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Study of Physical Vulnerability Mapping of the Coastal Areas of North - East Aceh

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Abstract

The coastal physical vulnerability study conducted in the North-East coast region of Aceh, which was focused on the calculation of the physical vulnerability index based on the Coastal Vulnerability Index (CVI) method which was integrated with the Geographic Information System (GIS) to determine the most dominant contribution to coastal vulnerability. The index is calculated based on six variables: geomorphology, coastal erosion, slope, changes in sea level, wave height and tidal range. Basically, the emphasis on methodological aspects is related to: (i) the use of GIS techniques to construct, interpolate, filter, and sample data for shoreline networks, (ii) physical vulnerability calculations using the CVI method approach, and (iii) values CVI is applied in vulnerability maps using the GIS program by providing CVI ratings to three levels, namely low, medium, and high. The results of this study indicate that the coastal physical vulnerability of the North East Aceh region is dominated by a moderate level of vulnerability of 83.61% with 51 sub-districts, and then a low vulnerability of 9.84% with 6 sub-districts, and a high vulnerability of 6.56% with 4 sub-districts out of a total of 61 Districts in 10 Regencies / Cities on the North-East coast of Aceh. According to physical conditions, each variable has the same weight, so that each variable has the same contribution to the vulnerability index of the North-East coastal region of Aceh.

Keywords: Coastal Vulnerability; CVI; GIS; Coastline

1. Introduction

Physically, the coast is a narrow area and is a transitional area or meeting between land and sea. In the land direction, the coastal area is dry land and submerged by water which is influenced by the nature of the sea such as effects: sea water intrusion, tides, and sea level rise due to the effects of global warming, while towards the sea is marine areas that are still influenced by natural processes that still occur on land such as freshwater flow and human activities. Even though coastal areas cover only 15% of the earth's surface, more than 60% of the world's population lives in this region (Rais, 1998b in Paharuddin, 2011).

Aceh Province is located between 01o58 '37.2 "- 06o04' 33.6" North Latitude and 94o57 '57.6 "- 98o17' 13.2" East Longitude with an average height of 125 meters above sea level. The borders of the Aceh Province, the North and East are bordered by the Malacca Strait, in the South with the Provinces of North Sumatra and the West with the Indonesian Ocean. Geographically, Aceh has the longest coastline among other provinces in Sumatra, which is 2,666.27 km. This length consists of a coastline on the mainland of Sumatra with a length of 1,253.58 km, and the rest along 1,412.69 km is the length of the coastline of other large and small islands surrounding the main island off the coast of Aceh (Acehprov.go .id, 2014).

Looking at the physical condition of the coast of Aceh with its long coastline and its position directly facing the high seas and most of its coastal areas are sandy and flat so it is very open to the influence of waves, tides and this is thought to make Aceh have considerable potential affected by the physical process of the sea and other marine activities, the influence of land and the slope of the coast and landforms and the absence of research along the North-East coast of Aceh Province. Based on this, the vulnerability assessment of Aceh's coastal areas is considered important to be carried out as a disaster mitigation effort. Agustin, S (2015) has focused on the coastal vulnerability index on the coast of Aceh which focused on physical vulnerability along the West-South coast of Aceh.

Vulnerability assessment in this study is physical vulnerability in the coastal areas of North-East Aceh which includes the City of Banda Aceh, Aceh Besar District, Pidie, Pidie Jaya, Bireuen, North Aceh, Lhokseumawe, East Aceh, Langsa and Aceh Tamiang with the Coastal Vulnerability approach Index (CVI) which is based on the ranking system of each variable. The value of physical vulnerability variables obtained from secondary data in the form of the results of research and studies that have been carried out and the acquisition of data through visual interpretation of remote sensing satellite imagery. The vulnerability index values obtained are then integrated into the Geographic Information System (GIS)

2. Area descriptions, methods and material studied

Coastal vulnerability was calculated based on physical vulnerability using variables and weighting modifying CVs . In determining the weighting of the scores for the variable and the calculation of the Coastal Vulnerability Index (CVI) modified by Kodeng (2011) referring to USGS (2007) the physical variables of the coast are divided into hree levels as shown in Table 1. following:

Table 1. Determination of Scores for the Coastal Vulnerability Index

Variable	Low	Is being	High
	1	2	3
Geomorphology	Rocky beach, thick beach	Estuaria, lagoon, gravel beach	Sandy, hugged, muddy, brackish swamps, deltas, mangroves, coral reefs
Erosion / accretion on the beach (m / year)	> 1	-1,0 - 1,0	<-1
Beach slope (%)	> 1.9	0.6 - 1.9	<0.6
Change in relative sea level elevation (mm / year)	<1.8	1,8 - 3,4	> 3.4
Average wave height (m)	<1,1	1.1 - 2.6	> 2.6
Average tidal range (m)	<2.0	2.0 - 4.0	> 4.0

Source: USGS (2007) modified in Koddeng (2011)

The determination of the value of the coastal vulnerability index uses the root method of multiplication for each variable ranking value divided by the number of variables as in equation 1 below

$$CVI = \sqrt{\frac{a \times b \times c \times d \times e \times f}{6}} \quad (1)$$

Where:

a = Geomorphology;
b = shoreline erosion rate (m / year);
c = Beach slope (%);
d = Relative SLR level (mm / year);
e = Mean significant wave height (m); and
f = R average tidal range (m).

The stage for obtaining the physical vulnerability index is to *overlay* all physical variables and calculate the index value using Equation 2.1. To determine the level of vulnerability, classification of the values obtained and classifying the level of vulnerability are shown as shown in Table 2.2 below:

Table 2. Danger Potential Class

Class	Description
0,1 - 1,0	Low
1.1 - 2.0	Is being
2.1 - 3.0	High

Source: USGS (2007) modified in Koddeng (2011)

Based on the way of analyzing and interpreting the data , the Geographic Information System (GIS) is a computer-based information system used to enter, store, manipulate, retrieve, analyze and issue data that is geographically (spatial) reference stored in the database obtained from i nformation spatial wear shop si in a coordinate system, k arena SIG has the ability to connect a variety of data at a given point on earth, combine, analyze and finally map the results. To represent objects such as building shapes, regional boundaries, highway lines, rivers, pillar positions, etc. that have geometric attributes.

Data acquisition techniques consisting of spatial data and tabular data can be seen on Table 3. Data type and method of data acquisition

No.	Data Type	Year	Data source
No.	Data Type	Year	Data source
1.	Geomorphology (landform)	2016	Peta rupa bumi Geo s Pasial Information Agency (BIG) Bappeda Aceh
2 .	Coastline Change	200 7 and 201 8	Obtained from visual interpretation of images of USAT 8 OLI / TIRS *time series* USGS
3 .	Kem i mild beach	2018	Obtained from the website http://tides.big.go.id/DEMNAS

4 .	Increase in Sea Level (SLR) Relatively	2016-2018	Obtained from the website : marine.copernicus.eu
5 .	Significant Wave Height	201 6-2018	Obtained from the website : marine.copernicus.eu

2.1. Variables and Indicators

In the assessment of coastal vulnerability variables from physical factors are used. The physical variables and indicators used are as follows:

1. Coastal geomorphology , as an indicator is a form of land that indicates the resistance of a part of the coast to erosion and accretion due to sea level rise .
2. The rate of coastline change (m / year), the indicator is the presence of coastal erosion or accretion which indicates how fast a part of the coastal line has undergone a change in the form of erosion (erosion) or accretion (addition).
3. Beach Slope (%), the indicator is the existence of a low area related to the weakness of a beach by the danger of flooding and with the speed of retreat or the advance of the coastline.
4. The rate of sea level rise (mm / year), is related to how global sea level rise affects a part of the coastline. The higher the rate of sea level rise will increase the danger of erosion and flooding.
5. The average wave height (m), the indicator is that the more wave height will affect the change in coastline and the geomorphological conditions of the area.
6. The average tidal range (m), the indicator is the tidal (range) difference that contributes to coastal flooding hazards , where the macrotidal region (large tidal range) will be more vulnerable than microtidal .

2.2. Analysis of Spatial Distribution of Coastal Vulnerability Indexes

a. Geomorphological Parameters

Coastal vulnerability analysis with CVI matrix shows high and medium vulnerability levels, but dominantly falls into the category of score 3 which shows a high level of vulnerability, it is because the geomorphology class along the North-East coast of Aceh has a geomorphological arrangement in the form of plains, alluvial plains, valleys alluvial, beach, swamp tide and terraces.Resistance land forms of the class of geomorphology is low against the threat of submersion and erosion of the beach, it was due to be n tuk land has a composition that is dominant with rock alluvium, sand, alluvium old sand, sediment sea Young (sand-sand, gravel), and also mud stone.

b. Coastline Change Parameters

Based on the analysis of coastline changes over a period of 11 years (2007-2018), it was found that regions experiencing physical vulnerability along the North-East coast of Aceh were obtained in 14 sub-districts with high vulnerability classes . The high level of vulnerability is spread across 6 districts, namely Bireuen Regency, North Aceh, Lhokseumawe City, East Aceh, Langsa City, and Aceh Tamiang .

c. Beach Slope Parameters

The coastal area of the North-East region of Aceh consists of sloping areas and is moderate to high areas by hills in the direction of land. Based on the DEM Model, each sub-district area is generally dominated by slope 0.6 - 1.9%,

d. Parameters of Relative Sea Level Advance (SLR)

SLR values from the results of the interpolation process using IDW in the form of SLR maps with CVI matrices , from the results of the SLR analysis showed that the values obtained were < 1.8 mm / year, with a value range of 0.0000 4 mm to 0.76 mm. So that the SLR parameters can be concluded that all regions in this study have a low level of vulnerability.

e. Wave Height Parameters

The interpolation process uses the IDW method and the classification of the distribution of wave height values in ArcGIS is in accordance with the CVI matrix with the distribution of wave height values obtained by 2 classes for wave heights namely low and medium . The results were then carried out by *overlaying* wave height data with the coastline to obtain a map that was more focused on the research area. The results of the *overlay* for classification are based on determining the determined coastal vulnerability score . From the results of the analysis, it is known that there are 2 vulnerability values for wave height averages, namely values 1 and 2. Value 1 is given in areas with a low level of vulnerability, and value 2 is given to areas with moderate levels of vulnerability .

f. Tidal Parameters

From the analysis, it is known that there is only one class for tidal data, with a value range of 0.3 meters to 1.20 meters. The analysis results are in the low class, where the value obtained is less than 4 meters. So it can be concluded that the results of tidal parameter analysis for all regions in this study have a low level of vulnerability.

2.3. Domination Analysis of Coastal Zone Vulnerability

From the results of the calculation of the vulnerability of the coastal North - East Aceh region , it can be seen the areas that most dominate the class of potential vulnerabilities in each of the Kecamatans. Furthermore, it is known class of vulnerabilities percentage of the total number of sub-district in the whole region of North coast - East Aceh, amounting to 61 the District 10 District / City. Calculation of the percentage of vulnerability classes is done by using the following equation:

$$\text{Percentage of Vulnerability Classes (\%)} = \frac{Number\ of\ Parts}{Total\ Number} \times 100\% \quad (2)$$

Where :
Number of parts = Number of Subdistrict class vulnerabilities
Total amount = Total District total

3. Results

Coastal Vulnerability

The results of the vulnerability analysis of the North-East region of Aceh show that the level of vulnerability is dominated by the moderate level of vulnerability, which is as many as 10 districts consisting of 6 1 sub-districts . The vulnerability class with the Low category consists of 3 Regencies consisting of 6 Districts . The North-East Aceh region shows that there are 4 sub-districts from 2 districts that have a high vulnerability index . If thoroughly reviewed in the CVI variable recapitulation table for the vulnerability of the North-East coastal region of Aceh in Appendix 20 , the level of physical vulnerability in the North East Aceh coastal region is more due to flat and flat geomorphological factors (landforms) and terrain, valleys , beaches and swamps that are particularly vulnerable to the threat of erosion and coastal erosion coupled with yet their safety on the coast.

3.1. Domination of Coastal Zone Vulnerability

The results of the analysis show that the level of vulnerability is dominated by a moderate level of vulnerability of 83.6 1 % consisting of 51 sub-districts from 10 regencies / cities, namely Banda Aceh City consisting of Kuta Alam District, Kuta Raja, Meuraxa and Syiah Kuala. Regency of Aceh Besar consists of the District Baitussalam, Mesjid Raya and Seulimeum. Pidie District consists of Batee District, Tanjong Flower, Sigli City, Muara Tiga and Simpang Tiga. Pidie Jaya Regency consists of Meurah Dua, Meureudu, Trienggadeng and Ulim Districts . Bireuen Regency consists of Gandapura, Jangka, Jeunib, Pandrah, Peudada, Peulimbang, Samalanga and Simpang Mamplam Districts. North Aceh Regency consists of West Baktiya, Dewantara, Lapang , Muara Batu, Seunuddon, Syamtalira and Tanah Pasir Districts . The city of Lhokseumawe consists of Banda Sakti, Blang Mangat, Muara Dua and Muara Satu Districts. East Aceh Regency consists of Biren Bayeun District, Idi Rayeuk, East Idi, Julok, Madat, Nurussalam, Peudawa, Peureulak Barat, Peureulak Timur, Ranto Seulamat, Simpang Ulim and Sungai Raya. Langsa consists of the District of Langsa West and Langsa East. District of Aceh Tamiang consists of the District Manyak Payed and Suruway.

S edangkan low vulnerability level of 9, 84 % in 6 sub-district of District 3 is the District of Pidie Jaya in K ecamatan Bandar Baru, Term B Uya and Pante Raja. Bireuen Regency is located in Jeumpa and Kuala Subdistricts, and North Aceh District is located in Syamtalira Bayu District.

For the high level of vulnerability there are 6.5 6 % in 4 Subdistricts from 2 Regencies , namely in East Aceh District in Darul Aman and Peureulak Districts and Aceh Tamiang District in Banda Mulia District and Treasurer .

Conclusions

1. Overall, the spatial distribution of the level of physical vulnerability in the North East Aceh coastal region is due to geomorphological physical factors, this is due to sloping and flat landforms and with areas composed of plains, valleys, beaches and swamps which are very vulnerable to the threat of coastal erosion and erosion coupled with yet their safety on the coast. Based on the results of the analysis of the variation of the CVI index, each variable namely geomorphology, shoreline change, slope, relative sea level rise, tidal height and tidal ride have the same weight and influence on coastal vulnerability in the North-East coastal region Aceh .

2. From the analysis on the obtained grade potential vulnerability that most men dominance of each sub-district , where the most dominant category of vulnerabilities were found in 51 District with an average of 83.61%. Furthermore, the low vulnerability categories found in 6 Subdistricts averaged 9.84%, followed by a high vulnerability category found in 4 Subdistricts with an average of 6.56% of all study areas with a total of 61 Subdistricts from 10 Districts / Cities in the North-East coastal region of Aceh.

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