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COASTAL VULNERABILITY STUDY FOR MARINE CULTIVATION ON DULLAH ISLAND, TUAL CITY

Studi Kerentanan Pesisir Untuk Budidaya Laut di Pulau Dullah Kota Tual

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ABSTRACT

Aquaculture provides more than half of the world's seafood supply with the world's per capita fish supply reaching a record in 2014 at 20 kg. Indonesia has the largest aquaculture potential in the world, namely 67.7 million tons per year. If we look at the decreasing availability of fresh water, most of the growth of aquaculture will take place in sea water. This research aims to analyze the level of vulnerability in the coastal area of Dullah Island, Tual City using a spatial approach. The research was conducted in Luv Bay (southern part of Dullah Island) and Divur Bay (north part of Dullah Island) which are part of North Dullah District. Determination of the vulnerability of the gulf coast was carried out to determine the value of the gulf coast vulnerability index using a modification of the coastal vulnerability concept of Gornitz and White (1992). The research method for gulf coastal vulnerability uses a spatial approach based on the physical conditions of the gulf coast, namely geomorphology, changes in coastline, elevation, relative sea level rise, maximum tidal range and wave height. The gulf coastal vulnerability index is divided into three classes, namely low, medium and high. Quantitative assessment of coastal vulnerability is carried out through scoring. The output of this research is a map of the vulnerability of the coastal area of Dullah Island. Divur Bay and Luv Bay have waters that fall into the non-vulnerable to moderately vulnerable category with vulnerability index values ranging from 0.00-19.37. The position of the bay mouth has a higher level of vulnerability than the inner bay.

ABSTRAK

Akuakultur menyediakan lebih dari separuh pasokan makanan laut dunia dengan pasokan ikan per kapita dunia mencapai rekor pada tahun 2014 yaitu sebesar 20 kg. Indonesia mempunyai potensi budidaya perikanan terbesar di dunia yaitu 67,7 juta ton per tahun. Jika kita melihat ketersediaan air bersih yang semakin berkurang, pertumbuhan budidaya perikanan sebagian besar akan terjadi di air laut. Penelitian ini bertujuan untuk menganalisis tingkat kerentanan di wilayah pesisir Pulau Dullah Kota Tual dengan menggunakan pendekatan spasial. Penelitian dilakukan di Teluk Luv (Pulau Dullah bagian selatan) dan Teluk Divur (Pulau Dullah bagian utara) yang merupakan bagian dari Distrik Dullah Utara. Penentuan kerentanan gulf coast dilakukan untuk mengetahui nilai indeks kerentanan gulf coast dengan menggunakan modifikasi konsep kerentanan pesisir Gornitz dan White (1992). Metode penelitian kerentanan pantai teluk menggunakan pendekatan spasial berdasarkan kondisi fisik pantai teluk yaitu geomorfologi, perubahan garis pantai, elevasi, kenaikan muka air laut relatif, jarak pasang surut maksimum dan tinggi gelombang. Indeks kerentanan pesisir teluk terbagi menjadi tiga kelas, yaitu rendah, sedang, dan tinggi. Penilaian kerentanan pesisir secara kuantitatif dilakukan melalui pemberian skor. Luaran penelitian ini berupa peta kerentanan wilayah pesisir Pulau Dullah. Teluk Divur dan Teluk Luv mempunyai perairan yang masuk dalam kategori tidak rentan hingga cukup rentan dengan nilai indeks kerentanan berkisar antara 0,00-19,37. Posisi teluk mulut mempunyai tingkat kerentanan yang lebih tinggi dibandingkan dengan teluk dalam.

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INTRODUCTION

The existence of small islands is very important for national development, not only because they are large in number, but also because they have coastal and marine areas that contain very rich natural resources and environmental services. This wealth of natural resources creates an attraction for various parties to utilize it and various agencies to regulate it. The potential for mariculture must also be supported by good marine ecosystem conditions, especially if carried out on small islands. Small islands have greater vulnerability to climate change than the mainland because small islands are the first to feel the negative effects of climate change.

Currently aquaculture provides more than half of the world's seafood supply with the world's per capita fish supply reaching a record in 2014 of 20 kg (FAO 2016). Indonesia has the largest aquaculture potential in the world, namely 67.7 million tonnes per year, originating from marine aquaculture of 47 million tonnes per year, brackish water aquaculture (ponds) of 15 million tonnes per year and freshwater aquaculture of 5.7 million tonnes. In 2015, total new aquaculture production amounted to 10.074 million tonnes or 14.88% of the total potential for sustainable products (Pusdatin KKP 2015). If we look at the decreasing availability of fresh water, most of the growth of aquaculture will take place in sea water. Mariculture is part of fisheries cultivation which is defined as planned and deliberate intervention by humans in the production process of aquatic organisms such as fish (finfish), shrimp (crustaceans), molluscs, echinoderms and algae (Effendi 2004). The area of national shallow waters suitable for mariculture (seaweed, grouper, snapper, rabbitfish, shellfish) is around 24.5 million ha (Minister of Maritime Affairs and Fisheries Decree No.18/2011). If roughly estimated based on the values calculated by Costanza et al. 1997, it can be estimated that the potential economic value of the aquatic ecosystem (as the coastal shelf) is US$ 53.3 billion per year/Rp. 37.31 trillion. The economic value of the national marine ecosystem that has been described if managed with the philosophy of an integrated ecosystem approach from land to sea is a great economic opportunity for the development of Indonesia's welfare in general and regional governments in particular.

The potential for mariculture must also be supported by good marine ecosystem conditions, especially if carried out on small islands. Small islands have greater vulnerability to climate change than the mainland because small islands are the first to feel the negative effects of climate change (Tompkins et al. 2005). Vulnerability also occurs in mariculture activities on small islands, although climate change is only one threat outside of environmental factors and human activity factors, but it can make it difficult to achieve sustainable management of aquaculture (FAO 2008).

Dullah Island is the largest of the 66 islands included in Tual City and has a coastline length of 85.85 km and an area of 93.32 km2. Regional conditions, especially coastal and marine conditions on Dullah Island, are very supportive for the development of aquaculture, especially mariculture. The potential area of marine cultivation land in the Tual City area reaches 7,524 ha, which includes 924 ha of pearl cultivation land, 3,100 ha of sea cucumber cultivation land, 1,000 ha of lola cultivation land, 2,500 ha of seaweed cultivation land and the rest can be used for fish cultivation (Department of Maritime Affairs and Fisheries Tual City 2010). Commodities that have been cultivated by the people of Tual City include seaweed, grouper fish and pearl oysters. Mariculture production in Tual City in 2013 was 145,578 tons (BPS Southeast Maluku 2013). The waters of Dullah Island which are locations for mariculture include Luv Bay and Divur Bay, but their utilization is not yet optimal due to capital constraints, the relatively low quality of cultivators, and inadequate facilities and infrastructure, making it slow to absorb technology. It is suspected that the mariculture that has been carried out does not take into account aspects of environmental carrying capacity because it is still traditional, and if it continues, it is likely that there will be a decline in water quality, resulting in a decline in the quality and productivity of mariculture commodities as well as fishermen's income.

Mariculture that has been developed by the people of Dullah Island has currently not achieved maximum results, with one indication that the economic level of marine cultivators is not evenly distributed and it is feared that this will reduce productivity and could hamper the sustainability of mariculture. Some of the reasons include the absence of a mariculture feasibility analysis that has been carried out, such as location feasibility and business feasibility. Communities carry out mariculture only based on visual observations of locations deemed suitable by the cultivators and simple economic calculations. Existing mariculture locations also do not pay attention to the vulnerability of the aquatic environment to seasonal changes. Apart from the suitability of the location, limited production infrastructure, the absence of setting selling prices for cultivated products by the local government, the low quality of cultivated products, as well as the low application of technology and the absence of institutions to oversee cultivators are the problems faced by marine cultivators on Dullah Island. This research aims to analyze the level of vulnerability in the coastal area of Dullah Island, Tual City using a spatial approach.

RESEARCH METHOD

The research was conducted in Luv Bay (southern Dullah Island) and Divur Bay (northern Dullah Island) which are part of North Dullah District.

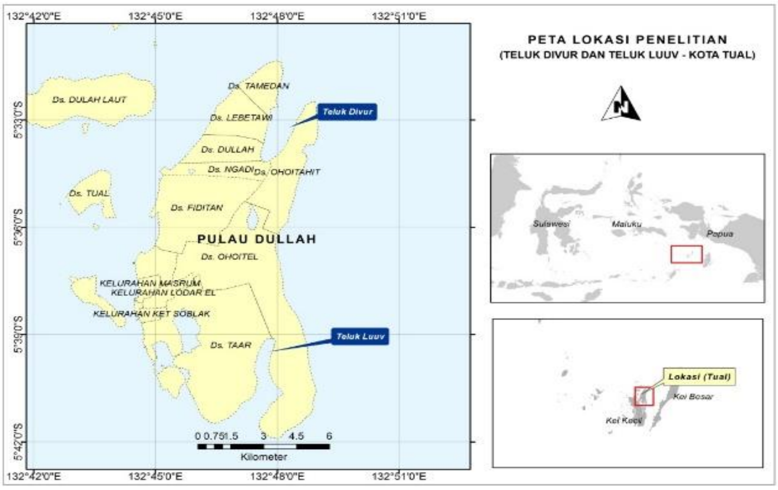

Figure 1. Research Sites

Determination of the vulnerability of the gulf coast was carried out to determine the value of the gulf coastal vulnerability index using a modification of the coastal vulnerability concept of Gornitz and White (1992). The research method for gulf coastal vulnerability uses a spatial approach based on the physical conditions of the gulf coast.

Method of collecting data

The data collected includes primary data and secondary data. Primary data is data that is directly obtained at the research location, either through measurement, sampling, observation or interviews with respondents. Secondary data is data that has been collected and published by other parties (Table 1).

Table 1. Method of collecting data

No	Data Type	Method of collecting data	Information
1.	Sea level rise	- tide gauge recording data -data from the SRES model -AVISO data	This research uses data from AVISO
2.	Sea level rise	AVISO data	

3.	Maximum tidal ride	Using a tide gauge	Obtained from the Hydrooceanographic Service
4.	Coastline changes	Measurement of beaches experiencing erosion or accretion	Obtained from interviews with the community regarding changes in the coastline from the previous year
5.	Beach elevation	Measurement and mapping using a total station tool	
6.	Coastal geomorphology	Field observations	Observed directly in the field then plotted on the map under study

Data analysis method

In this research, the data analysis carried out basically displays the relationships between information that will be used as the basis for research. The criteria and benchmarks are in the form of physical parameters determined based on modified studies from Gornitz (1991), namely geomorphology, changes in coastline, elevation, relative sea level rise, maximum tide range and wave height. In this article, it is explained about the grouping of the gulf coast vulnerability index into five groups, namely very not vulnerable, not vulnerable, moderate, vulnerable and very vulnerable. Quantitative assessment of coastal vulnerability is carried out through scoring. The scoring according to the criteria can be seen in Table 2.

Table 2. Assessment of physical variable scores for the gulf coast

No	Parameter	Skor				
		Sangat tidak rentan 1	Tidak rentan 2	Sedang 3	Rentan 4	Sangat rentan 5
a	geomorfologi	Batuan beku	Batu karang		Lumpur	pasir
b	Perubahan garis pantai (m/thn)	>2,0	1,0-2,0	1,0-(-1,0)	-1 – (-2)	<-2,0
c	Elevasi (m)	>30,0	20,1-30,0	10,1-20,0	5,1-10,0	0,0-5,0
d	Kenaikan muka laut relatif (mm/thn)	<-0,1	-1,0-0,99	1,0-2,0	2,1-4,0	>4,0
e	Tunggang pasut maks (m)	<1,0	1,0-1,9	2,0-4,0	4,1-6,0	>6,0
f	Tinggi gelombang (m)	<0,75	0,75-1,0	1,0-1,25	1,25-1,50	>1,50

Sumber: Gornitz (1991)

Each parameter that has a score is calculated for its vulnerability. Determination of the level of vulnerability is carried out by adopting and modifying the general equation regarding the coastal vulnerability index (IKP). In this research, the coastal vulnerability index is calculated based on the equation proposed by Gornitz and White (1992), namely as follows:

$$IKP = \sqrt{\frac{(a * b * c * d * e * f)}{6}}$$

dimana: a = geomorfology — b = coastline changes
c = elevation — d = relative sea level rise
e = maximum tidal range — f = wave height

The IKP equation describes the level of vulnerability to physical parameters in the sea. The IKP values obtained are then grouped at the level of vulnerability into three areas, namely not vulnerable, moderate and very vulnerable. The distribution of vulnerability levels is in accordance with the index division carried out by Gornitz and White (1992) which is based on percent with a range between classes of 33 percent. Values with a range of less than 33 percent are included in the non-vulnerable index with a blue indicator color KA. Values in the range of 34-66 percent are included in the medium index with a yellow indicator color. Values with a range of more than 67 percent are included in the very vulnerable index with a red indicator color.

RESULT AND DISCUSSION

Maps of coastal vulnerability (coastal vulnerability index/IKP) in Divur Bay and Luv Bay on Dullah Island in two seasons, namely the west season and the east season are presented in Figures 2 and 3.

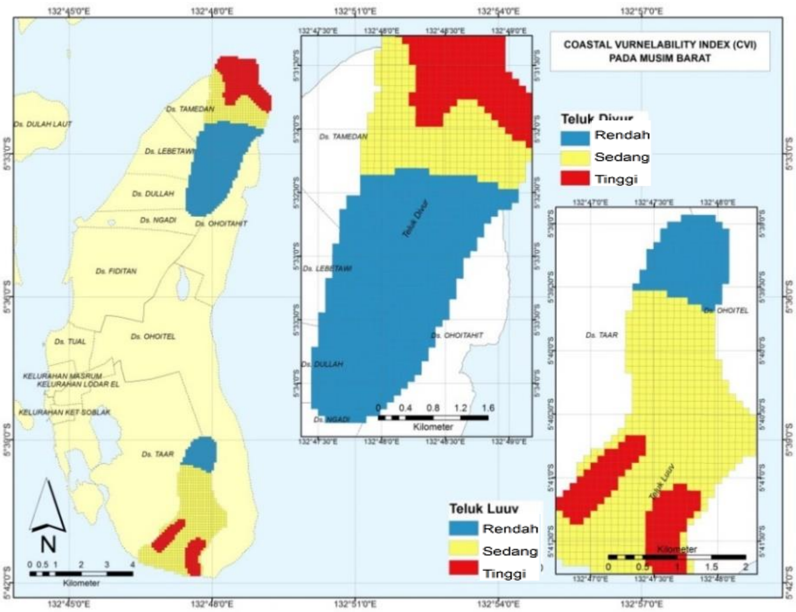

Figure 2. West season IKP

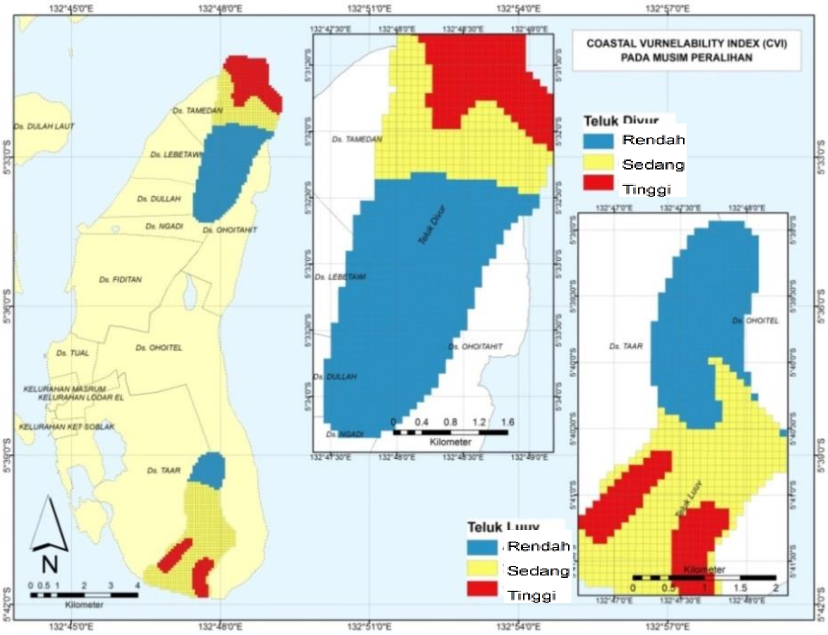

Figure 3. IKP for the eastern season

The vulnerability index can be used as an indicator of the level of vulnerability. The level of vulnerability is an important thing to know because it can influence the occurrence of disasters. New disasters will occur in vulnerable conditions. The division of classes or levels of vulnerability is based on research conducted by Gornitz and White (1992) where the classes are divided based on percentages with the distance between classes being 33%. Values included in the percent less than equal to 33 are included in the non-vulnerable index. Values included in the percent between 34 and 67 include the moderate index, while values included in the percent more than 67 include the vulnerable index.

In the west season, the coastal vulnerability index value in Divur Bay ranges from 6.74 to 11.62, while in Luv Bay it ranges from 0.00 to 15.00. In the transition season, the coastal vulnerability index value in Divur Bay ranges from 7.74 to 10.96, while in Luv Bay it ranges from 4.47 to 14.14. In the east season, the coastal vulnerability index values obtained range from 11.61 to 15.00 in Divur Bay and 7.74 – 19.37 in Luv Bay. The level of vulnerability of the Divur Bay coast in the three seasons does not differ much, ranging between 6.74-15.00.

In Luv Bay, the level of coastal vulnerability during the transition season and east season is slightly different from the west season. In every season, Divur Bay has a vulnerable water area at the front of the bay, while in Luv Bay it is on the left and right of the mouth of the bay. This is thought to be because at the mouth of the bay, the influence of tides in open sea waters is still high which influences the currents at the mouth of the bay (Rampengan 2009). In addition, the current movement pattern associated with the tidal process is the main driving force for the circulation of water masses in narrow and semi-enclosed waters such as bays (Rampengan 2009; Hadikusumah 2008) and involves water masses in very large quantities and has alternating directions (Triatmodjo 1999). For bay waters, tidal influences are more dominant than seasonal and wave influences (CRMP 1998). Apart from that, tides also cause currents that occur in the waters of bays and lagoons which are caused by masses of water flowing from higher surfaces to lower surfaces. When tidal waves propagate into shallow waters such as river estuaries or bays, the water bodies in this area will react to the action of open waters (Wirasatriya et al. 2006).

Tides are rhythmic fluctuations (rising and falling movements) of sea level due to the gravitational force of objects in the sky, especially the moon and sun, on the mass of sea water on earth. The pair of sun and earth produces tidal phenomena which are similar to the phenomena caused by the pair of earth and moon depending on the tidal driving force (GPP). The GPP caused by the sun is only half the strength caused by the moon. This is caused by the distance of the moon to the earth which is closer than the distance of the sun to the earth. The periodic nature of tides means that tide data can be predicted (Mahatmawati et al. 2009). Therefore, the deeper you go into the bay, the lower the level of water vulnerability because the current speed is relatively weak and the obstruction of large energy and the limitations of water hydrodynamics (Wisha et al. 2015).

CONCLUSION

Divur Bay and Luv Bay have waters that fall into the non-vulnerable to moderately vulnerable category with vulnerability index values ranging from 0.00-19.37 for two seasons (west season and east season). The position of the bay mouth has a higher level of vulnerability than the inner bay.

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