EVALUATION OF COASTAL VULNERABILITY ASSESSMENT AND COASTAL MANAGEMENT FOR KARANGANTU COASTAL AREA IN BANTEN - INDONESIA

Coastal and offshore protection and engineering

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ABSTRACT

Coastal erosion has caused shoreline changes in various coastal areas in Indonesia that threaten the lives and livelihoods of coastal communities. Beach damage in the coastal areas has an impact on the disruption of day-to-day activities for the community, on the disruption of transportation systems, on the industry and trade, as well as on the environmental and public health impacts. Based on this phenomenon, it is necessary to evaluate a coastal vulnerability assessment and coastal disaster management. The purpose of this study is to analyze changes in the coastline and to evaluate the extent of damage to the coast in order to obtain priority coastal management. The location of Karangantu coastal area in Banten Province - Indonesia is studied. The results of this study can be used as a reference to address the damage to the Karangantu coastal area in Banten Province – Indonesia.

KEYWORDS: coastal, erosion, management, vulnerability assessment

INTRODUCTION

Indonesia is an archipelago country with the longest coastline in the world and with the high risk level of earthquake. Indonesian coastal hazards come from the tsunami. Mitigation of earthquake and tsunami must be done thoroughly, not only by preparing earthquake-resistant buildings, but also physically prepare coastal defenses.

The damage of Indonesia coastal areas are many and need to be dealt with coastal protection efforts, either natural or artificial protection. Natural protection can be done if the level of damage was mild or moderate and infra-structures are protected away from the coastline. If the level of damage has been very severe, where the shoreline is very close to the protected facilities such as residential areas, shops, roads, places of worship etc., the artificial protection is the most effective (Triatmodjo, 1999 and 2012).

The cost of coastal structure is very expensive, so it is necessary to order the preparation of coastal damage prevention priorities and needs to be carried out studies to determine the extent of damage and prioritizing the coast handling damage in various regions in Indonesia. There are three parameters are taken into account in determining the level of damage to coastal erosion/abrasion, sedimentation, and the environment. Each parameter is given a value according to the level of damage. Further prioritization of countermeasures coast is to link the level of coastal damage beach with the level of interest. The value of coastal vulnerability assessment and the level of importance for each beach's damage are used to determine the priority of the beach in each region.

The results of this study are the coastal vulnerability assessment and the coastal management handling priority. The level of coastal damage is grouped under conditions of low, medium, high and very high. Coastal management priority level is classified into less preferred, preferred, highly preferred, and very highly preferred.

This study was conducted to analyze shoreline changes that occur and determine the level of vulnerability of the Karangantu's beach in Serang, Banten province, Indonesia. The results of the vulnerability of the Karangantu's beach in Serang, Banten province can afterward be determined the priority handler beach and so can be done by making the soft protection structure (mangrove planting) and/or the hard structure (breakwaters, beach walls of buildings, etc.) and/or a combination of soft and hard structure.

METHODOLOGY

The Coastal Vulnerability Index (CVI) is commonly used and simple methods to assess coastal vulnerability (DKP, 2004). The CVI provides a simple numerical basis for ranking sections of coastline in terms of their potential for change that can be used by managers to identify regions where risks may be relatively high. Vulnerability of coastal areas against the threat of the damage is determined on the shore of the ranking of nine variables, namely: (a) Shoreline change rate, (b) Observations visual damage, (c) Length of damage, (d) Width of damage, (e) Lithology, (f) Wave height, (g) Tidal range, (h) Land use, and (i) Coastal slope (Table 1).

Table 1 Ranking of coastal vulnerability index

Variable	Very Low	Low	Moderate	High	Very High
	1	2	3	4	5
Shoreline change rate (m/year)	0	0-1	1-5	5-10	>10
Observations visual damage	Visible symptoms of damage	Looks scours but still stable	Scour occurs and will happen collapse	Scour and debris occur but not jeopardize facilities or infrastructures	Scour and debris occur and endangering facilities or infrastructure
Length of damage (km)	<0.5	0.5-2	2-5	5-10	>10
Width of damage (m)	0	1-10	10-50	50-100	>100
Lithology	Igneous, sedimentary and metamorphic, compact and hard	Fine-grained sedimentary rocks, compact and soft	Gravel and coarse sand, rather compact	Sand, silt, clay, rather compact	Sand, silt, clay, mud, loose
Wave height (m)	<0.5	0.5-1	1-1.5	1.5-2	>2
Tidal range (m)	<0.5	0.5-1	1-1.5	1.5-2	>2
Land use	Moor, mangrove forests, vacant land and bogs	Domestic tourist areas and traditional farms	Rice fields and intensive ponds	Settlements, ports, offices, schools and provincial roads	cultural heritage, international tourist areas, industry, country roads, and national defense facilities
Coastal Slope (%)	0-2	2-5	5-10	10-15	>15

Once each section coastline is assigned a risk value based on each specific data variable, the CVI is determined by adopting and modifying of the general equation determining coastal vulnerability index from some researchers (DKP, 2004). In this study coastal vulnerability index is calculated as the square root of the product of the ranked variables divided by the total number of variables as follows:

$$CVI = \sqrt{\frac{a \times b \times c \times d \times e \times f \times g \times h \times i}{9}} \quad \text{..(1)}$$

Based on the CVI, the level of damage can be categorized as in Table 2.

Table 2 Level of damage based on the CVI

CVI	0-25	25-50	50-75	>75
Level of damage	Low	Medium	High	Very high

Damage to beaches all over Indonesia are numerous, ranging from slightly damaged, heavy to very heavy. According Triatmodjo (1999 and 2012), the damage needs to be dealt with coastal protection efforts, either natural or artificial coastal protection structure. Natural protection can be done if the level of damage was medium and infrastructures are protected away from the coastline. If the level of damage has been very high, where the shoreline is very close to the protected facilities such as residential areas, shops, roads, places of worship, etc. then the artificial protection is the most effective.

RESULTS AND DISCUSSIONS

The location coastline study is Karangantu's beach in Serang, Banten province, Indonesia. The fecth, also called the fetch length, is the length of water over which is given wind is blown. Figure 1 shows the fetch length of Karangantu's coastal area. Fetch length, along with the wind speed determines the size (sea state) of waves produced.

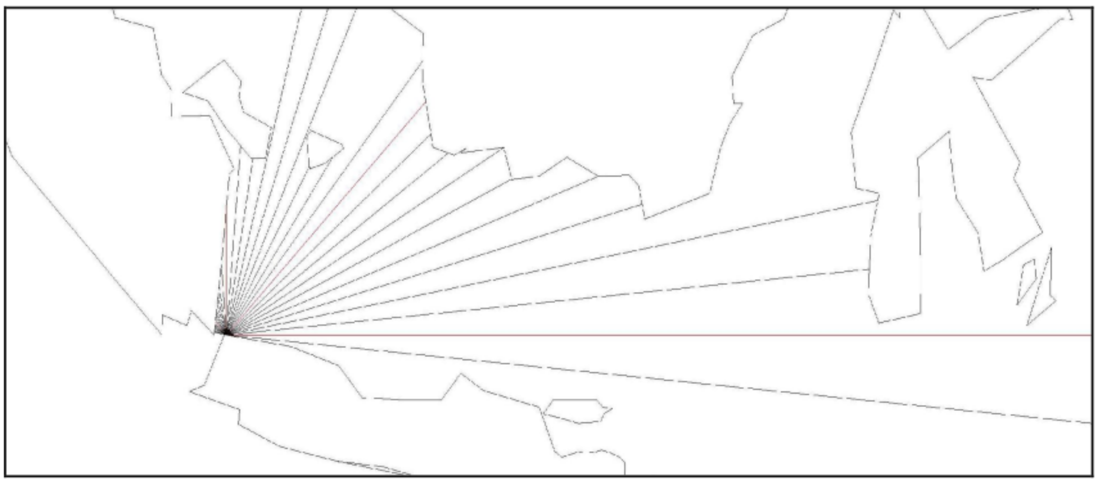

Figure 1 Fetch length of Karangantu's coastal area

The effective fetch is computed using the equation:

$$F_e = \frac{\sum F_i \cos\alpha_i}{\sum \cos\alpha_i} \quad \text{.......(2)}$$

where F_i is the fetch length (m) in the i direction and α_i is the angle ($^\circ$)between the wind direction and the i direction. Table 3 shows the effective fecth of Karangantu's coastal area for 8 cardinal directions.

Table 3 Effective fetch of Karangantu's coastal area

Direction	Effective fetch(m)
North	838996
North East	537154
East	1108254
South East	0
South	0
South West	0
West	7886
North West	31965

Wave data can be derived from wind field information by used of method known as hindcasting. Hindcasting is applied for estimating wave height at given site from knowledge of the windspeed, effective fetch, and duration. The windspeed used in this study is obtained from Tanjung Priok's station during the years of 2000-2011. The wave height estimation for several return period (in years) can be seen in Table 4. The wave height estimation at Karangantu's offshore location is used 9.98 m for return period in 50 years.

Table 4 Wave height estimation at several return period in Karangantu's offshore location

R_T (in years)	H (m)
2	0.58
3	0.72
5	1.03
10	1.84
25	4.59
50	9.98
100	23.10
200	56.49

The prediction of shoreline change can be obtained using numerical method over a given period (Hanson and Kraus, 1989). The initial position of Karangantu's shoreline is firstly done as an input by making the grids at a certain distance in accordance to the long coastline that will be modeled. The distance between the grid is 30 m with grid number is 81. Figure 2 shows the shoreline model for Karangantu's shoreline.

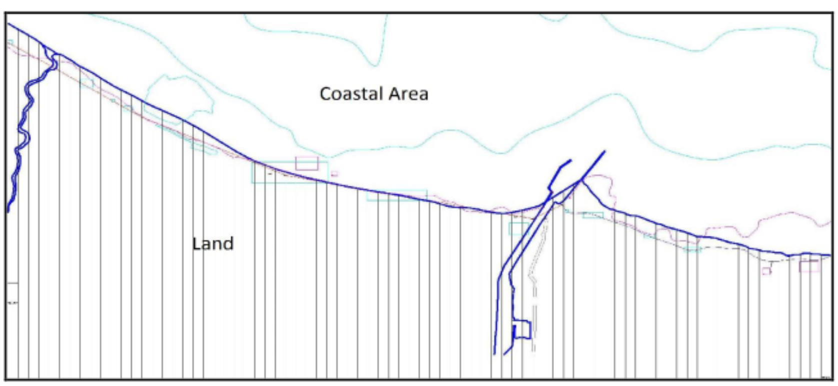

Figure 2 Shoreline model for Karangantu's coastline

The output of shoreline change for Karangantu's coastline can be seen in Figure 3. The shoreline change can be obtained by substracting the shoreline origin (input) and the shoreline change (numerical output) and divided by 12 based on the used of wind data from the year 2000-2011.

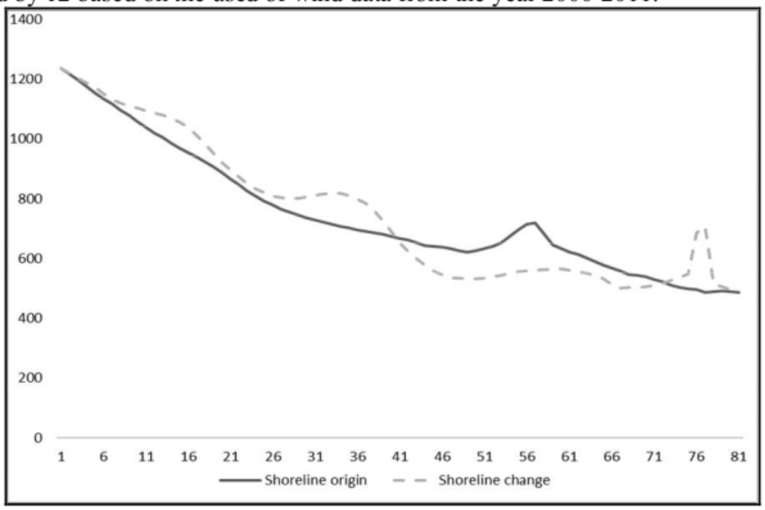

Figure 3 Shoreline change at Karangantu's coastal area

The maximum of shoreline change rate is 18.3 m/year. The shoreline change shows that *grid* 41-72 contain erosion, and *grid* 2-40, 73-80 have sedimentation. The result shows that Karangantu's shoreline encounter the sedimentation with the volume 35.400 m^3 and also the length of Karangantu's shoreline damage is 5.88 km.

The width of Karangantu's coastal damage is determined based on the change in shoreline position with the maximum distance forward/retreat of the shoreline. The width of the coastal damage occurred on the grid 77 and the maximum value obtained by sedimentation 219.6 m to estimate for the next 12 years.

Lithology is a description of the characteristics of rock types including color, mineral composition, rock size, and shape. Lithology of the Karangantu's coastal area based on the results of drilling to a depth of 6.00 m, the unit is composed of a layer of sand silt, clay and silt, light brown, light gray, very low plasticity, moist, very soft (Table 5). Karangantu's coastal area has a beach slope of 0-5%.

Table 5 Lithology of Karangantu's coastal area

Location	Depth (m)	Thickness of layer (m)	Conus Resistance (qc) kg/cm^2	Type of layer	Consistency
K-1	0.00 – 9.20	9.20	5.57 – 9.94	Sand silt	Soft
	9.20 – 29.80	20.60	11.93 – 26.05	Silt	Teguh
K-2	0.00 -8.80	8.80	8.95 – 9.94	Clay	Soft
	8.80 – 29.80	21.00	11.93 – 25.85	Silt	Teguh
K-3	0.00 -10.00	10.00	6.96 – 9.94	Clay	Soft
	10.00 – 29.80	19.80	10.94 – 24.80	Silt	Teguh

Figure 4 shows the tidal that occur around the Karangantu's coastal area. Maximum tidal range that occurs around the Karangantu's coastal area is 0.86 m.

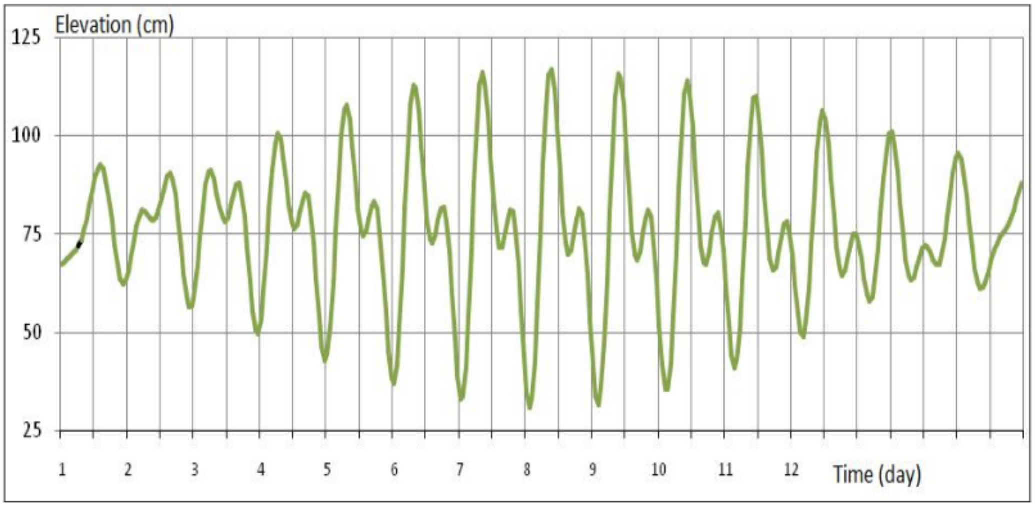

Figure 4 Tidal ranges around Karangantu's coastal area

Land use around Karangantu's coastal area including Nusantara Fishery Port (Figure 5), the Navy Main Base (Figure 6), the Port Health Office (Figure 7), the Police Office (Figure 8), and the College of Fisheries (Figure 9).

Figure 5 Nusantara Fishery Port at Karangantu

Figure 6 Navy Main Base in Karangantu

Figure 7 Karangantu's Port Health Office

Figure 8 Karangantu's Police Office

Figure 9 College of Fisheries in Karangantu's coastal area

The Jetty at Karangantu's coastal area has already damaged caused by the wave, so it is necessary to repair the Jetty. In addition, the condition of the shoreline on the left of Jetty's structure encountered the erosion problems. This erosion occured because the sediment transport processes that hampered the existing Jetty. Eroded shoreline conditions of Karangantu's coastal area can be seen in Figure 10. In addition there is also the problem of silting the estuary, making it difficult for boats with larger sizes to enter and exit. Estuary silting problems can be seen in Figure 11 and the damage of Karangantu's jetty can be seen in Figure 12.

Figure 10 Conditions Shorelines eroded at Karangantu's coastal area

Figure 11 Estuary Siltation at Karangantu's coastal area

Figure 12 Damage condition on Karangatu's Jetty

The rank of coastal vulnerability variables for Karangantu's coastal area can be seen in Table 6 which shows the rank of the 9 variables that influence the vulnerability of Karangantu's coastal area.

Table 6 Ranking of Coastal Vulnerability for Karangantu's coastal area

Variable	Result of analysis and observation	Rank
Shoreline change rate (m/year)	18.3	5
Observations visual damage	Looks scours but still stable	2
Length of damage (km)	5.88	4
Width of damage (m)	219.6	5
Lithology	Sand, silt, clay	4
Wave height (m)	9.98	5
Tidal range (m)	0.86	2
Land use	Settlements, ports, offices, schools	4
Coastal Slope (%)	0-5	2

Thus, the Coastal Vulnerability Index of Karangantu's coastal area values, as follows:

$$CVI = \sqrt{\frac{5\times 2\times 4\times 5\times 4\times 5\times 2\times 4\times 2}{9}} = 84.3$$

Based on the Karangantu's Coastal Vulnerability Index value of 84.3 and based on the level of vulnerability (Table 2) can be determined that the vulnerability of coastal Karangantu classified as very high. In the other hand, with a very high degree of vulnerability, the priority coastal management for Karangantu's coastal area is extremely preferred to make the soft and/or hard coastal protection structure. The existing Jetty at Karangantu's coastal area is also extremely prefferred to repair soon.

CONCLUSION

1. The evaluation of coastal vulnerability assessment is based on the coastal vulnerability index
2. The variables that affect the value of coastal vulnerability index for Karangantu's coastal area in Serang, Banten Province, Indonesia is the shoreline change rate, observations visual damage, length of damage, width of damage, lithology, wave height, tidal range, land use, and coastal slope
3. Karangantu's coastal vulnerability index to the value of 84.3 is exceptionally high, so the priority of coastal management is extremely preferred
4. The urgent priority of coastal management for Karangantu's coastal area is build the soft and/or hard coastal protection structure at Karangantu's coastal area, including the existing Jetty.

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