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The threat of extreme wave disasters and coastal abrasion in the coastal areas of Makassar City

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Abstract. Global warming has a great effect on the climate changes and the hydro-oceanography activities in the ocean, has caused threats of the extreme wave disasters and the coastal abrasion along the coastal areas. This research aims to investigate the level of extreme wave threats and the comparative descriptive analysis method. To look at the causality correlation between the study parameter and the interpretation parameter which is used to conclude the disaster level of threat of the extreme wave and the coastal abrasion. The data analysis uses the software of QGIS 2.8.11, and the analysis table is taken from the regulation of chief of the National Disaster Management Agency number 2 of 2012, which has been modified by the author based on the local conditions of the research location. The research results indicate that the coastal areas of Makassar city have threats of the extreme waves and the coastal abrasion with the total threat value ranging from 1,30-3,00. The threat of extreme wave disaster and the category of the abrasion were high in the coastal area of Tamalate, which has the total threat values of to 3,00, while the threat categories in the sub-districts of Wajo, Ujung Tanah, and Tallo were medium ranging from 1,70 to 2,20. The lowest categories were found in the sub-districts of Biringkanaya, Tamalanrea, and Mariso of which the threats range from 1,3 to 1,6. Decreasing the disaster risk can be done through several strategies, including developing a disaster management plan, establishing a program of decreasing disaster risk, creating an early disaster warning system, and disseminating the program of decreasing disaster risk to the coastal community.

1. Introduction

The coastal area has unique characteristics both physically and ecologically. Physically, the coastal area is a strategic area for various human activities such as settlement, education, sports, tourism, cultivation, and industry [1]. Ecologically, the coastal region has a variety of marine and brackish ecosystems such as various types of fish, crustaceans, and stretches of mangrove ecosystems as brackish forests that have the benefit of reducing wave energy [2].

Coastal areas also become vulnerable and threatened areas when climate change occurs [3, 4]. Climate change influences wind speed which in certain circumstances can change hydro-oceanographic activities in the sea so that extreme storms occur which also affect coastal abrasion in coastal areas [5, 6, 7, 8].

Makassar City is one of the cities in Indonesia located in the coastal area. It has an area of 175.77 km2 and a coastline length of ± 30km with a total population of 1,449,401 people and a population growth rate of 1.41% per year [9, 10].

The phenomenon of climate change has affected hydro-oceanographic activities in the coastal waters of Makassar City. This was found in the extreme wave phenomenon released by the Meteorology, Climatology and Geophysics Agency Region IV Makassar and coastal abrasion which occurred in the coastal area of Makassar city [11]. Based on this, research into the threat of extreme wave disaster and coastal abrasion was carried out to see the level of extreme wave disaster threat and coastal abrasion in the coastal areas of Makassar City [12].

2. Research Method

This study uses descriptive-comparative analysis method. Analysis and data interpretation was carried out to see the effect of study parameters on the level of threat of extreme and coastal abrasion waves in the coastal area of Makassar city. Data collection is done through field measurements and surveys and secondary data analysis. Processing data using QGIS 2.8.11, data analysis using hazard index analysis table extreme waves and coastal erosion are sourced from Peraturan Kepala Badan Nasional Penanggulangan Bencana (Perka BNPB) 2/2012.

2.1. Research Time and Location

This research was conducted in October 2016 until May 2017 and located in the coastal area of Makassar city.

2.2. Tools and Materials

The tool used in this research is the global positioning system (GPS) to determine the location of the research location, current kites that are modified to measure current velocity, stopwatch used for calculating time, roll meter for measuring mangrove data retrieval plots, writing stationery to record retrieval data, data shapefile of Makassar City administration boundary from BAPPEDA of Makassar City which is used for data analysis, 2011-2015 wind speed data from the Meteorology, Climatology and Geophysics Agency Region IV Makassar, Microsoft Excel 2013 which is used to input data and QGIS 2.18.11 is used to analyze data and map research results.

2.3. Measurement Procedure

Parameter measurements in this study include measurement of wave height, current velocity, the density of mangroves, data collection of shoreline shape and beach characteristics. Wave height measurement uses wave prediction based on wind speed data, wind direction, and the length of the wind blowing area without a hitch (fetch). Long fetch is the length of the sea that is bounded by the island at both ends. Effective fetch is calculated using equations

$$F_{eff} = \frac{\sum X_i \cos\sim}{\sum \cos\sim} \quad (1)$$

where F_{eff} is mean of effective fetch, X_i is fetch segment length, and $\sim$ is deviation on both sides of the wind direction by using an increase of 6^0 to 42^0 on both sides of the wind direction [13].

Flow velocity measurement using modified current kites. Calculation of flow velocity is carried out by releasing the current kite and holding the end of the rope that has been determined at the same time as the stopwatch is started. After the rope is tightened, the stopwatch is stopped. Calculation of flow velocity uses equations

$$v = \frac{s}{t} \quad (2)$$

where v is flow velocity (m/s), s is the length of rope when tightened (m), and t is time (s).

Mangrove density is a calculation of the number of species of mangrove ecosystem stands in a plot area. Mangrove species density is calculated using equations

$$R = \frac{n_i}{A} \quad (3)$$

where R is density, n_i is the amount of upright type i, and A is an area of the plot (10 m x 10 m) [14]. Coastal line data collection is done by looking at the shape of the coastline of the coastal area of Makassar City on digital raster map of Rupa Bumi Indonesia (RBI) in the scale of 1:50,000 (2013) made by the Geospatial Information Agency while data collection on coastal characteristics is done by looking at the soil type data in the coastal area of Makassar city and changes in coastal characteristics by development.

2.4. Data Analysis

Data analysis and classification of disaster threat level uses an analysis table sourced from Perka BNPB No. 2/2012 which was modified by the authors based on the local conditions of the study (Table 1 and Table 2). Disaster threat value is calculated using the following equation

$$H_{tot} = H_1 + H_2 + H_3 + H_4 + H_5 \quad (4)$$

$$H_i = S_i + B_i \quad (5)$$

where H_{tot} is total threat value, H_i is parameter indicator i, S_i is parameter class value, and B_i is the rate of indicator i.

Table 1. Disaster threat assessment index analysis

Component	Indicator	Index Class			Rate
		Low (1)	Medium (2)	High (3)	(%)
Hydro-Oceanography	Wave height (m)	< 1	1 - 2	> 2	30
	Flow velocity (m/s)	0 - 0.05	0.06 - 0.09	> 0.09	30
Ecosystem	Mangrove vegetation density (%)	> 10	1 - 10	-	15
Physical environment	Coastline shape	Bay	Bay-straight	Straight	15
	Coastal characteristic	Permanent building	Rocky-sandy/muddy	Sandy, muddy	10

Table 2. Classification of levels of extreme wave and beach abrasion disasters

Threat value (H_{total})	Category
<1,67	Low
1,67- 2,34	Medium
>2,34	High

3. Results and Discussion

Parameter data from the measurement and analysis of research data are presented in Table 3 and Table 4. The results of the analysis of research data show that the coastal area of Makassar City has a high level of threat of extreme wave and coastal abrasion (> 2.35), medium (1.67 -2.34) and low (<1.67). The high category of disaster threat is found in the coastal area of Tamalate sub-district with a threat value of 3.00 while the threat in the medium category is found in the coastal areas of Wajo sub-district, Ujung Tanah sub-district, and Tallo sub-district with a threat range of 1.70-2.20. The low category of disaster threat is found in Biringkanaya sub-district, Tamalanrea sub-district, Ujung Visi sub-district and Mariso sub-district with a range of threat values of 1.30-1.60. The description of the level of threat of extreme wave disasters and coastal abrasion of the coastal areas of Makassar City is presented in figure 1.

Table 3. Results of research data in the coastal area of Makassar City

Sub-district	Wave height (m)	Flow velocity (m/s)	Mangrove density	Coastline shape	Coastal characteristic
Biringkanaya	1.69	0.03	39.5	Straight	Muddy, sandy, overgrown with mangroves
Tamalanrea	1.68	0.03	29.14	Straight, bay	Muddy, sandy, overgrown with mangroves
Tallo	1.67	0.03	8.5	Straight, bay	Muddy, overgrown with mangroves and partially covered with stones
Ujung Tanah	1.66	0.05	0.0	Straight, bay	Sandy, covered with coastal buildings
Wajo	1.68	0.07	0.00	Straight	Sandy, covered with coastal buildings
Ujung Pandang	0.54	0.05	0.00	Straight, bay	Sandy, covered with coastal buildings
Mariso	0.35	0.03	0.00	Bay	Sandy, covered with coastal buildings
Tamalate	2.1	0.13	0,00	Bay	Open sandy

Table 4. Results of data analysis of extreme wave and beach abrasion disaster levels in the coastal area of Makassar City

Sub-district	H_1	H_2	H_3	H_4	H_5	H_{Total}	Category
Tamalanrea	0.6	0.3	0.15	0.3	0.1	1.45	Low
Biringkanaya	0.6	0.3	0.15	0.45	0.1	1.60	Low
Ujung Tanah	0.6	0.3	0.45	0.3	0.2	1.85	Medium
Tallo	0.6	0.3	0.3	0.3	0.2	1.70	Medium
Tamalate	0.9	0.9	0.45	0.45	0.3	3.00	High
Wajo	0.6	0.6	0.45	0.45	0.1	2.20	Medium
Ujung Pandang	0.3	0.3	0.45	0.3	0.1	1.45	Low
Mariso	0.3	0.3	0.45	0.15	0.1	1.30	Low

This study shows the coastal area of Makassar City has a level of threat of extreme wave disasters and coastal abrasion with low, medium and high categories. The coast of Tamalate sub-district is a coastal area with a high category of disaster threat. This is caused by several factors. Namely, the waters of Tamalate sub-district tend to have greater wave height than other sub-districts so that they are susceptible to coastal abrasion. The coastal areas which were hit by a high wave and current forces can cause coastal abrasion [15,6,1]. Beach forms that tend to be straight and open and face to face with the Makassar strait are other factors that make the coast of Tamalate sub-district vulnerable to the direct influence of ocean waves. The occurrence of coastal abrasion in Padang coastal areas is caused by relatively straight beaches [7]. The absence of coastal vegetation (mangrove) which serves as a damper of wave energy and the characteristics of the beach which is dominated by sand, increasingly adds to the abrasion rate of the coast in the coastal area of Tamalate sub-district [4]. The type of lithology of the coastal area which is dominated by alluvium deposits (sandy) has low resistance to erosion by waves and ocean currents [18]. The existence of mangrove ecosystems as coastal natural ecosystems is capable of reducing ocean wave energy before reaching the coast 1 [19,2].

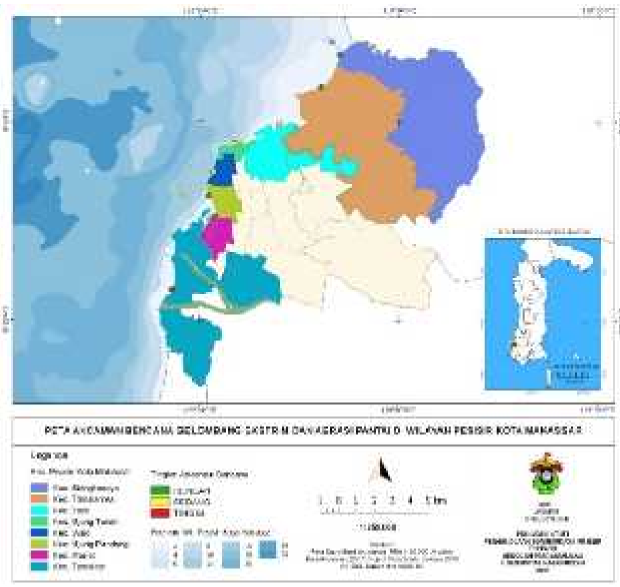

Figure 1. Map of the analysis of extreme wave and beach abrasion disaster threats in the coastal area of Makassar City

The threat of extreme wave and coastal abrasion categories is found in the coastal areas of Wajo sub-district and Tallo sub-district, while the low category is found in Biringkanaya sub-district, Tamalanrea sub-district, Ujung Pandang sub-district and Mariso sub-district. This is because the characteristics of the coastal areas in the district are overgrown with mangrove ecosystems and some of the coastal areas have been covered with coastal buildings to maintain the stability of the coastline. Also, the sub-district has less influence on wave energy due to the presence of Lae-Lae Island and Kayangan Island in front of it. The waves will experience diffraction when passing obstacles in the form of islands or breakwater structures [7]. The existence of mangrove ecosystems and coastal buildings make the coastal area of the sub-district, quite stable to face the influence of waves and coastal abrasion. The stability of the shoreline position due to the barrier is a factor that reduces abrasion [20].

The phenomenon of extreme waves and coastal abrasion has a negative impact on coastal areas in Indonesia. Extreme wave disasters and coastal abrasion can damage people's settlements, infrastructure, disrupt fishing activities, and disrupt the activities of aquaculture ponds in coastal areas. The damage to the beach building (white screen monument) on Tanjung Bayang beach, Tamalate district was caused by coastal abrasion [12]. The impact of coastal abrasion in Pondok-Bali has damaged people's settlements, mangrove forest areas and aquaculture ponds [21]. The finding the impact of coastal abrasion in the coastal areas of Sayung has damaged fishing settlements, infrastructure and reduced fishermen's income [22]. Seeing the high scale of impacts caused by extreme wave disasters and abrasion, some disaster risk reduction strategies are needed, namely by preparing a disaster management plan, building an early warning system against extreme wave disasters and abrasion, and disseminating disaster risk reduction programs to coastal communities.

4. Conclusion

The level of extreme wave threat and coastal abrasion in the coastal area of Makassar city is in the high category in the Tamalate sub-district, the category is in Wajo sub-district, Ujung Tanah sub-district, and Tallo sub-district, and the low category is Biringkanaya sub-district, Tamalanrea sub-district, Ujung Pandang and Kecamatan sub-district Mariso.

References

[1] Ukkas M 2009 Studi Abrasi dan sedimentasi di perairan bua-passimarannu kecamatan Sinjai

Timur Kabupaten Sinjai *J. Akuatik* **3** 20-29
[2] Taufiqurohman A 2014 Pemodelan tinggi gelombang akibat adanya hutan mangrove di Desa Mayangan, Kabupaten Subang *J. Akuatika* **5** 1-7
[3] Muhammad S, Wiadnya D G R and Sutjipto D O 2009 Adaptasi pengelolaan wilayah pesisir dan kelautan terhadap dampak perubahan iklim global *Semin. Nas. Pemanasan Glob.* **1** 12
[4] Tejakusuma I G 2011 Pengkajian kerentanan fisik untuk pengembangan pesisir wilayah Kota Makassar *J. Sains dan Teknologi Indonesia* **13** 82-87
[5] Setyadinto O 2007 Analisa erosi dan perubahan garis pantai pada pantai pasir buatan dan sekitarnya di Takisung, Propinsi Kalimantan Selatan *J. Teknik Sipil* **7** 224-235
[6] Ruswandi R, Mangkuprawira S, Saefuddin A and Kardono P 2008 Identifikasi potensi bencana alam dan upaya mitigasi yang paling sesuai di terapkan di pesisir Indramayu dan Ciamis *J. Riset Geologi dan Pertambangan* **18** 1-19
[7] Umar 2011 Kajian pengaruh gelombang terhadap kerusakan pantai matang danau Kabupaten Sambas *J. Teknik Sipil* **11** 93-102
[8] Parauba R, Jasin M I and Mamoto J D 2016 Analisis gelombang pecah di pantai Niampak Utara *J. Sipil Statik* **4** 595-603
[9] Hidayat A 2012 Analisis pengembangan kawasan pesisir berbasis mitigasi sea level rise (kenaikan muka air laut) studi kasus kawasan kota lama Makassar *J. Lingkungan Binaan Indonesia* **1** 87-100
[10] Badan Pusat Statistik 2016 *Makassar dalam Angka* (Makassar: BPS)
[11] Fajar 2016 *BMKG Minta Nelayan Tidak Melaut* (Makassar: Fajar) pp 1-11
[12] Koddeng B 2011 Zonasi kawasan pesisir pantai Makassar berbasis mitigasi bencana group *Tek. Arsit.* **5** 4-20
[13] Triatmodjo B 2012 *Perencanaan Bangunan Pantai* (Yogyakarta: Beta Offset)
[14] Odum E P 1993 *Dasar-Dasar Ekologi Edisi ke III* (Yogyakarta: Gadjah Mada Press)
[15] Nugroho S H 2012 Mitigasi Dampak Kenaikan Muka Laut di Pantai Alam Indah Kota Tegal Jawa Tengah Melalui Pendekatan Geomorfologi *J. Lingkungan dan Bencana* **3** 31-40
[16] Fajri F, Rifardi, and Tanjung A 2012 Studi Abrasi Pantai Padang Kota Padang Provinsi Sumatera Utara *J. Perikanan dan Kelautan* **17** 36-42
[17] Istijono B 2013 Tinjauan Lingkungan dan Penanggulangan Abrasi Pantai Padang-Sumatra Barat *J. Rekayasa Sipil* **9** 42-49
[18] Solihuddin T B 2011 Karakteristik Pantai dan Proses Abrasi di Pesisir Padang Pariaman, Sumatra Barat *Globe* **13** 112-120
[19] Krisyanto A, Armono H D and Soemarno 2013 Kemampuan Hutan Mangrove Rumpun Rhizophora Sp dan Avicenia Sp dalam Meredam Gelombang Laut *J. Pendidikan Fisika Indonesia* **9** 173-183
[20] Prawiradisastra S 2003 Permasalahan Abrasi di Wilayah Pesisir Kabupaten Indramayu *Alami* **8** 42-46
[21] Achiari H, Wulandari N, Yustiani Y M, and Harlan D 2015 Study Erosion and Coastal Destruction at Pondok-Bali, North Coast-West Java of Indonesia *Int. J. Manage. App. Sci*. **1** 317-320
[22] Marfai M A 2012 Preliminary Assessment Of Coastal Erosion and Local Community Adaption in Sayung Coastal Area, Central Java-Indonesia *Quaestiones Geographicae* **3** 47-55
[23] BNPB 2012 Peraturan Kepala BNPB Nomor 02 Tahun 2012 Tentang Pedoman Umum Pengkajian Risiko Bencana (Jakarta: BNPB)