Mapping of Coastal Sedimentation using Landsat Satellite Image and Bathymetry Map (Case study: Batu Gong Coastal, Southeast Sulawesi, Indonesia)

Laode Muhammad Golok Jaya*

1Department of Informatics, Faculty of Engineering, Halu Oleo University, Kendari, Indonesia

Email: *Laodemgj@uho.ac.id

Abstract. Sedimentation in coastal areas poses a threat to the sustainability of coastal ecosystems. Besides damaging coastal ecosystems such as coral reefs, sedimentation also reduces the quality of the beach as a tourist area. This is economically detrimental. This study aims to monitor and map sedimentation in coastal areas through physical interpretation based on Landsat satellite imagery data and bathymetry maps. Landsat 2003 image was used in this study and bathymetry map was coming from geological map. Band intensity is used to magnify the water column. Image processing shows the intensity of each band can be used to interpret land cover, but the blue channel can penetrate the water column deeper than the other channels. The result of the research was ensuring that the sediment would be deposited due to the gravel size and the current speed. Both of 12 cm/sec and 25 cm/sec current speed do not have enough energy to disperse the sediment which consists of gravel with 2 mm in diameter. Since the river discharged the coast continuously and the sediment deposited into the seabed then it would be accumulated. The accumulation of sediment in the study area was interpreted by the thickness of the sediment overlay with the bathymetry map.

1. Background

The eastern coast of southeast Sulawesi province is important area since the location of major human settlements and activities took place in this region. Here, there are some important tourism objects, coral reef, mangroves, mining activities, ports, cities, villages, and sea conservation area. In the other hand, the human activities, also the environmental process have caused a threat of this area. They have significant impacts on the operation of coastal process on the point of environmental and socio-economic degradation.

Estimation the sediment and the associated shoreline is important for coastal construction and long term or short-term planning, which also include the management, safety and other regulations which may be applied by some authority1. Fast, up to date and availability of historic information of coastal areas will help to understand the condition of coastal area processes and produce suitable specific planning.

The most significant changeable in this area is the estuary. In this region there are two biggest estuaries namely Konaweha estuary and Lasolo estuary. Lasolo estuary lies at the northern part of Konaweha estuary. This research will focus on Konaweha estuary (Figure 1) since near of this area there are some important places such as Batu Gong tourism area, Soropia coral reef, Soropia port,
fishery activities in Bondoala district and the city of Kendari. Konaweha estuary is place where the Konaweha River and the Banda Sea meet.

The estimation of the coastal process specially the sedimentation and coastal change has been studied by many researchers with vary methods. The most method for studying the coastal process is remote sensing [1-4 and 11-13] although the accuracy is not as good as ground survey [1]. This study aims to map of coastal sedimentation using Landsat satellite image through physical interpretation of blue channel of Landsat.

2. Method

2.1 Location

The location of the research is at the eastern coastal of south east Sulawesi province. The position of the area is 3º50'36,31" S and 122 º29'44,24" E to 3º54'02,43" S and 122 º33'52,88" E. The area is a part of Konawe regency, one of twelve regencies in south east Sulawesi province.

2.2 Data

This research is conducted using Landsat TM remote sensing data as primary data that was captured in 2003. The secondary data are bathymetry, current direction, current speed, sediment grain size, and water quality. The methods for this aim are literature compilation from vary of data and interpretation of remote sensing imagery to predict the coastline formation and the water column.

2.3 Data Interpretation

For the interpretation necessity, the imagery is separated into three channels namely the Red, Green and Blue channel. By magnifying each band and comparing between them, it can be obtained the strongest band penetrate water column, that is, the Blue channel. The blue channel, 0.45-0.52 μm of wave- length, is used to identify the water body. Image processing software was used process the Landsat satellite image. For making sure the object that show up in the imagery, the traverse technique was conducted using the software.
3. Result and Discussion

3.1 Coastal characteristics

The research of water quality the Konaweha river has been done by Partowijoto [5] which the result is the river has been contaminated in the middle level. The matter contaminated the river consist of sediment and domestic waste. From the data of distribution of marine sediment, this area is dominated by rock and gravel. All sediments of which the predominant particle size is 2 mm in diameter such as rock, gravel, basalt, mud, and manganese nodules [6].
Figure 3 Map that shows bathymetry and current direction. The current direction on February (→) and August (←). The current speed in February is about 12 cm/sec and August is about 25 cm/sec [source: 4, 5 and 7].

Based on Marine and Coastal Environment data[6], this area is continental shell which has depth between 0-200 m. The Geological map (scale 1:250,000)[7] and map of Marine Coastal Resources Management Plan (scale 1:50,000) issued by Konawe Regency Planning Board[8], both support the data of bathymetry where the range of the depth in this area is 0 to 100 in meter. The sea surface current in February is about 12 cm/second and August 25 cm/second[6] (see Figure 3).

Figure 4. Diagram showing the range of average current speeds at which sediment particle of different sizes are transported, in suspension or as bedload, and below which they are deposited. The broken line indicates the transition between bedload and suspension transport[9].

Consequently, in February when the current speed is about 12 cm/second, according to diagram of average grain size vs. average current speed[9], then the sediment will be deposited (see Figure 4). It also occurs in August, when the current speed is about 25 cm/sec. The sediment will also be deposited. It does not depend on where the direction of the sea current. Both of current speeds do not have enough energy to disperse the sediment in the water column.

3.2 Landsat Channel Characteristics

The Konaweha river, estuary and the location around are important area since many vital objects and activities took place here such as mentioned in previous section. Sedimentation that occurred in this area will cause some negative impact to those activities. The sedimentation will be covering the coral reef and making it destroy. It will also be covering the seabed of the port that can bother of transportation. One of the main effects of that sediment which occurs at the present is making shallow water in the Batu Gong tourism[10] area and the freshwater becoming unclear. It supposed occurring by sand and mud.

From the Landsat data, it can be obtained pre assumption the existence of the sediment. From [2] it can be concluded that the maximum penetration of the blue channel is up to 25 meters into water column. When the blue channel penetrates the water column, where the sediment suspended, at the same time the imagery is captured. Then the energy that penetrated the water column would be back to the sensor at the satellite. Finally, what we see in the imagery than is a bright object in the water body (see figure 2 (D)). The bright object then must be sediment. According to [5,6], the assumption seems to be true.
For ensuring what the object displayed on the blue channel in the study area, the traverse method was conducted. For example, take three cross sections of the imagery horizontally along of the water body (see figure 5). From this, we obtain a graphic showing a digital number (DN), the position and the depth of water.

![Figure 5. Result of traverse method for each cross section in the study area.](image)

Using the blue channel, it can be obtained a higher DN at the brighter color in the water body. This is the material suspended into the water column. Let us see and compare each cross section. The material in landward section is solid (mainland) but rough so that the reflectance would not be smooth. The seaward section perhaps consists of sediment or not. From experiment, it can be obtained a non-smooth path of the traverse graphic for the clear water due to domination of water reflectance. It proves us that the smooth path has relation to object in the water column, that is, the sediment. The smooth path due to the smooth particle suspended into the water column. The sediment almost dominated the water column.

Compare these with the red and green channel. Since the energy is lower than the blue one, the water body will absorb the energy in the near surface layer of water. The energy will not be reflected to the sensor. Figure 6 shows the penetration energy of red and green channel into water body.
From interpretation of imagery, it can be predicted that the river mouth will be changed since its very dynamic environment. It also can be interpreted the shoreline is young formation. The river mouth is expected to erode but since there is a river, this part is deposited in seaward. The shoreline of the river mouth will be developed and also the around because the river supplies the sediment. It means the shoreline will be change due to the process from the river, that is, the river sediment discharge.

4. Conclusions

The Landsat data can provide us the preliminary assumption about condition of coastal area such as sedimentation. Traverse method is one method to assume the sediment suspended into the water column. The cross section result of the Traverse method shows that dominated suspended smooth sediment into the water column will be smooth path. Compare between each channels of the Landsat imagery, the usage of blue channel imagery can provide us more information about water column since its deep penetration into water body. In this paper, it may be concluded that the river brought sediment from the mainland and discharge water column and since the energy of the current is not enough to disperse the sediment to the ocean, then it would be deposited into seabed at that place. If this happen for a long time, it may be assumed that the shoreline would be change.
References

[1] Zakariya, R. Y. Rosnan, S. A. Saidin, M. H. Yahaya, I. Kasawani, H. Lokman, 2006, Shoreline Detection and Changes for Terengganu River Mouth from Satellite Imagery (Landsat 5 and Landsat 7), Faculty of Science and Technology, Kolej Universiti Sains dan Teknologi Malaysia, Terengganu D. I. Malaysia, Journal of Sustainability Science and Management 2006 Volume 1(1):47-57

[2] Edwards, A. J., 1999, Applications of Satellite and Airborne Image Data to Coastal Management, UNESCO, Paris, France

[3] Harintaka, Kartini, CN., 2002, Application of Remote Sensing for Coastal Natural Resources in Seribu Island, Jakarta

[4] Vidal, Susan, Doug Graham, Maryellen Sault, 1999, CSCAP: Coast and Shoreline Change Analysis Program;Using High-Resolution Satellite Imagery for Shoreline Change Evaluation Within Ports, Remote Sensing Division, NGS, NOS, NOAA

[5] Partowijoto, Achmadi, 2004, Water Quality Monitoring for Safeguarding of River in Several Provinces, The World Water National Seminar, Department of Public Works Republic of Indonesia

[6] National Coordination Agency for Surveys and Mapping (Bakosurtanal), 2006, Atlas of Marine Resources, Center for Atlas, ISBN 972-26-6908-6

[7] Rusmana, E., Sukido, Sukarna, D., Haryono, E., Simandjuntak, T.O., 1993, Geological Map of Lasusua Kendari Quadrangles, Sulawesi-Scale 1:250.000, Transverse Mercator Projection, Copy Right: Pusat Penelitian dan Pengembangan Geologi

[8] Konawe Regency Planning Board (Bappeda Kab. Konawe), 2004, Final Report of Marine Coastal Resources Management Plan (MCRMP)

[9] Brown, Evelyn, Park, D., Phillips, J., Rothery, D., Wright, J., 1999, Waves, Tides, and Shallow- Water Process, The Second Ed., The Open University, p:102-103

[10] Ridwan, H., Iswandi, M., Hos, J. & Husain, M. N. (2020). Public Understanding of Tourism Communication in the Coastal Region of Southeast Sulawesi. *Indonesian Journal of Social and Environmental Issues* (IJSEI), 1(3), 199-205.

[11] Sartika, M., Jaya, LMG., Nurgiantoro, 2019, Pemetaan Sebaran Total Suspended Solid (TSS) Dan Klorofil-a (Chl-a) Pada Perairan Sungai Wanggu Menggunakan Citra Sentinel-2, JAGAT (Jurnal Geografi Aplikasi dan Teknologi), Vol 3, No 2.

[12] Lobo, F.L., Costa, M.P., Novo, E.M., 2015, Time-series analysis of LandsatMSS/TM/OLI images over Amazonian waters impacted by gold mining activities. Remote Sensing Environ. 157, 170–184.

[13] Quang Vinh Pham, Nguyen Thi Thu Ha, Nima Pahlevan, La Thi Oanh, Thanh Binh Nguyen, and Ngoc Thang Nguyen, 2018, Using Landsat-8 Images for Quantifying Suspended Sediment Concentration in Red River (Northern Vietnam), Remote Sens. 2018, 10(11), 1841; https://doi.org/10.3390/rs10111841