Vulnerability of the East Coast of Balikpapan City in East Kalimantan (Lamaru Beach - Klandasan Beach)

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Abstract. Balikpapan City located in the east coast of Kalimantan Island. The city of Balikpapan is directly adjacent to the Makassar Strait. The problem faced by Balikpapan City is the function of the land, namely the reclamation of the construction of shopping centre which results in changing the shape of the coast so that it has the potential to experience abrasion. In the city of Balikpapan for the past 6 years there has been an abrasion of 40 meters which has resulted in a decrease in Regional Original Income (PAD). Research on the vulnerability of the east coast of Balikpapan City to changes in coastline in 2005 and 2018 was focused on the calculation of social vulnerability and changes in coastline analyzed using crosstab. This study divides the area based on the shape of the beach, namely fine sand beaches, coarse sand beaches, and thick beaches. Based on the results of the analysis there are three levels of vulnerability, namely low, medium, and high. Areas with a high level of vulnerability are found in the rough sand segment. The level of vulnerability is along the fine sand beach segment and the low level of vulnerability is along the shore coast segment.

1. Introduction

Indonesia is an archipelagic country or maritime continent located between the Continent of Australia and the Asian Continent and borders the Pacific Ocean and Indian Ocean. This can be seen from the existence of the Indonesian coastline along ± 81,000 km, taking a second place to the longest coastline after Canada. As an archipelago that has a long coastline and a wide sea, Indonesia is wealthy in biological and non-biological resources.

The sea and coastal area is an area which is very important for most of Indonesia's population. According to Dahuri, in the history of human civilization, coastal areas were used as settlements, where more than 70% of the world's major cities are located in coastal areas which resulted in an increase in settlements accompanied by human activities or activities to continue to survive. Nearly 60% of the total Indonesian population lives and is active in coastal areas [1]. The Department of Maritime Affairs and Fisheries, 2003 explained that 7.5% of the total population of Indonesia depends their lives on activities in coastal areas [2].

The existence of rapid population growth in coastal areas is a major problem in coastal areas [3]. As a strategic place, the coastal area is used for various human activities, namely the exploitation of fisheries, forestry, mining, gas and oil, and groundwater resources. Coastal areas have a strategic value with comparative and competitive advantage that has the potential as an initial driver of national area development. Historically coastal areas have functioned as centre of community activity because of their physical and geographical superiority.
Utilization and ongoing activities in coastal areas have a negative impact. Impacts such as abrasion, erosion, and sedimentation and changes in land use. The population of the oil city has increased every year. In Balikpapan City and South Balikpapan there are large shopping centres. Information from the Central Statistics Agency of Balikpapan City that 47% of North Balikpapan residents enter urban areas, namely Balikpapan City. This, this causes increased activity along the coastline increased. The construction of shopping centres in the city of Balikpapan, especially in Balikpapan City and southern Balikpapan is carrying out beach reclamation. Some parties mentioned that the reclamation changed the coastline. The East Kalimantan Wahana Lingkungan Executive Director Isal Wardhana said that changes in the shape of the coast would change the hydrological flow of the coast while increasing the potential for abrasion. This is due to changes in ocean currents that reach the coastline obstructed by a stretch of reclamation.

Within 6 years the coast in East Balikpapan Subdistrict, Manggar Beach, had lost 40 meters of its shoreline. The abrasion even made six firs of tens of years old collapse at the beginning of 2019. Manggar Segara Sari beach was threatened by abrasion attack, some points of the coast began to be eroded by sea water. The Head of the Balikpapan City Youth, Sports and Tourism Office stated that Manggar Segara Sari Beach was declared prone to abrasion, considering that August is a season of high waves and strong winds. Beaches in the city of Balikpapan are tourist beaches that are a source of PAD (Regional Original Income) for the surrounding community, if not corrected then the PAD will participate according to the Chairman of Commission II of the Balikpapan DPRD Muhammad Taqwa. In 2005 there was a large abrasion on one of the beaches in East Balikpapan District, which damaged the road.

In this connection, the ability to see and analyze the vulnerability of the Balikpapan coast of East Kalimantan is needed. This study requires a temporal spatial approach to examine shoreline changes that occur at Lamaru Beach - Klandasan Beach using single band Landsat imagery using Landsat in 2005 and 2018 using a combination of band 543 and band 643 in RGB (Red, Green, Blue) format for line determination the coast uses visual interpretation because there will be a clear line between water and land.

2. Study area
Balikpapan City is the gateway to East Kalimantan Province which is located at 1.0 LS - 1.5 LS and 116.5 East BT - 117.5 East BT. Balikpapan has a strategic location that has an impact on the development of the City of Balikpapan as a service, industry and trade centre for the Province of East Kalimantan. Balikpapan City has 5 sub-districts, namely South Balikpapan, East Balikpapan, North Balikpapan, West Balikpapan and Central Balikpapan. Administratively, the overall area of the City of Balikpapan according to the 2012-2020 RTRW is an area of 81,495 Ha with a sea area of 31,164 Ha. In the northern part of Balikpapan City it is bordered by Kutai Kartanegara Regency. The southern and eastern part of Balikpapan City is directly bordered by the Makassar Strait, and in the western part is bordered by North Penajam Paser Regency.

2.1 Beach shape
There are three segments that divide the study area. The first segment explains that the beaches in this segment are fine sandy beaches with gentle slopes and relatively weak sea waves so that finer sand particles are created. Segment two explains that the beaches in this segment are coarse sandy beaches with a rather steep slope and sea waves that are strong enough to form coarser sand particles. Segment three explains that the beaches in this segment are rocky beaches with relatively large waves and cliffs.
2.2 Land use
The land use classification is based on the level of social and economic vulnerability to coastal vulnerability. Table 1 shows the level of class development. In the table listed the level of vulnerability is divided into 3 levels, namely vulnerable, moderate, and very vulnerable.

Table 1. Classification of land use

| No. | Class                                      | Score |
|-----|--------------------------------------------|-------|
| 1   | Water body, Vacant Land                    | 1     |
| 2   | Mixed Garden, Plantation                   | 2     |
| 3   | Habitation, Industry, Office Space         | 3     |

Table 2. Size of land use

| No. | Types of Land Use          | Wide (m²)     |
|-----|----------------------------|---------------|
| 1   | Pond                       | 1.558.478     |
| 2   | Rice Fields                | 679.765       |
| 3   | Field / Moor               | 4.301.968     |
| 4   | Plantation                 | 8.902.735     |
| 5   | Habitation and Office Space| 25.857.752    |
| 6   | Airport                    | 1.477.201     |
2.3 Population density
Population density in this study was obtained from the division between the population of the village and the area of the village. The more people who live in coastal areas, the more the population. The more densely populated the coastal area, the more vulnerable the coast is to a disaster. Table 4.5 informs population density in each kelurahan in the study area. The highest population density is Kelurahan Klandasan Ulu, which is 18146 inhabitants / km$^2$ followed by Klandasan Ilir at 16971 inhabitants / km$^2$. The smallest density of villages is Lamaru Village with 216 people / km$^2$.

2.4 Livelihood
Human activities that live in the vicinity of disaster-prone areas cause a higher vulnerability of the population to disasters [4]. A livelihood consists of assets, namely resources, activities required as a means of life, and abilities [5]. Indonesia is a watershed country with the potential for various types of abundant fauna, there are still many traditional fishermen who live in poverty. Fishermen are identical with poverty [1]. Many factors affect the lives of fishermen because of uncertain income. This erratic income resulted from damage to the marine ecosystem, decreasing fish stocks in the sea due to pollution, and extreme climate change. High waves in certain seasons make traditional fishermen unable to go to sea.

2.5 Building density
Building density is obtained from the total area built up divided by the total area of the kelurahan. Where the area is dominated by settlements and commercial areas. Table 3 informs that the kelurahan with the highest building density are Klandasan Ulu Kelurahan with a value of 112.2% and Ilir Kelurahan with a value of 100.7%.

| No. | District            | Total area building (m²) | Area of village (m²) | Building Density (%) |
|-----|---------------------|--------------------------|----------------------|----------------------|
| 1   | Damai               | 1596055                  | 2220000              | 71.9                 |
| 2   | Damai Bahagia       | 2074643                  | 3740000              | 55.5                 |
| 3   | Klandasan Ulu       | 998779                   | 890000               | 112.2                |
| 4   | Prapatan            | 2188668                  | 3140000              | 69.7                 |
| 5   | Sepinggan Raya      | 1160152                  | 6590000              | 17.6                 |
| 6   | Sungai Nangka       | 1420317                  | 3200000              | 44.4                 |
| 7   | Telaga Sari         | 1364547                  | 2530000              | 53.9                 |
| 8   | Sepinggan           | 2361949                  | 7810000              | 30.2                 |
| 9   | Manggar             | 5597159                  | 35260000             | 15.9                 |
| 10  | Lamaru              | 2237562                  | 48550000             | 4.6                  |
| 11  | Manggar Baru        | 2311634                  | 38400000             | 60.2                 |
| 12  | Klandasan Ilir      | 1439656                  | 14300000             | 100.7                |

Source: Processing Results, 2019
2.6 Distance of building from the beach
The absence of settlement boundaries towards the sea causes the number of slums to increase so that the development of these settlements tends to occupy spaces above the water (stilt houses) [6]. These settlements cause increasingly fewer coastal borders that have been determined by PEPRES No. 51 of 2016 concerning the border of the beach where the building is at least 100 meters from the beach border.

3. Methods
Data processing in this study was carried out using ArcGis 10.4 software and image processing. Data processing was carried out prior to the field as a preparation to facilitate researchers in identifying the research area. The map is a land use map and a time series coastline map from Landsat imagery.

The stages in making this image classification include:

a. Performing radiometric corrections to improve image conditions due to radiometric errors that can cause signal interference (noise), in the form of white spots on the image [7].

b. Digitizing coastlines on Landsat images in 2005 and 2018 using a combination of band 543 and band 643 in RGB format.

c. Perform the overlapping method (overlay) by conducting a union to find out which part of the coast occurs abrasion and accretion.

d. Calculating the results of the extent of the change in coastline by making the area experiencing abrasion and accretion.

| Vulnerability | Changes Costline |
|---------------|------------------|
|               | High             | Moderate | Low   |
| Low           | Moderate         | Low      | Low   |
| Moderate      | High             | Moderate | Low   |
| High          | High             | Moderate | Low   |
|               |                  |          | Moderate |

Source: Saraswati (2018), Modified.

In this study, a temporal spatial analysis was performed by comparing shoreline changes obtained from 2005 and 2018 images with the overlay method. The results will be obtained is the change in coastline distance in 2005 and 2018 and the location of abrasion and accretion. Analyzing areas that change due to abrasion and accretion in the form of distance changes and old and new coastlines. The next analysis is an accuracy test to see the relationship that occurs as a result of abrasion and accretion to the vulnerability of the study area by comparing the results of the pre-field data with the results of the post-survey field data. After that, coastal vulnerability analysis is carried out using the formula of the coastal vulnerability index.

4. Result and discussion

4.1 Change in coastline in 2005 and 2018
Changes in the coastline can be caused by abrasion and accretion. This analysis results from calculations based on changes in coastline length between periods. Figure 2 explains that there were changes in the coastline in 2005 and 2018. The length of the coastline from Lamaru Beach - Klandasan Beach in 2005 was 31,309 km. The length of the coastline from Lamaru Beach - Klandasan Beach in 2018 is 31,261 km. Visible changes in the coastline between 2005 and 2018, amounting to 0.048 km.
Abrasion and accretion that occur along the coastline in the study area are listed in table 5. Relative abrasion occurs along the coastline in the study area except Klandasan Ilir Village which has the same area or does not occur abrasion or accretion. Kelurahan that have been accreted are Klandasan Ulu Kelurahan, Kelurahan Manggar, and Kelurahan Manggar Baru.

Table 5. Occurrence of abrasion and accretion in every village

| Alteration | Segment       | Area          | Wide (m²) | Total (m²) |
|------------|---------------|---------------|-----------|------------|
| Abrasion   | Find Sand Beach| Lamaru        | 86930     |            |
|            |               | Manggar Baru  | 22137     | 125968     |
|            |               | Manggar       | 16902     |            |
|            | Rough Sand Beach| Damai Bahagia| 30291     |            |
|            |               | Klandasan Ulu | 1295      |            |
|            |               | Klandasan Ilir| 1115      | 77861      |
|            |               | Sepinggan Raya| 45161     |            |
|            | Cliff Beach   | Prapatan      | 1497      | 1497       |
| Accretion  | Find Sand Beach| Manggar       | 7292      |            |
|            |               | Lamaru        | 13267     | 98685      |
|            |               | Manggar Baru  | 78127     |            |
|            |               | Damai         | 4683      |            |
|            | Rough Sand Beach| Damai Bahagia| 75242     |            |
|            |               | Klandasan Ulu | 53785     | 232542     |
|            |               | Sepinggan Raya| 56371     |            |
|            |               | Klandasan Ilir| 42461     |            |
|            | Cliff Beach   | Prapatan      | 41301     | 41301      |
| Permanent  | Find Sand Beach| Manggar       | 32911500  | 73372900   |
|            |               | Lamaru        | 35378900  |            |
|            |               | Manggar Baru  | 5082500   |            |
|            | Rough Sand Beach| Damai        | 2198900   |            |
|            |               | Damai Bahagia | 3573200   | 28154689   |
|            |               | Klandasan Ulu | 931989    |            |
Alteration | Segment | Area (m²) | Total (m²)
---|---|---|---
Telaga Sari | 1761750
Sepinggan | 8671100
Klandasan Ilir | 1473310
Sepinggan Raya | 6353890
Sungai Nangka | 3190550
Cliff Beach Prapatan | 4286010

Source: Processing Result, 2019

4.2 Exposure to research areas
Population density is one indicator that influences the area's vulnerability exposure based on social indicators. Population density has a weight of 60% of exposure to coastal vulnerability. The results of exposure are obtained from overlaying population density data with the livelihood percentage of vulnerable sectors. In figure 3, the high exposure value is in Klandasan Ulu and Klandasan Ilir with 2.2 in the fine sand beach segment. Low exposure was in Damai Bahagia, Sepinggan Raya and Sepinggan villages with a value of 1.

![Figure 3. Exposure to research area](source)

Source: Processing Result, 2019

4.3 Research area sensitivity
Sensitivity is obtained from the weighting between land use, building quality and the distance of the building from the coastline. Scoring for land use uses a scoring that has been modified from previous studies, namely by Sulma (2012).
In figure 5, it is divided into three classifications, where if the kelurahan has an institutional commitment to reduce abrasion and food accretion, the value is 1. The region that has a value of 1 in this adaptive capacity is the Sepinggan Raya Village. In the research area the value of adaptive capacity is dominated by the value of 3, where there are no institutions or institutions but have not been actively committed to reducing abrasion and accretion.
4.5 Social vulnerability in research areas
The socio-economic vulnerability of the study area was obtained from an overlay of three indicators of vulnerability, namely exposure, sensitivity, and adaptive capacity. Figure 6 divides the level of vulnerability into three classes, namely low, medium and high. Low with a value of $<3$, moderate with a value of $3-7$, and high with a value of $>7$.

![Figure 6. Social vulnerability in research areas](Source: Processing Result, 2019)

4.6 Vulnerability of the east coast of Balikpapan City
Areas with vulnerability levels that are currently above areas with high levels of vulnerability. The dominant land use is plantation. Areas with low levels of vulnerability are above areas of moderate vulnerability. The dominant land use is the forest.
5. Conclusion

The east coast area of Balikpapan City, East Kalimantan has a vulnerability to changes in coastline with low to high classification. Areas with a high level of vulnerability are in the coarse sand beach segment due to the dominating use of land are settlements and places of activity as well as many buildings that are not in accordance with PEPRES, (2016) about the distance of the building from the coastline. The level of vulnerability is being along the fine sand beach segment. Low vulnerability is in the northern part of the fine sand beach segment.

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