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Estimation of Seafloor Bathymetry across the Shallow Waters of Coastal Region using Remote Sensing and GIS Techniques: A Case Study of Andaman Islands, Territory of Indian Administration, India

M. Vinay, Ramu, B.Mahalingam and B.V Shobha*

Centre for Geoinformatics Technology, DOS in Geography, University of Mysore, Mysore-05, Karnataka, India.

****Corresponding Author Email: vinaymanohar.gis@gmail.com***

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ABSTRACT

The present study is conducted in order to determine the depth of sea floor. Study of Bathymetry is very importance in terms of navigation, Ship Docking and to understand the coastal process. Usage of Remote sensing data and generating a spatial database makes us to efficient use of data for the research purpose, the methodology for determining the bathymetry follows an empherical method of Geostatistical regression that the band ratio of Logarithm of Blue band divided by Logarithm of Red band of Landsat imagery versus Vertical Sounding data obtained from nautical chart. The obtained linear equation is multiplied with the output band. Then the results shows the bathymetry of seafloor across Shallow water of coastal region up to 50m of depth.

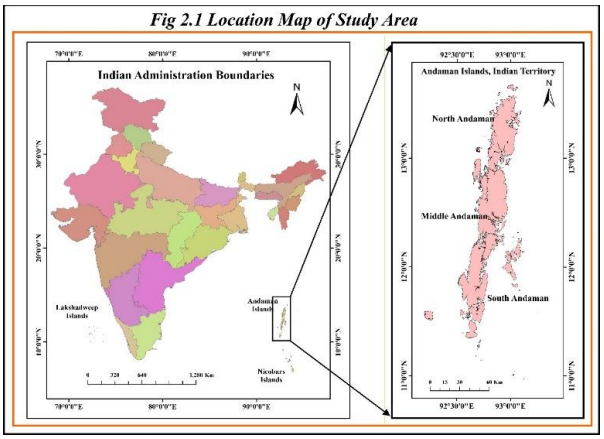
Introduction:

Bathymetry is depth of Ocean or Sea from Mean Sea Level. It is dynamic is nature that constantly varies in Coastal areas due to Sedimentation and due to anthropogenic activities. But determining a Bathymetry across the shallow waters is very difficult because of accessibility of Instruments that used for Bathymetric Surveys. The present GIS and Remote Sensing Technologies have played a major role in monitoring the Coastal Zones with different aspects. The review of literature found that there are several methods are there to estimate the bathymetry such as Stumpf Model, Birwirth Model, Artificial Neural Network, Principle Component Analysis and Single Band Algorithm. Among these Stumpf Model is very much familiar and several researchers used for their study. So, Stumpf Model is adopted for the present study.

Study Area:

The Andaman Island is considered for the present study. Figure 2.1 shows the location map of study area. It geographically extends from 10° 57' 37" to 13° 40' 39" Latitude and from 93° 15' 17" to 92° 11' 53" Longitude. The study area consists of three main regions of Andaman Island namely Andaman North, Andaman Middle and Andaman South. These Islands were in control of Indian Administration, The Port Blair is the capital place for Andaman Island and situated in east coast of South Andaman, the main mode of connectivity is sea ways and harbor is situated in capital of study area.

Fig 2.1 Location Map of Study Area



The geological formation is like 70% of the area is underlain by Marine sedimentary group of rocks, about 15% by volcanic rocks, and remaining areas by igneous rocks and coralline formations. The major geomorphic structure were Intermountain narrow valleys, gently sloping coastal tracts including swamps and overall altitude varies from 732 meters up to the sea level and most of the study area were covered by the major soil groups of Entisols, Inceptisols and Alfisols. The major Drainage systems found in study area are Kaplong and Karmatang in North Andaman, Badamnala, Kalsinala and Rangat in Middle Andaman, Burmanala,

Dhanikhari, Mithakhari, Premanala, Prothrapurnala in South Andaman. The major commercial activity of study area is Fishing and Tourism. Thus most of the civilians residing in these study area are mainly depended on ocean resources.

Materials:

The data used for the present study is a Cloud Free Landsat 8 OLI image, which were downloaded from United States Geological Survey website http://www.earthexplorer.usgs.gov and The Nautical Chart with 1:250000 Scale were used for obtaining Vertical Sounding bathymetry data.

Methodology:

The methodology used for the study is very simple but efficient. The methodology consists of following steps

(a) Water and Land Separation:

For separating Land and water, Band 6(NIR) from Landsat 8 is obtained. The reason behind separating water and land is the reflectance value of land is very much fluctuating due to the heterogeneous feature in Land. But water is a homogenous feature and almost shows a constant reflectance. And the main objective for the study is to determine the bathymetry, so that Land and Water needs to be separated. The threshold value of water is carefully determined using Histogram in ArcGIS software , Land showed a fluctuating values but Coastal water shows a constant value decreasing from 9600 DN value. In this case the value 9600 is selected but it varies from one study area to another. So, that threshold values of water must carefully need to be observed for other study area. To subset a water from land, firstly convert all three bands NIR, Blue and Green from Integer to Float using Math Toolset. Then Apply Low Pass filter for all bands to remove the speckle noise. Then Finally Use Conditional Set Null Tool from Spatial Analyst Tool box, Input Conditional Raster as NIR Band and Expression as "Value >9600" and Input false raster as Blue Band and Repeat this for Green Band. Then we have the two land removed bands such as Blue and Green Bands.

(b) Bathymetry Algorithm:

The absorption of spectral reflectance varies from one sensor to another. The algorithm based on *Stumpf et al (2003)* developed a reflectance ratio model, then the equation is given below

$$Z = m_1 \frac{\ln(nR_w(\lambda_i))}{\ln(nR_w(\lambda_j))} - m_0$$

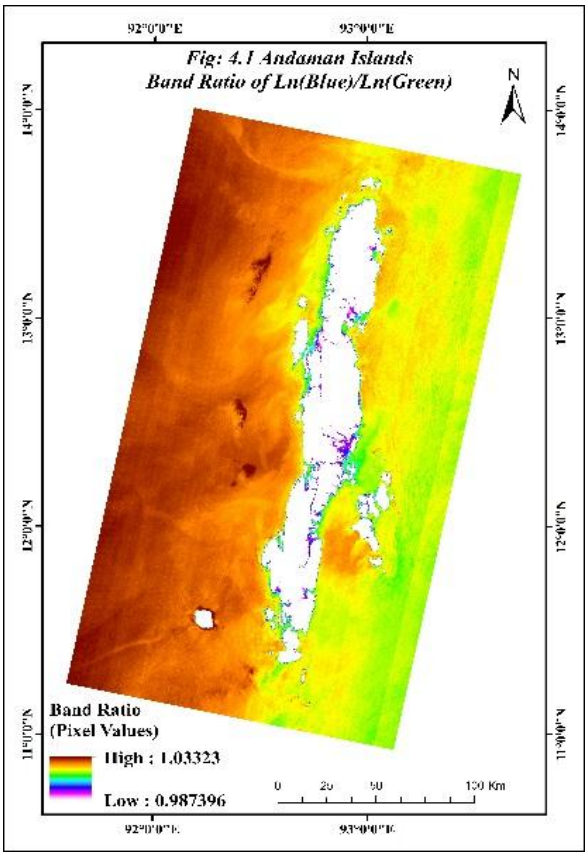
(Equation 1)

Where

Z= depth,
m1 and m0 obtained from regression of linear equation,
Rw(λi)= Atmospherically corrected Blue Band,
Rw(λj)= Atmospherically corrected Green Band
N= Equation constant that is neglected while calculation
ln= logarithm

(c) Finding of ln(nRw(λi))/ln(nRw(λj)):

By applying Ln (Blue)/Ln (Green) in ArcGIS Raster Calculator (Fig: 4.1)

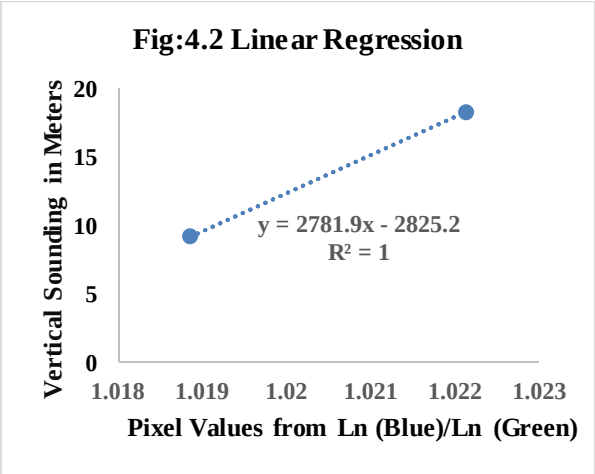


(d) Finding of m1 and m0:

Finding of m1 and m0 is very easier task. First we need a georeferenced Nautical Chart that consists of Isolines of depth measured using Vertical Sounding. When Georeferenced map were overlapped on Band that obtained by applying Ln (Blue)/Ln (Green). In this study, only two Isolines were obtained from nautical chart with 5 fathoms (9.144 m) and 10 fathoms (18.288 m) depth. Where ever the Isolines are passing the pixel values are identified using Identify tool in ArcGIS. The more sample points obtained and found the average pixel value that passes on 9.144m and 18.288 Isolines is 1.0188 and 1.0221 respectively. Then Regression of average Pixel values along X-axis and Vertical Sounding in Meters along Y-axis were plotted using Excel (Fig: 4.2), and found the linear equation

y = 2781.9x - 2825.2 **(Equation 2)**

Here
m1 = 2781.9
m0 = 2825.2

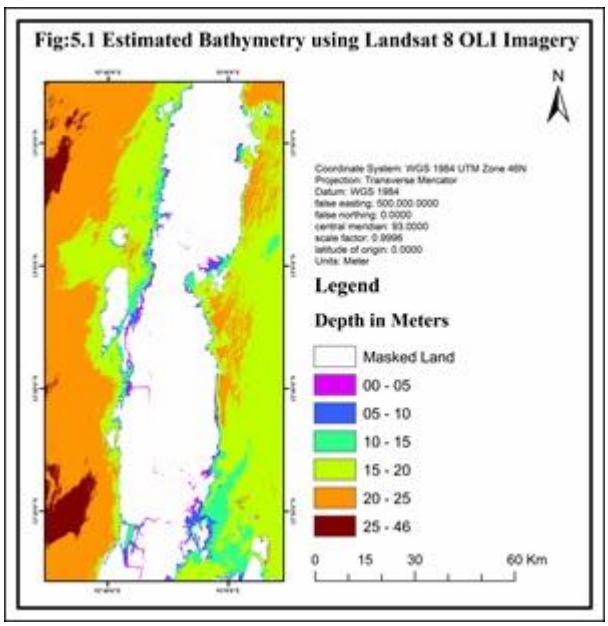


(e) Obtaining Bathymetry of Shallow water:

By the use of equation two, The Band that obtained by applying Ln (Blue)/Ln (Green) is multiplied in the place of "x" using raster calculator

Results and Conclusion:

Using the methodology described, the bathymetry of the Shallow Coastal waters can be mapped using Landsat images. The fig: 5.1 shows the Bathymetry of Andaman Island over shallow waters of Coastal region. Modern Geospatial Technologies played in major role in end to end application and one of them is determination of Bathymetry. This analysis can be suggested for further researches related to coastal applications.



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Authors Information:

Mr. **M.Vinay** and Ms. **B.V Shobha**, Both were Graduated Bachelor of Science in Physics, Mathematics and Mathematics from University of Mysore, Mysore, India in the year 2013. Presently both are pursuing their Master of Science degree in Geographical Information System for Sustainable Development in University of Mysore, Mysore. Vinay having a specialization in Thermal Remote Sensing, GIS application in Coastal Environment, Urban Studies and Geological Studies. Shobha have trained and certified by ESRI Desktop Associate and she have a specialization in customizing the Open Source Geospatial Products, Agro Meteorology, and Crop Modelling.

Mail: Shobhabv19@gmail.com

Dr. Ramu is the Course coordinator for Center for Geoinformatics Technology, DOS in Geography, University of Mysore. He has specialization in Climatic Change Impact Assessment, Agricultural Science and Hydrological Studies. He published more than 20 International and National Journals. He guided the more than 300 Students for their Major Research in the field of GIS and Remote Sensing.

Mail: drramumysore@gmail.com

Mr. **B. Mahalingam** is the Guest Faculty, Teaches the end to end geospatial technology. Being a geospatial evangelist, he constantly working towards new innovation and technology. His Field of Specialization is Spatial Modelling and Remote Sensing. He published 12 International and National Research journals.

Mail: mahabose@gmail.com