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Coastal Vulnerability Assessment and Coastal Management (Case Study: Lontar's Coastal Area in Serang, Banten Province, Indonesia)

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ABSTRACT

The damage of Indonesia coastal areas are many and need to be dealt with coastal protection efforts, either natural or artificial protection. 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. This study was conducted to analyze shoreline changes that occur and determine the level of vulnerability of the Lontar's coastal area in Serang, Banten province, Indonesia. The results can afterward be determined the priority handler beach and so can be done by making a soft and/or a hard protection structure.

KEY WORDS: Coastal management; coastal structure; coastal vulnerability

INTRODUCTION

The construction costs of coastal protection structure is very expensive, so that it needs to arrange the priorities rank to handling the coastal damage and necessary studies to determine the extent of damage and prioritizing the handling of damage to the coastal areas in various regions in Indonesia. There are three parameters that are taken into account in determining the level of damage, i.e. beach erosion/abrasion, sedimentation, and environment. Each parameter is given a value corresponding to the level of damage. Further prioritization of countermeasures is done by associating coastal damage level with the level of interest. Total value of coastal vulnerability assessment and the level of importance for each coast's damage is used to determine the priority handling of the coastal in each region.

Results of this study are the arrangement of the damage level and the priority handling of the coast. The level of damage grouped under conditions of low, medium, high and very high. The priority handling classified as less favored, preferred, highly preferred, and very highly preferred.The issues that will be examined is collecting wind data, soil data, and topography of the shoreline position early at Lontar's coastal area in Serang, Banten province, analysis of the determination of the effective fetch, hind casting, and waves, analysis of shoreline change, the coastline changes, visual observation of the damage, the damage length, the width of the damage, lithology, wave height, tidal range, land use, and the slope of the beach, the width of the green belt is not included in the weighting of the vulnerability of coastal areas, analysis of the vulnerability of coastal areas and its handling priority.

This research was conducted with the aim to analyze coastline changes that occur and determine the level of vulnerability coast at Lontar's coastal area in Serang, Banten province in order to obtain priority handling of the coast. The results of the coastal vulnerability can be further assessment to the priority handling of the coast by making the coastal protection structure in the form of soft structure (planting mangrove) and/or a hard structure (breakwater, building coastal wall, etc.).

METHODOLOGY

Framework and research hypothesis is as follows:

a. Beach location of this research is Lontar's coastal area in Serang, Banten Province
b. Wind data is used as the main generator and required for forecasting wave height and wave period. Hourly wind data taken from Tanjung Priok station (from the year 2000 to 2011)
c. Soil and topography data (shoreline initial position data) at Lontar's beach in Serang, Banten province obtained from direct measurement. The majority of Serang district consists of rock fire with surface sediment mostly located on the north and eastern coast. From the northern coastal morphology has a flat area, with a slope of 0-5%. Besides, the existing soil on the north coast is generally sandy and pebbly.
d. In the review the generation of waves in the ocean, fetch limited by the form of land surrounding the sea. In the area of formation of the wave, the wave is not only raised in the same direction as the wind direction but also in a range of angles to the wind direction. Fetch effectively calculated using the base map and software Autocad in order to obtain precise calculation. The efective fetch is calculated for 8 direction of the wind and is determined by Eq. 1.

$$F_e = \frac{\sum F_i \cos \alpha_i}{\sum \cos \alpha_i} \qquad (1)$$

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.
e. Wind data and fetch parameters entered for numerical calculations using the software so that obtained the hindcasting
f. The wave data, soil data, and the data is the initial position

coastline enter parameters for numerical computations in order to obtain the end position coastline that occurs within a certain time with existing conditions.

g. Changes in shoreline position data obtained from the line start and end at the Lontar's beach in Serang, Banten province
h. Changes coastline parameter is important to determine the level of vulnerability of the coast
i. Physical variables are included in the determination of coastal vulnerability index value of the coastal areas is the coastline changes, visual observation of the damage, the damage length, the width of the damage, lithology, wave height, tidal range, land use, and the slope of the beach.
j. The coastal areas of vulnerability index gained an early stage in determining the priority handling of the beach to choose the alternative of an effective coastal protection structure.

COASTAL DAMAGE

Damage to the beach in the whole of Indonesia is numerous, ranging from light damage, severe to very severe. According to Triatmodjo (2012), the damage needs to be addressed with efforts to protect the coast, either naturally or artificially protection. Natural protection can be done if the level of damage was mild or moderate and infrastructure is protected away from the coastline. If the level of damage has been very severe, where the coastline is already very close to the protected facilities such as residential areas, shopping malls, roads, places of worship, etc. then the artificial protection is the most effective.

The vulnerability of coastal areas against the threat of damage that occurred on the shore is determined on the weighting of 10 physical variables beaches, namely: Shoreline change rate (PP), Observations visual damage (K), Length of damage (PK), Width of damage (LK), Lithology (L), Wave Height (H), Tidal range (PS), Land Use (PL), and beach slope (β). Based on the weighting to nine physical coastal's variables are then calculated the value of Coastal Vulnerability Index (CVI) by adopting and modifying the equation of coastal vulnerability index of some researchers (DKP, 2004). In this study coastal vulnerability index is calculated by using Eq. 2.

$$CVI = \sqrt{\frac{PP \times K \times PK \times LK \times L \times H \times PS \times PL \times \beta}{9}} \qquad (2)$$

Based on CVI, the level of damage can be clasified as shown in Table 1.

Table 1 Level of damage based on the CVI

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

In detail, the physical vulnerability of coastal weighting variables are shown in Table 2-10.

Table 2 Ranking of shoreline change (m/year)

Very Low	1	0
Low	2	0-1
Moderate	3	1-5
High	4	5-10
Very High	5	>10

Table 3 Ranking of observations visual damage

Very Low	1	Visible symptoms of damage
Low	2	Looks scours but still stable
Moderate	3	Scour occurs and will happen collapse
High	4	Scour and debris occur but not jeopardize facilities or infrastructures
Very High	5	Scour and debris occur and endangering facilities or infrastructure

Table 4 Ranking of length of damage (km)

Very Low	1	<0.5
Low	2	0,5-2
Moderate	3	2-5
High	4	5-10
Very High	5	>10

Table 5 Ranking of width of damage (m)

Very Low	1	0
Low	2	1-10
Moderate	3	10-50
High	4	50-100
Very High	5	>100

Table 6 Ranking of width of damage (m)

Very Low	1	Igneous, sedimentary and metamorphic, compact and hard
Low	2	Fine-grained sedimentary rocks, compact and soft
Moderate	3	Gravel and coarse sand, rather compact
High	4	Sand, silt, clay, rather compact
Very High	5	Sand, silt, clay, mud, loose

Table 7 Ranking of wave height (m)

Very Low	1	<0.5
Low	2	0,5-1
Moderate	3	1-1.5
High	4	1.5-2
Very High	5	>2

Table 8 Ranking of tidal range (m)

Very Low	1	<0.5
Low	2	0,5-1
Moderate	3	1-1.5
High	4	1.5-2
Very High	5	>2

Table 9 Ranking of land use

Very Low	1	Moor, mangrove forests, vacant land and bogs
Low	2	Domestic tourist areas and traditional farms
Moderate	3	Rice fields and intensive ponds
High	4	Settlements, ports, offices, schools and provincial roads
Very High	5	cultural heritage, international tourist areas, industry, country roads, and national defense facilities

Table 10 Ranking of coastal slope (%)

Very Low	1	0-2
Low	2	2-5
Moderate	3	5-10
High	4	10-15
Very High	5	>15

RESULTS AND DISCUSSIONS

The location coastline study is Lontar'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. Fetch length, along with the wind speed determines the size (sea state) of waves produced.Table 11 shows the effective fecth of Lontar's coastal area for 8 directions.

Table 11 Effective fetch of Lontar's coastal area

Direction	Effective fetch (m)
North	603878
North East	524244
East	1103373
South East	0
South	0
South West	0
West	11114
North West	45052

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 12. The wave height estimation at Lontar's offshore location is used 4.8 m for return period in 50 years.

Table 12 Wave height estimation at several return period in Lontar's offshore location

R_T (in years)	H (m)
2	3.4
3	3.7
5	3.9
10	4.2
25	4.6
50	4.8
100	5.0
200	5.3

The prediction of shoreline change can be obtained using numerical method over a given period (Hanson and Kraus, 1989). The initial position of Lontar'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 1 shows the shoreline model for Lontar's shoreline.

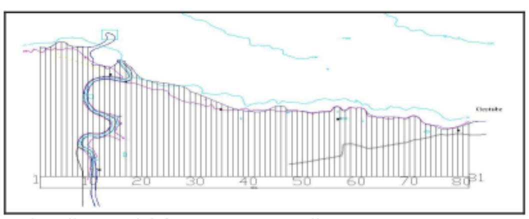

Fig. 1 Shoreline model for Lontar's coastline

The output of shoreline change for Lontar's coastline can be seen in Figure 2. 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.

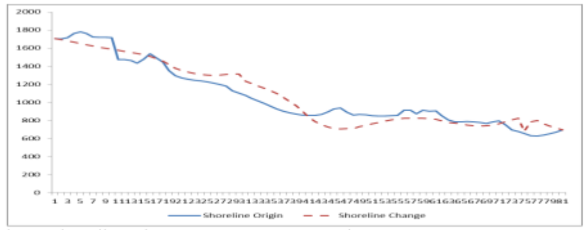

Fig. 2 Shoreline change at Lontar's coastal area

The maximum of shoreline change rate is 19.3 m/year. The shoreline change shows that *grid* 11-15, 18-40, 72-80 contain erosion, and *grid* 2-10, 16-17, 41-71 have sedimentation. The result shows that Lontar's shoreline encounter the sedimentation with the volume 163.000 m^3 and also the length of Lontar's shoreline damage is 3.579 km. The width of Lontar'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 231.4 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 Lontar'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. Lontar's coastal area has a beach slope of 0-5%. Maximum tidal range that occurs around the Lontar's coastal area is 0.89 m. The use of land around the Lontar's coastal areas are Manggroves plant and breakwater (Figure 3), dock for fishing boat (Figure 4), and the fish auction place and settlement (Figure 5).

Fig. 3 Breakwater and Mangrove plant Lontar's coastal area

Fig. 4 Dock for fishing boat at Lontar's Pier

Fig. 5 Fish Auction Sites and Settlements in Lontar's coastal area

Lontar coastal erosion is one of the areas in Serang. The problems is already damaging the coastal area and the pond has begun to threaten the road connecting to the villages (Figure 6-10).

Fig. 6 Erosion at Westward Lontar's coastline

Fig. 7 Erosion at East Lontar's coastline

Fig. 8 Combine Mangrove plant and breakwater

Fig. 9 Condition Lontar's coastline protected by breakwater parallel to the beach combined with early mangrove plant

Fig. 10 Sand Mining at Lontar's beach

The rank of coastal vulnerability variables for Lontar's coastal area can be seen in Table 13 which shows the rank of the 9 variables that influence the vulnerability of Lontar's coastal area.

Table 13 Ranking of Coastal Vulnerability for Lontar's coastal area

Variable	Result of analysis and observation	Rank
Shoreline change rate (m/year)	19.3	5
Observations visual damage	Occurs scouring but still stable	2
Length of damage (km)	3.579	3
Width of damage (m)	231.4	4
Lithology	Silt, clay	4
Wave height (m)	4.8	5
Tidal range (m)	0.89	2
Land use	Settlements, Magrove Plant, Pond, Wharf	4
Coastal Slope (%)	0-5	2

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

$$CVI = \sqrt{\frac{5 \times 2 \times 3 \times 4 \times 4 \times 5 \times 2 \times 4 \times 2}{9}} = 73$$

Based on the Lontar's Coastal Vulnerability Index value of 73 and based on the level of vulnerability (Table 1) can be determined that the vulnerability of coastal Lontar classified as high. In the other hand, with a high degree of vulnerability, the priority coastal management for Lontar's coastal area is highly preferred to make the soft and/or hard coastal protection structure.

CONCLUSIONS

The evaluation of coastal vulnerability assessment is based on the coastal vulnerability index. The variables that affect the value of coastal vulnerability index for Lontar'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. Lontar's coastal vulnerability index to the value of 73 is high, so the priority of coastal management is highly preferred. The urgent priority of coastal management for Lontar's coastal area is build the soft and/or hard coastal protection structure at Lontar's coastal area. Further studies to complete the determination of coastal vulnerability index by including the variable coastal green belt. However, further research can be done to determine the proper location of the coastal protection structure to reduce the coastal vulnerability.

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