Analysis of shoreline changes using the bilko method on landsat imagery in Karawang regency (1999-2019)

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Abstract. Karawang Regency is one of the districts in Indonesia which has the longest coastal area, with a length of 76.42 km and an area of around 1,168.85 km² of coast. The dominant process that occurs on the coast of Karawang Regency is abrasion and the coastline retreating between 50-300 meters in a direction. The purpose of this study was to determine the extent of shoreline changes that occurred in Karawang Regency using multi-time Landsat imagery with a tidal approach. The result Changes in the shoreline were more dynamic during the period 1999 - 2009 with an abrasion area of 8611954m² and an accretion of 5471645m². This is because during that period, there were two different types of tides, where in 1999 there was a mixed-semidiurnal (Double Leaning), while in 2009 the tide was mixed-diurnal (Leaning Tunggal). Then for the period 2009 - 2019, there was the same type of tide, namely the mixed-diurnal type tide (Leaning Tunggal), which caused the detected coastline to experience slight changes. Each segment experienced different line changes in each study period due to variations in slope, land cover, and river estuary morphology.

1. Introduction
The Karawang Regency is one of the regencies in West Java which has the longest coastal area, with a shoreline length of 76.42 km or 18.5% of the entire north coast of West Java and a coastal area of about 1,168.85 km². The dominant process that occurs on the coast of Karawang Regency is abrasion and regressing between 50-300 meters inland, which causes a lot of damage to land uses such as roads and settlements. Abrasion in Karawang Regency occurred mainly due to tidal flooding. Karawang Regency is also recorded as having the largest mangrove function change in West Java, covering an area of 1,801.5 hectares [1].Apart from the high conversion of land use in mangrove forests, there are several factors of changes in the coastline that come from marine and land processes.

Shoreline changes in Karawang regency can be detected with the help of Landsat remote sensing technology. Landsat imagery has a resolution of 30m x 30m and has the advantage of multi-time and multi-spectral observations. Then to increase the sharpness of land-sea boundaries using the BILKO algorithm, which has an accuracy of 85.71%[2].So that the results of observations in Karawang Regency are obtained more optimally than if the BILKO algorithm is not used.

2. Methods
Coastal areas are land areas that are side by side with the sea and still receive sea influences such as tides, sea breezes, and seawater seepage. Coastal typology in Indonesia is categorized into three dominant ones, namely marine deposition coast, subaerial deposition coast, and karst coast. Similar to shore, it is a waterlogged area that is influenced by the highest tide and lowest tide of seawater [3].
coast is a flat or wavy area with a height difference of not more than 200 meters, which is formed by coastal sediment and loose rivers, characterized by the presence of dry (land) and wet (swamp) parts [4]. Shorelines changes in time periods due to human and natural factors. These changes can be detected differently by Landsat imagery depending on the type of tide that occurs in seawater.

2.1. Study area
Karawang Regency is geographically located between 107° 02' - 107° 40' East Longitude and 5° 56' - 6° 34' South Latitude. The area of Karawang Regency is ± 1,753.27 km² or 175,327 Ha, which is 3.73% of the area of West Java Province [5]. According to the Karawang Regency Regulation No. 2/2010, the length of Karawang shoreline is 76.42 Km and the coastal area is about 1,168.85 km² or 2/3 of the total area.

![Figure 1. Administrative map of Karawang](image1.jpg)

Then the plains of Karawang Regency if divided into classes based on the classification by the Spatial Planning Law, then what seems to dominate is class 0 - 8% with the form of flat plains covering an area of 80.44% of the total land, while a small portion of the Karawang plains is located at 15.1% - 25% grade with a rather steep shape [5].

![Figure 2. Slope map](image2.jpg)

2.2. Land and sea segmentation using landsat imagery
Using satellite imagery of landsat multi temporal shoreline, changes can be observed. Observation using imagery begins with the determination of the image in accordance with the observation criteria, such as
cloud cover below 30% and does not obstruct the shoreline image of the Landsat imagery. Then separate
land and sea using the Bilko method, namely by entering the formula below:

\[ \frac{\text{INPUT1}}{(N^*2)+1}*(-1)+1 \]

Where \( \text{INPUT1} \) Band 4 for Landsat 7 and band 5 for Landsat 8
\( N \) Band Value of Land (30 for Landsat 7 and 7000 for Landsat 8)

Thus producing the shoreline for each observation years show in Figure 3.

![Figure 3. Shoreline in Karawang 1999, 2009 and 2019](image)

Land-sea delineation using the BILKO method on Landsat 7 imagery recorded on August 27, 1999,
resulted in a BV value with a vulnerability of 0 - 1. In the digitization process in 1999 it was quite easy
because the difference in land-sea color was clear and there was no similarity in the pixel values on the
coast. Meanwhile, 2009 and 2019 are a little complicated, requiring some zooming and increasing the
histogram to see the pixel value and the land delineation - the sea is a bit fuzzy (predominantly gray).

Land-sea delineation using the BILKO method. Landsat 5 imagery Recording October 1, 2009, yielding
BV values with susceptibility of 0.0856 – 0.9677. Then for Landsat 8 imagery recording October 29,
2019, resulting in a BV value with susceptibility of 0.0073 - 0.9999.

3. Result and discussion

3.1. Factors affecting shoreline change

The parameters that greatly affect the change of shoreline are due to the influence of waves, currents,
tides and winds that hit the coast continuously, which ultimately causes changes in the beach profile.
Tides are the rhythmic movements of the rising and falling of sea level caused by the gravitational forces
of the earth, moon and sun. Tides are classified into three classes, namely diurnal, semidiurnal and mixed
tide [6]. Sea waves are events that rise and fall of sea level vertically that form a sinusoidal curve/graph
[7]. Generators of sea waves include wind (wind waves), the attractive force of the earth-moon-sun (tidal
waves), earthquakes (volcanic or tectonic) on the seabed (tsunami waves, or waves caused by ship
movement [8]. Then the current is the movement of a mass of water from one place (position) to a
different place. The main energy that moves the mass of seawater comes from the sun. Ocean currents
in Indonesia are influenced by the west monsoon (December-February) and the east monsoon (June-
August), which occur alternately throughout the year.

3.2. Shoreline changes from 1999 to 2009
In the period 1999 to 2009, there was a reduction in the coastal area of 8611954m² and an additional area of 5471645m². Abrasion is a shoreline change process that dominates during this period. Especially the stretch of coast along the coast of segment A, B, part C, part D and a small part of segment E. While the distribution of accretion is in segment C partly, D is partly and dominantly occurs in segment E.

![Shoreline Changes 1999 to 2009](image)

**Figure 4. Shoreline Changes 1999 to 2009**

According to the theory of Whitfield & Elliott (2012), the effective limit when it is high tide is on the coast of a river mouth. In Segment C & D (Cilebar District) is a high estuary because it has many channels but is narrow and there is deposition towards the sea (accretion), while in Segment E (Cilamaya Wetan sub-district) is a high estuary because it experiences accretion on the west and east sides, but right at the mouth of the river there is abrasion, and the shape of the coast is uneven or has a narrow channel.

3.3. **Shoreline changes from 2009 to 2019**

Unlike the period 1999 to 2009, which experienced significant changes, from 2009 to 2019 the coastline of Karawang Regency has changed very little. This is because both of these years were detected to experience the same type of tides, namely mixed tide semi-diurnal. In the period 2009 to 2019, a reduction in the beach area was detected by 49662m² and an additional beach area of 711882m². Because the shoreline changes that occurred on the coast of Karawang Regency in the 2009-2019 period were very thin, the distribution patterns were not clearly visible Figure 3.
3.4. Abrasion and accretion

Segment A

According to observations from the period 1999-2019 and 2009-2019, the Tanjung Pakis Tourism Beach was detected to experience abrasion. At the survey point, figure 6 island cover in the form of a stretch of beach sand and was carried out on November 7, 2019, at 16:52 WIB which, according to the tide chart is at low tide. Along the coastal stretch of Tanjungpakis Tourism Beach, there are no river estuaries.

![Figure 6. (a) Tourism beach and (b) Non tourism beach have wide stretch due to abrasion in Segment A](image)

Segment B

When observation in segment B were local residents who lived long enough in Cibuaya District, who felt it was appropriate to conduct a short interview. The resident's name is Anwar. According to Anwar's narrative, originally in the 1990s the mangrove forest which was inundated by water was the beach (mainland). Then in the late 90s the seawater continued to rise until it was attached to the main road. This proves that at least in the period 1999 to 2009 segment B has experienced a reduction in landward sediment, in accordance with the results of observations of changes in the shoreline of Karawang Regency in this observation. Figure 7. was taken on November 6, 2019, at 12:45 WIB, which according to the tide chart, is at high tide. At this survey point, there is no visible river estuary.
Figure 7. Water bodies approaching the road bodies due to abrasion in segment B

Segment C
In segment C three survey points were taken. These three survey points experienced different shoreline changes the north is in an area of abrasion, the middle tends to be stable, and the most south is the accretion area. At the first survey point, the Cibuaya Coast was detected to have experienced abrasion and a retreat of 184m. At this survey point, it is known that the land cover is in the form of built up land (settlement). Figure 8 was taken on November 6, 2019, at 11:32 WIB, which according to the tide chart, is at high tide.

Figure 8. (a) Settlement damage and (b) Road damage due to abrasion in segment C

At this sample point, there has been abrasion that has displaced 40 households (Pasaribu, 2020). This is what makes residential areas close to water bodies and exceeds the safe limit for housing construction. In addition, there are damaged roads which are a result of abrasion in the area.

Then at the second point of the survey, the middle part of segment C is a natural (sandy) coast. According to observations from the period 1999-2009 and 2009-2019, the middle of segment C was detected to experience a little abrasion but tends to be stable. Figure 9. was taken on November 6, 2019, at 10:52 WIB which, according to the tide chart is the hour leading up to the tide. The coastal stretch at the second survey point is classified as flat and there is no visible coastline (the part that is affected by the highest tide).

Figure 9. Stable in segment C (Middle)

According to an incidental interview, it is known that recently (around 5 May 2019) there was a tide that made the water rise ± 20m and made the tourist beach temporarily closed. Meanwhile, the restaurant
The shack on the coast was flooded. This is in accordance with the results of observations in the period 2009 to 2019, which states that the coast tends to be stable with little abrasion.

The third survey point located in Pedes District. At the survey location there is a wave breaker building. The breakwater structure allows trapping of sediment and causes sediment deposition (accretion) over time. Figure 10 was carried out on November 5, 2019, at 15:14 WIB, which according to the tide chart, is at high tide towards low tide. This building is a suitable building to be placed in Pusakajaya Utara Village, Cilebar District (Segment C) according to Pasaribu’s research (2020).

![Figure 10. Breakwater Causes Accretion (South)](image)

**Segment D**
According to observations from the period 1999-2009 and 2009-2019, the Coastal Segment D was detected to experience accretion. The land cover in segment D is mangrove. Figure 11 was carried out on November 7, 2019, at 13:30 WIB which according to the tide chart is at high tide.

![Figure 11. Mangrove land use causes Accretion in Segmen D](image)

**Segment E**
According to observations from the period 1999-2009 and 2009-2019, the Coastal Segment E was detected to experience accretion. The land use at the time of the survey was pond land. Figure 12 was carried out on November 7, 2019, at 11.31 WIB which according to the tide chart is the hour leading up to the tide.

![Figure 12. Accretion in segment E](image)

### 4. Conclusion
The coast of Karawang Regency based on digitizing Landsat imagery in 1999, 2009 and 2019 experienced changes in the shoreline in the form of abrasion and accretion. With details in the period 1999 to 2009 it was dominated by abrades and it was detected that a reduction in the beach area was
8611954m². Meanwhile, the period 2009 to 2019 was dominated by accretion, and a reduction of the coastline was detected by 49662m². In a period of 10 (ten) years, it was detected that from 1999 and 2009 there were many shoreline changes compared to the 2009 and 2019 periods. This is because in the three years, there were two different types of tides, where in 1999 there was mixed-semidiurnal tide, while in 2009 and 2019, there were mixed-diurnal tides. Then for each segment, there is a different line change in each study period due to variations in slope, land cover, and river estuary morphology.

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