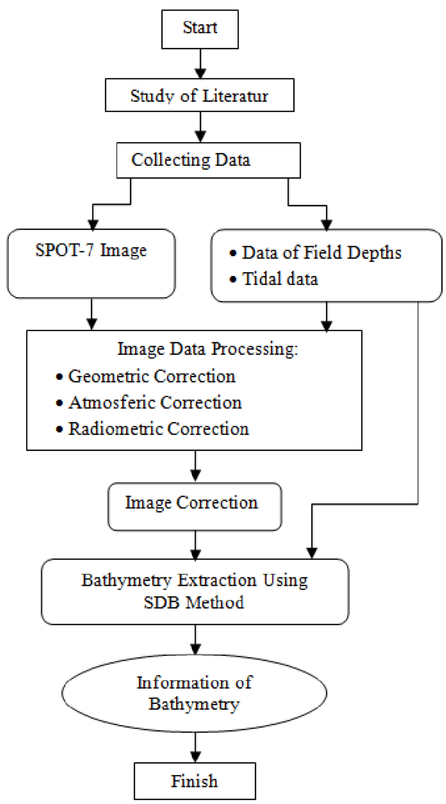

Figure 2. Flow Chart of Research

Data retrieval depth of field was done by sounding. Sounding performed using a single beam echosounder Garmin GPSmap 585 types and use means of transportation such as boats motor that works with the principle of echoes to measure the depth of the water and get the data. Before carried out soundings make lane planning in advance to get the best results. According Poerbandono and Djunarsjah (2005) lanes sounding can be straight lines, concentric circles or more depending on the needs and research purposes. Tidal data using the data received from the measuring stations are sourced from BIG. Tidal data is used to correct the depth of field measurement data.

3. Result

The process begins with collecting data and then proceed with the preliminary data processing activities, such as atmospheric and radiometric correction. Atmospheric correction method used of the dark pixels method. Atmospheric correction done to eliminate or reduce the effects of the atmosphere on the data generated by the sensors so that the data was the result of reflection from each object while the radiometric correction is done to provide stability in the reflection of each object. Radiometric process was done by converting the digital value of each pixel values into reflectance values.

Extraction of depths using SPOT-7 imagery was a process for extracting information of depths values. The extraction process by utilizing every pixel image reflectance value of each channel is visible on the image. Kanno et al. (2011) developed a model of Satellite Derived Bathimetry (SDB) to estimate the depth of the sea using satellite imagery. This model is a model that was developed from Lyzenga 2006 methods

Bathymetry extraction method using SDB was the development of the satellite remote sensing technology. In this method takes into account the principle of light wave propagation in the water an incident light intensity decreasing along with the increasing depth. In the principle of extraction of shallow ocean depths with satellite imagery, there are four basic components, that is: the path radiance (component atmospheric scattering), surface reflection component, the component in-water volume scattering, and reflection bottom component.

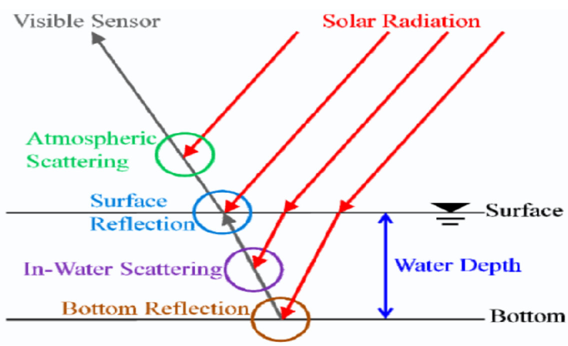

Figure 3. Component of Bathymetry Satellite (Kanno et al. 2001)

Bottom reflection component is the main component that is used as a value in generating depth of the sea while the other three components as residue or noise components that need to be eliminated or to search for value for correcting the spectral values of the image received by the satellite sensors that can be formulated as follows:

$$L(\lambda) = \{V + (B - V)\exp(-kh)\}TE + S + A, \quad (1)$$

Information :

L (λ) : Spectral radiance of the wavelength of visible light
V : bias water value (in water scattering).
B : seabed reflectance value (bottom reflectance).
k : attenuation coefficient. value
h : depth in situ (Insitu depth) value
Q : The value of the transmission in the atmosphere and the surface of the water.

E : The value of transmission down (downwelling irradiance atmosfere).
S : The value of the water surface reflections (Surface reflection).
A : Atmospheric scatering. value

Lyzenga 2006 methods entering a value of Near Infra Red (NIR) channel as a value for correcting the pixel values of the blue channel, green, and red. NIR channel regarded as being entirely absorbed by the water so that the value of the NIR channel used instead of pixel values in deep ocean waters that are considered entirely as a noise then formulated as follows:

$$L_\infty(\lambda) = VTE + S + A = \alpha_0 + \alpha_1 L(\lambda_{NR}) \quad (2)$$

Information :
$L\infty(\lambda)$: Spectral reflectance of visible wavelengths (blue, green, and red) in the deep sea.
$\alpha 0$: Constant value.
$\alpha 1$: Constant value at NIR wavelengths.
$L(\lambda NR)$: Spectral reflectance of NIR wavelengths.

$$L(\lambda) = (B - V)\exp(-kh)TE + \alpha_0 + \alpha_1 L(\lambda_{NR})\,. \quad (3)$$

$$X(\lambda) \equiv \log\{L(\lambda) - \alpha_0 - \alpha_1 L(\lambda_{NR})\} = -kh + \log\{(B - V)TE\}\,. \quad (4)$$

$$\mathbf{X} \equiv (1\ X_1 \cdots X_M)\,, \quad (5)$$

$$\mathbf{k} \equiv (0\ k_1 \cdots k_M)\,, \quad (6)$$

$$\mathbf{C} \equiv (1 \quad \log\{(B_1 - V_1)T_1E_1\} \ \cdots \ \log\{(B_M - V_M)T_M E_M\})\,, \quad (7)$$

where M is the visible band was used, in this study used three bands visible are blue band, a green band, and red band so that the value of M is:

$$\mathbf{X} = -h\mathbf{k} + \mathbf{C}\,. \quad (8)$$

$$\hat{h} = \mathbf{X}\boldsymbol{\beta}\,, \quad (9)$$

$$\begin{cases} \mathbf{k}\beta = -1 \\ \mathbf{C}\beta = 0\,. \end{cases} \quad (10)$$

Where:
h : extraction depth value resulting from the method SDB
X : refelektansi spectral value of each band
β : coefficient of spectral refelektansi of each band.

Image processing to extract bathymetry model with SDB is the main stage of the research project. Processing activities include atmospheric correction, radiometric correction, analyzes each pixel spectral reflectance in all three bands were used, the regression between the spectral reflectance of the image field measurement data, and extracting the absolute depths from sPOT-7 imagery.

Reflectance values of blue, green, and red channels performed multiple linear regression with a value of depth of field. (Figure 4). Value depth of field used already done tidal correction. Calculations and regression modeling was done on software R so that we do all the calculations automatically.

However, it should build on software R program scripts to run the calculation of modeling SDB extraction processing method is done automatically so that the resulting extraction of bathymetry from SPOT-7 imagery in the waters of Tidung Island, Seribu Islands shown in Figure 5. The extraction of bathymetry in the waters of Tidung Island using SPOT-7 image produces the value range of depths up to 20 m.

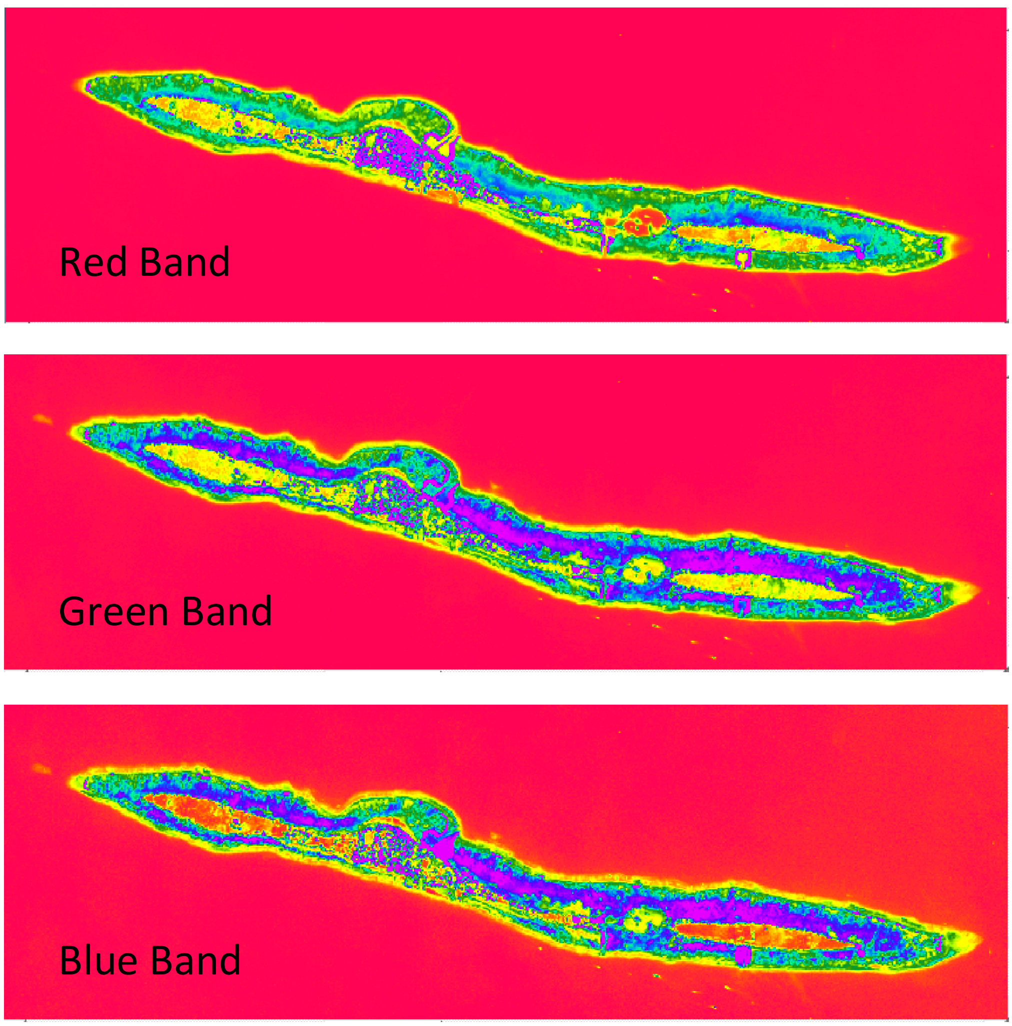

Figure 4.Reflectance SPOT 7 Image

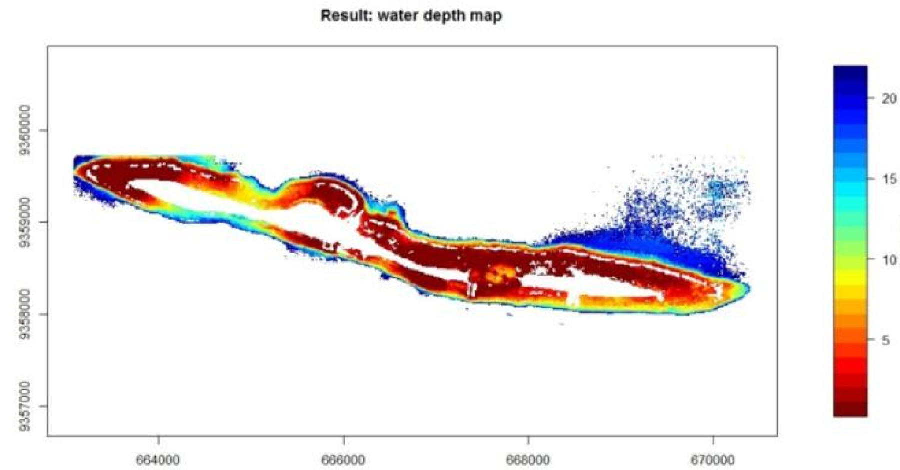

Figure 5. The Result of Bathymetry Extraction

The extraction of bathymetry in the Tidung Island using SPOT-7 imagery can be grouped into four categories, that is: a depth of 0-5 meters; a depth of 5-10 meters; a depth of 10-15 meters; and a depth of 15-20 meters. The result of bathymetry extraction then we created the contour map to see more detailed information in the line depth interval as seen in Figure 6. In this study has not been conducted validation tests related to the extraction of bathymetry generated so we need further studies to look at the effectiveness once the accuracy of bathymetry extraction methods used.

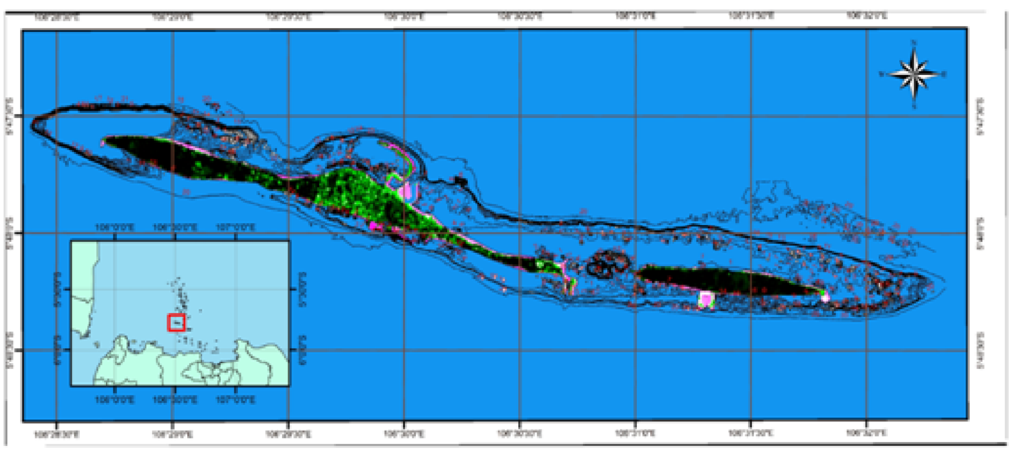

Figure 6. Bathymetry Contour

4. Conclusion

SPOT-7 imagery acquired on April 4, 2015 can be used to extract information on the bathymetry in Tidung Island, Thousand Islands, Province of Jakarta. Extraction bathymetry of the image by using channel 2, 3, and 4 obtained a depth of 0 m to 20 m. Based on the depth contour lines shows the distribution around the coastline and around the edge of the ramps are very steep.

Acknowledgments
Thanks to Director of Remote Sensing Application Center to support and facilities this research.

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