Identifications of increase, distribution pattern, and density level of sedimentation using Landsat 7 satellite images in the coastal area

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Abstract. Sedimentation at coastal of Cirebon City is caused by considerable abrasion process in Indramayu regency and the impact of sand mining on Gosong Island, Indramayu Regency, besides that, the habit of residents in coastal of Cirebon City who heap up garbage at the coastal for years to utilize the area for residential purpose also contributed significantly the problem of sedimentation in the coastal area of Cirebon City. This research applying remote sensing technology of Landsat 7 2005, 2010, and 2015 using Lemigas Algorithm to gain information of special and temporal increase of sedimentation, distribution pattern, and density level of sedimentation. The result shows that the most significant increase of sedimentation happened at 2010 to 2015 with 46,072 Ha. There are 2 types of distribution pattern at Cirebon City, the first one is the sedimentation that ends in the estuary of river. The other type is the sedimentation caused by the presence of longshore currents which carry sediment and stuck on the coast along coastal of Cirebon City. Identification of natural and artificial sedimentation is carried out based on surveys in the field. The Lemigas Algorithm used only for classification of sedimentation based on density level of sedimentation content (mg/L). This research contributes to the Cirebon City government in resolving the problems of abrasion, accretion, and siltation in coastal areas, for the development of the Cirebon City coastal area to be an asset supported the economy in the future.

1. Introduction
About 600 million people (mostly concentrated in several of the world’s largest megacities) live very close to the sea at an altitude less than 10 m and this number is expected to double by 2060 [1]. In many of these regions, populations are exposed to a variety of natural hazards (e.g., extreme weather such as damaging cyclones and their associated storm surges), to the effects of global climate change (e.g., sea level rise), and to the impacts of human activities (e.g., urbanization). In the future, these risks are expected to increase due to the combined effects of climate change and human activities [2]. One of them is the phenomenon of sedimentation that occurs in coastal areas of Cirebon City, Indonesia it...
caused by the deposition of material carried by ocean currents and people who dispose of waste continuously resulting in accelerating very dynamic changes in coastal areas.

Therefore, regular monitoring is needed to obtain information about the physical state of the coastline including the ongoing change process. One way to get information on physical changes in coastline is by remote sensing technology that is able to provide detection of land changes and shoreline changes. Besides that, the addition of sedimentation, sedimentation distribution pattern, then the type of sedimentation density can also be known using satellite image data.

Cirebon City is located at north coast of eastern West Java at 108°34’57”-108°31’55” East Longitude and 6°04’1”-6°43’56” South Latitude. It is stretching ± 8 kilometer from East to West and ±11 kilometer from North to South, with altitude ±5 meter from sea level. Sedimentation process in coastal area of Cirebon City in general is caused by a considerable abrasion process in Indramayu Regency and sand mining in Gosong Island, Indramayu Regency (Figure 1). The total length of the coastline in Indramayu Regency reaches 147 km. By these lengths, 50% are affected by abrasion. About 70 km of coastline in Indramayu are affected by abrasion [3].

On arising land in Cirebon City, besides being formed naturally from sedimentation in the coastal area which happens continuously, the formation of land arises also accelerated by the existence of informal land development activities by the population which are generally used as a place to live. The activities that are commonly found are efforts to reduce shallow seas by using garbage to become a land plot until considered stable for housing [4]. Figure 2 is shown a picture of a land built by garbage.

This research is using 30 m spatial resolution Landsat Satellite Imagery using Lemigas Algorithm to classify existing types of sediments. In addition, information was also obtained about the rate of the process of increasing sedimentation, the pattern of sedimentation spread and the level of sedimentation density.

J Li, S Gao, and Y Wang identified spatial and temporal variations in Suspended Sediment Concentration (SSC) in Chanjiang waters [5]. The method used in this research is the regression equation between the SSC surveyed and the suspended sediment index chosen to take SSC from Landsat Image TM (taken on May 18th 1987, August 4th 1998, and July 28th 2007). In addition, tidal harmonic analysis is performed to calculate tidal conditions that are in accordance to the time taken from satellite image. The result showed that the spatial pattern of SSC was similar to the result of observations which showed the highest SSC in areas with maximum turbidity in the Changjiang estuary.

E. Parwali analyzed the phenomenon of lagoon constriction which is closely related to the rate of sedimentation in the Segara Anakan waters [6]. The data used are Landsat MSS, TM and ETM in 1978, 1991, 1995, 1998, and 2003.

Bidayah quality of sea water can be seen based on the parameters of temperature, salinity and turbidity of seawater [7]. Turbidity is caused by the presence of organic and inorganic material suspended and dissolved (e.g. silt and fine sand), as well as inorganic and organic materials in the form of plankton and other micro-organisms. Remote sensing can be used to map the extent of turbidity of water quickly to a wide area, with satellite remote sensing image data can be used to map the extent
of the turbidity of water quickly to a wide area. Based on the band used, and Jing Li Budiman algorithm using reflectance, whereas Lemigas algorithm using the DN (Digital Number). Higher resolution such as Landsat TM, Landsat ETM, and ASTER enable the discrimination of smaller areas within these environments [8,9].

Pahlevi and Wiweka conducted analysis the type of sedimentation density using the Lemigas Algorithm and the Jingli Algorithm [10]. The research used ASTER Satellite Imagery data from 2005 to 2008 as the main data, the image of Landsat 7 ETM satellite in 2003 and Landsat 5 TM in 1994.

2. Methods
The research used is as follows:

![Figure 3. Research methodology diagram.](image-url)

The data used in this research are Landsat 8 Imagery in 2015 and Landsat 7 Imagery in 2005 and 2010, with TIFF data format. Landsat 8 and Landsat 7 data used are shown in Table 1.
Table 1. Landsat image data.

| No | File Data Name (GeoTIFF File Format) | Date     | Satellite |
|----|--------------------------------------|----------|-----------|
| 1  | L71PFS1105184070101                   | July 3rd, 2005 | Landsat 7 |
| 2  | L71EDC1110214050300                   | August 2nd, 2010 | Landsat 7 |
| 3  | LC81100662015191LGN00                 | July 10th, 2015  | Landsat 8 |

Landsat 8 Imagery data can be downloaded on NASA's USGS site at [http://earthexplorer.usgs.gov/](http://earthexplorer.usgs.gov/) [11]. The type of Landsat 8 and 7 Satellite Imagery data used is Level 1 Terrain (L1T) types that have radiometric and geometric corrections. Satellite imagery data in TIFF format has been radiometric and geometric corrected because it already has GCP in metadata. The downloaded satellite image is still in separate bands.

Lemigas shows that spectral channels that have a close relationship with physical and chemical parameters are channel 1, 2, 3 and 4. Estimation conducted by Lemigas that water turbidity can be detected at a wavelength range of 0.4-0.7 nm [12]. If this wavelength is applied to Landsat TM which has channels 1, 2, and 3 in the wavelength range 0.4 to 0.7 nm, then the level of turbidity of the waters is a sum function of channels 1, 2 and 3. The Lamigas Formula is written below:

\[
S \left( \frac{mg}{L} \right) = 10.6678 + 0.55085 \times B3 + 0.04563 \times B3^2 + 0.009775 \times (B2 \times B3)
\]

\(B2\), Band 2 (Green).
\(B3\), Band 3 (Red).

3. Result and analysis

3.1. Mapping of sedimentation increase

The results of separating land and sea method are used for the delineation or digitization process along the lines that separate water and land. The results of digitizing the Cirebon coastline based on 2005, 2010 and 2015 Landsat Images are in Table 2. Based from Table 2 in 2005 – 2015 the largest sedimentation occurred in Lemahluwuk Subdistrict at 56,989 Ha with a sedimentation rate of 5,699 Ha/year. On the mapping of sedimentation increase (Figure 4), there is a significant change in coastline between 2005, 2010 and 2015. The red coastline is the 2005 coastline, the yellow coastline is the 2010 coastline and the black coastline is 2015 coastline.

Table 2. Sedimentation result of Cirebon city.

| No | Sub-District       | Sedimentation (Ha) | Sedimentation Area (Ha) | Sedimentation Accretion (Ha/Yr) |
|----|--------------------|--------------------|-------------------------|--------------------------------|
|    |                    | 2005-2010          | 2010-2015               |                                |
| 1  | Lemahwungkuk       | 14,250             | 42,739                  | 56,989                         | 5,699                           |
| 2  | Kejaksan           | 1,450              | 15,041                  | 16,491                         | 1,649                           |
|    | Total:             | 15,650             | 57,780                  | 73,480                         | 7,348                           |

3.2. Mapping of sedimentation distribution pattern

The pattern of sedimentation distribution is divided into 2 types, the first type of pattern is caused by sedimentation of longshore currents and the second sedimentation which empties into river deltas. Based on Figure 5, sedimentation along the coastline is marked with a yellow square box, while sedimentation which empties into the river delta is marked with a red circle. Apart from the natural sedimentation formation process, the habit of people who dispose of garbage on the shoreline is also a factor that
increases sedimentation which can lead to increased sedimentation. The purpose of the community who dispose garbage in their public beach is generally to be used as residential land.

3.3. Mapping of sedimentation density level

In the mapping of density level sedimentation, the red color indicates that the region experienced fairly dense sedimentation, which is between 110-120 mg/L, yellow indicates the value of sedimentation density ranges from 100-110 mg/L, light green color indicates sediment density values ranging from 90-100 mg/L, while dark green indicates sediment density values ranging from 80-90 mg/L.

According to Pahlevi, the value of the classification results for the Lemigas Algorithm is ranging from 0 to 117.8843 mg/L [11]. If this limit is exceeded, it is not classified. The results of the Lemigas Algorithm in the coastal areas of Cirebon City for 2005 and 2010 were at the level of 10 mg/L - 85 mg/L. In 2015 the sediment class increased at the level of 10 mg/L - 120 mg/L, but still below <150 mg/L. To analyze the type of sedimentation density in Cirebon City, Digital Number (DN) results of the Band 2 and 3 Combination were used using the Lemigas Algorithm on Landsat 7 and 3, 4 on Landsat 8. In Figure 6, there are 4 locations of coordinate sample points obtained from the survey field. The four points are then plotted on the results of the Lemigas Algorithm image.

In 2005, the location of point 1 was still in the marine area with the Digital Number (DN) at a value of 80 mg/L. At location point 2, it is not classified because the area is in the form of land. Location 3 shows that the area is in the marine area with the Digital Number (DN) being at a value of 83 mg/L, while for location point 4, it is not classified with the Lemigas Algorithm because it is a land area. Next the sample coordinates are plotted in the 2010 Landsat7 image of the Lemigas Algorithm Results.
In 2010, location of point 1 was already in the land area, so it was not classified by the Lemigas Algorithm. The location of point 2 shows that the area is in the sea water area with a value of Digital Number (DN) 79 mg/L. This indicates that at location 2 between 2005 and 2010 there was an abrasion. Location 3 shows that the area is in the marine area with the Digital Number (DN) at a value of 78 mg/L. While for location point 4, it is not classified with the Lemigas Algorithm because it is a land area. Then the four locations were plotted on 2015 Landsat 8 images that were included with location photos. Based on Figure 7 below, the four locations for taking coordinates and photos are already on land. The relationship between the location of sampling and the type of sedimentation density will be explained in Table 3.

### Table 3. Table of relations between sedimentation density and coordinate sampling locations.

| Point | Density Level         | 2015 | 2010 | 2005 |
|-------|-----------------------|------|------|------|
| 1     | Land                  | Land | (Waters) 80 mg/L |
| 2     | Land (Waters) 79 mg/L | Land |      |
| 3     | Land (Waters) 78 mg/L | Land | (Waters) 76 mg/L |
| 4     | Land                  | Land |      |

Based on Table 3, the location of the first coordinate sampling changed, at the time of 2005, the location was still in the form of marine waters, then in 2010 and 2015 the location became solid land. At the second coordinate sampling location in 2005, it was still in the form of land, changes in coastline actually occurred in 2010. Changes to the coastline occurred because of the abrasion so the location became a territorial water. In 2015, there was an increase in sedimentation causing the area to become land again. The coordinate sampling locations in the third region in 2005 and 2010 had sedimentation densities ranging from 70-80 mg/L causing the area to become land in 2015. At the fourth location from 2005 to 2015 the sampling location was a dense land.

The four location points for taking field coordinates in Table 3 are in the type of artificial sedimentation. In the 2005 and 2010 classification images, two locations from the four locations observed had high reflectance values. This indicates that in the type of artificial sedimentation, the reflectance value produced by the Lemigas Algorithm has a type of sedimentation with high density.

### 4. Conclusion

- The most significant increase in sedimentation occurred between 2010 and 2015, which was 46,072 Ha. Whereas from 2005 to 2010, there was only an increase of 15,675 Ha sedimentation.
- There are two types of sedimentation distribution patterns in Cirebon City. First, sedimentation empties downstream of the river. Second, sedimentation caused by longshore current that carries sediment supply and is retained on the coastline along the coast of Cirebon City.
- Identification of natural and artificial sedimentation in this research is still carried out based on surveys in the field. The Lemigas Algorithm is used only to classify sedimentation (natural and artificial) based on the density level of sedimentation content (mg/L).

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