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Coastal Vulnerability Zonation of Pinrang District and Parepare City Area Based on Morphodynamic Review

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Abstract*—The understanding and analysis of morphodynamic are essential to explain coastal vulnerability. This paper aims to present a mophodynamic review by assessing validity of the Wright and Short method, and then make zonation map The research method using the conceptual beach classification based on relationships between the characteristic of different types of beaches consisting of wave condition, sediment size, shoreline change and field observations that indicating the occurrence of coastal erosion. The classification presented by Wright and Short known as a function of the dimensionsless fall velocity parameter (Ω) or Dean's number. In this research, observations are presented from 15 beaches around the west coast of Sulawesi Island and their divided into six zones. Morphodynamic state of Lapakaka and Lanrisang – Ujung Tape beaches are reflective (Ω = 0.179 – 0.801), coarse grain with a D_{50} of 0.31 – 1.52. Maroneng and Ujung Lero beaches are intermediate (Ω = 1.842 – 2.389), fine – coarse grain sediment and D_{50} of .0.16 – 0.53. Kappe – Data and Sibo beaches are disspative (Ω = 1.842 – 14.089.), fine grain sediment and D_{50} of 0.22 – 0.29. The interpretation result of Landsat 5 (1995) and Landsat 8 (2015), showed significant shoreline change by erosion process in the Lapakaka beach reached about 26040.62 m^2 and Lanrisang – Ujung Tape of 166727.64 m^2. Based on morphodynamic review and field study, showed that Lapakaka and Lanrisang – Ujung Tape beaches are susceptible, Maroneng and Ujung Lero beaches are intermediate and Kappe – Data and Sibo beaches are resilience.

***Index Terms*— Morphodynamic, erosion, vulnerability, zonation**

I. INTRODUCTION

The coast is one of the most dynamic parts of the earth surface. About 23% of the world's population live within 100 km of the coast and about 10 % of the population live in extremely low-lying areas (< 10 m above mean sea level). Many geophysical processes like coastal erosion, storm surges, coastal flooding, tsunamis and sea level rise pose hazards to these people [1]. The coastal zone is highly vulnerable. Therefore, an assessment of the degree of its vulnerability is important since it is related to the way decisions are to be made regarding the reduction of exposure to the impacts of coastal hazards.

Assessment of vulnerability involves measuring the susceptibility to loss from a hazard and estimating the system's resilience or the capacity to recover from the hazard. Many past vulnerability assessment studies have been criticised that too much emphases have been put on the physical affects, which results in separation of physical and socioeconomic elements within vulnerability studies [2].

The earth is geologically active and experiences gradual but continous change in climate and affected on the entire surface of the earth including coastal area. Shoreline erosion is a natural coastal process with a number of contributing factors including waves, longshore currents, sediment supply, storm events, and sea-level rise. Because the magnitude and relative importance of these factors differs along various shoreline segments, the rate of coastal erosion often varies throughout the state. It is a major problem around the world. Globally, about 70% of the sandy beaches are experiencing acute erosion [3].

Indonesia is a maritime country [4] data showed that the island belongs to Indonesia is approximately 17.504 islands and about 70% of its sea's territory shoreline is 104.000 km or fourth in the world after the United States, Canada and Russia. The objective condition with wide coastal areas and have potential of them as cultured fisheries, industry, tourism and others. However, based on a survey, concluded that 20% of Indonesia shoreline has been damaged [5].

The aims of this study is, firstly to present a mophodynamic review by assessing the validity of the Wright and Short method (and, secondly, to make zonation based on coastal vulnerability especially coastal erosion and its impact on the surrounding environtment. Risks and vulnerabilities can be minimize and managed by concerns of coastal resiliency and sustainability have become prominent in discussions of hazard planning and coastal management.

II. MORPHODYNAMIC BEACH STATE

Beaches are wave-deposited accumulations of sediment located at the shoreline. They require a base to reside on, usually the bedrock geology, waves to shape them, sediment to form them, and most are also affected by tides. The beach extends from wave base where waves begin to feel bottom and shoal, across the nearshore zone, though the surf zone to the upper limit of wave swash. In the coastal zone ocean waves are transformed by shoaling, breaking, and swash. In doing so they interact with the seabed, and determine the beach morphology or shape, a process called beach morphodynamics [6].

The conceptual beach classifications are empirical models based on the relationships between the characteristics of different types of beaches (wave climate, sediment size and tidal regime) and field observations [7].

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The classification of Australian beach model [8], is based on the field observations collected. This classification indicates the prevailing conditions in the surf zone: dissipative, intermediate or reflective, as a function of the dimensionless fall velocity parameter (Ω), also known as the Dean's number :

$$\Omega = \frac{Hb}{WsT}$$

where Hb is the breaking wave height, T is the wave peak period corresponding to the breaking conditions and Ws is the sediment fall velocity.

Reflective beaches are produced by lower waves (H<0.5 m), occur where $\Omega < 1$, longer wave periods, coarser sediment and cobble/boulder. They consist of a relatively steep beach face (5–20°), with waves breaking by surging and no bar or surf zone[6]. Their dynamic is driven by surging breakers or collapsing over the step. The strong swash in turn build the steep, high beach face.

Intermediate beaches occur when $1 > \Omega > 6$, moderate to high waves, fine to medium sand and longer wave periods.

Dissipative beaches occur where $\Omega > 6$ and are characterised by fine sand, high wave energy, and preferably short wave periods, low gradient swash zone, a wide surf zone, containing two to five subdued parallel bars and troughs. Their dynamic is driven by spilling breakers.

III. THE STUDY SITE

The study area extends 15 beaches around the west coast of Sulawesi Island and their divided into 6 zones from Maroneng to Lapakaka (3°35'72" – 4^0 4' 51"S and 119°30'.59" - 119°37'12" E) along the western coastal of South Sulawesi, Indonesia covering about 30 km. Bounded in the northern by Polewali Mamasa District, eastern by Sidenreng Rappang District; in the South by the Barru District and in the west by Makassar Strait. There are two river mouth consist of Saddang River in Pinrang District and Karajae River in Parepare Municipality. Some of which the beach is a tourism area [9].

Regionally, study area which located Sulawesi Island in the center of the Indonesian archipelago, formed by the accumulation of micro plates derived from a variety of sources such as fragments of Asia, Pacific and Australia [10]. Since its formation in the Tertiary period to the present, it consequently produces continuous complex geological and tectonic phenomena. Due to the insistence of influence/pressure by the three major plates, it becomes a very vulnerable condition and includes one of the most active islands in the world.

IV. MATERIALS AND METHODS

This research using the field observation and laboratory analysis has been done to complete this study. Besides that, done hydrodynamic data prediction based on ECMWF data downloaded for time periodic 1983 – 2013 consists of wind direction and speed, also interpretation remote sensing data to determine shoreline change, consists of Landsat 5 image with time periode 1995 and Landsat 8 image for 2015.

The purpose of field observation is to see the beach appearance both the composition and topography especially a result of coastal erosion. Laboratory analysis is done by petrography observation and for each fraction textural analysis was performed using D_{50} sieve size (Sirajuddin, 2015). All of sand samples were collected at 15 sandy beaches. Samples were taken at several the shore at locations with different features and chracteristic. Samples dried 24 hours in the oven at 90°C and divided into sub-samples for sieving and petrography analysis. Grain size distributions were determined using the GRADISTAT software package. For each beach, the Dean' number were calculated for use to predict the beach state and then compared by field observed [9]. Finally, make a coastal vulnerability zonation map based on analaysis of morphodynamic review and field data.

V. RESULTS AND DISCUSSIONS

The result of hydrodynamic data processing, showed that wind direction comes from northwest, west and southeast (Figure 1), wherein wave and current direction are dominant leads to south (Figure 2). Wind direction and speed data for time periods from 1983 - 2013, has been downloaded from the ECMWF Public Datasets web interface.

The hydrologic and mechanical action of wind and waves are constantly working either to erode cliffs or deposits sediment on beaches, re-shaping the coastline over a relatively short time-scale. Its different for tectonic activity, usually acts across geologic time scale. In research area, this phenomenon is clearly visible in the field. Wave activity has damaged coastal building and house. However, this is not same in all regions.

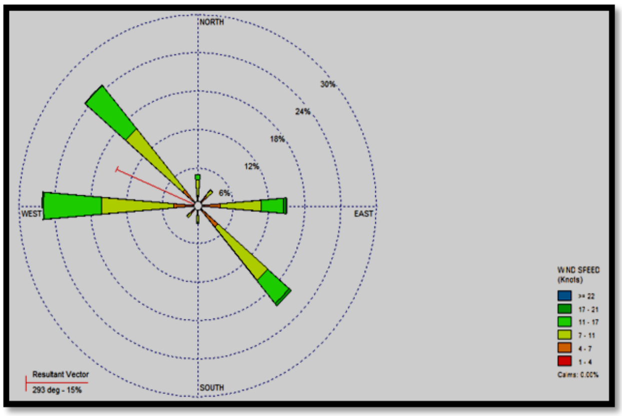

Figure 1. Wind rose diagram from 1983-2013.

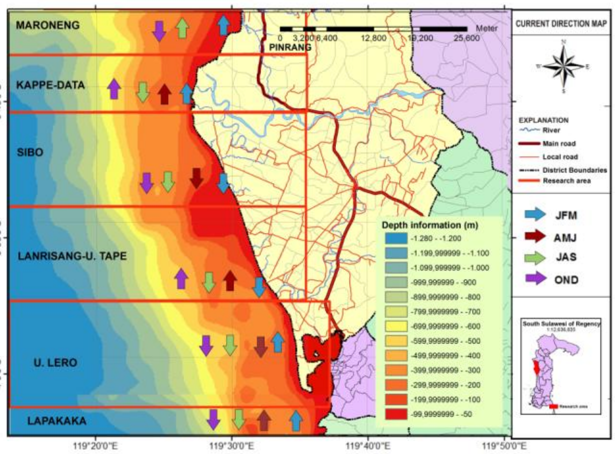

Figure 2. Current direction map

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Parepare City and Pinrang have different characteristics, which Parepare beach has curved shoreline, while Pinrang beach has straight shoreline. This occurs because of the sediment material different on the beach.

Current speed and direction every month during 1983 – 2013 showed the highest numbers in Lanrisang – Ujung Tape beach that is 0.581 m/s to the south and 0.559 to the north with average current speed about 0.200 m/s. This data shows that the Lanrisang – Ujung Tape area always get a strong current so that in some places found some damage due to currents and wave erosion. Current speed in January, February and March has maximum speed is higher than in the other month groups, because of wind factor from the sea is not same.

The result of data processing by Gradistat software and field appearance, sediment characteristic on the southern and northern part of research area are different. On the Lapakaka beach (Figure 3) at south composed by the coarse sand 25.2%, medium sand 6.7% and clay 0% with D_{50} 1.52 mm. As for the Ujung Lero beach have finer sediment characteristic are composed of fine sand 38.6%, medium sand 14.9% and clay 6.2% with D_{50} 0.16 mm (Figure 4 and Table 1). Maroneng beach in the nothern is the dominant fine sand 40.3%, medium sand 33.6% and coarse sand 7.9% (Figure 5).

Figure 3. The field appearance of Lapakaka beach

The number of Ω at research area showed that Lapakaka beach and Lanrisang – Ujung Tape has number 1.52 and 0.495 and in the field seen erosion at coastal building and house, their include reflective of morphodynamic state. The beaches are susceptibility. Maroneng and Ujung Lero beaches has number of Ω 1.842 and 2.389, that is intermediate of morphodynamic state. For Kappe – Data and Sibo beaches has number of Ω 7.849, 14.089 and 12.743, no erosion, so classified as resilience (Figure 6).

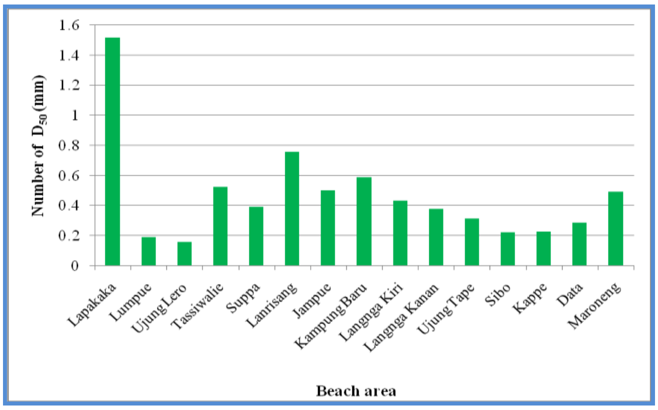

Figure 4. Graphic Number of D_{50} (mm)

Table 1. Grain size analysis result at research area

No.	Beach Area	Total weight	APERTURE (mm)							D_{50} (mm)
			2.36	1.18	0.6	0.425	0.3	0.15	PAN	
1	Lapakaka	99.983	36.04	22.1	28.21	7.309	2.242	4.007	0.081	1.52
2	Lumpue	99.641	0.557	0.512	2.249	2.102	1.394	64.56	28.264	0.19
3	Ujung Lero	99.996	1.071	0.128	1.091	1.016	1.23	50.14	45.322	0.16
4	Tassiwalie	99.992	3.987	5.751	26.14	37.2	22.19	4.52	0.217	0.53
5	Suppa	99.991	0.349	1.797	16.65	25.71	25	28.03	2.054	0.39
6	Lanrisang	99.993	7.511	13.12	44.88	26.84	6.319	1.201	0.119	0.76
7	Jampue	99.994	0.528	2.448	31.08	31.11	19.49	14.95	0.381	0.50
8	Kampung Baru	99.849	4.134	10.17	34.47	24.96	15.35	10.3	0.478	0.59
9	Langnga Kiri	99.992	3.274	2.912	18.01	27.63	27.77	19.41	0.993	0.43
10	Langnga Kanan	99.993	0.326	0.465	6.811	29.61	39.02	23.15	0.612	0.38
11	Ujung Tape	99.991	0.063	0.065	4.427	18.5	31	42.13	3.807	0.31
12	Sibo	99.985	0.216	0.029	0.643	3.733	16.8	67.4	11.168	0.22
13	Kappe	99.992	0.076	0.26	4.179	8.917	15.26	53.76	17.543	0.23
14	Data	99.991	0	0.347	6.963	14.15	25.75	46.48	6.304	0.29
15	Maroneng	99.993	0.148	0.611	19.18	52.82	23.66	3.204	0.368	0.49

Figure 5. The field appearance of Maroneng beach

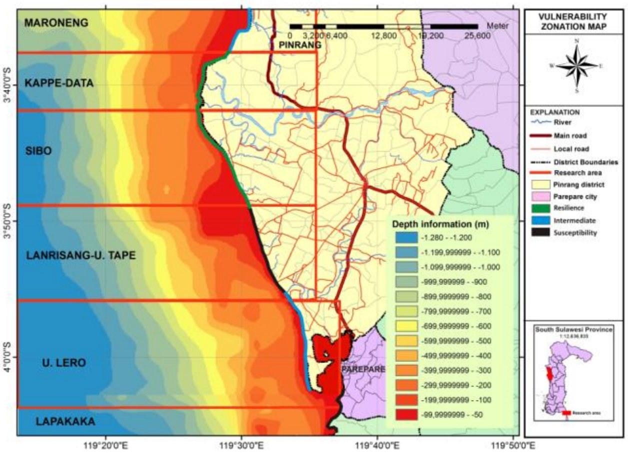

Figure 6. Coastal vulnerability zonation map of Pinrang District and Parepare City

VI. CONCLUSION

The study area has lithology and morphology varies, composed of lava, volcanic breccias, tuffs and alluvial, cause of different beach material. The beach morphodynamic state reflective, intermediate and dissipatve in the study area described by different of sediment grain size and the field appearance of them. Based on morphodynamic review by sediment texture of sand grain analysis and compare with field data,

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Lanrisang – Ujung Tape and Lapakaka beaches including in beach morphodynamic state of reflective, coarser sand indicated high wave energy so as to erode, the beaches are classified as susceptibility. Meanwhile, Sibo and Kappe - Data beaches including in dissipative, fine sand, indicated low wave energy, no erosion so classified as resilience.

The research parameter presented in this paper maybe does not suffice to determine beach morphodynamic state so need furthermore research in order to supporting coastal planner to obtaining more accurate data.

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REFERENCES

1. Mukhopadhyay, A., Dasgupta, R., Hazra, S., and Mitra., D.,(2012, January). Coastal Hazards and Vulnerability : A Review [Online]. International Journal of Geology, Earth and Environmental Sciences. 2(1), pp. 57 – 69.Available: http://www.cibtech.org.jgee.htm
2. IPCC (Intergovernmental Panel on Climate Change), Climate Change 2001 : Impact, Adaptation and Vulnerability, Cambridge University Press, 2001
3. Bryant, E., Natural Hazards, 2nd edition Cambridge University Press, 2005
4. The Ministry of Maritime and Fisheris, The Maritime and Fisheris in Number, Working Group of Aligment The Maritime and Fisheries Data, Statistic and Information Data Center, Jakarta, 2001
5. The General Directorate of Water Resources and Public Works Ministry, Coastal Safety Guidelines, Jakarta, 2007
6. Short, A.D., Coastal Process and Beaches, Nature Education Knowledge, 2012, 3(10):15.
7. Abanades , J., Greaves, D., Iglesias, G., (2015), Wave Farm Impact on Beach Modal State, (Online), Marine Geology Journal 361, 0025-3227/2015 Elsevier B.V, p.126-135. Available: At Marine Geology, Science Direct, http://www.elevier.com./locate/margio
8. Wright., L.D., May, S.K., Short, A.D., Green, M.O., Beach and surf zone equilibria and response time, Coastal Engineering, 1984, p. 2150-2164
9. Sirajuddin, H., Surimihardja, D.A., Imran, A.M., Thaha, M.A. (August 2015),, Influence of Sediment Texture on Beach Morphodynamic State, (Online), International Journal of Development Research , Vol. 05 Issue, 2015, ISSN: 2230-9926, p.6249-5254. Available : http://www.jounalijdr.com
10. Sirajuddin, H., Surimihardja, D.A., Imran, A.M., Thaha, M.A., , Coastal vulnerability based on tectonics and shoreline change along coastal area of Lumpue Coast South Sulawesi, Proceeding 9th International Sympotium on Lowland Technology, Saga, Japan, 2014, ISBN: 4 -921090-06-8, p.617-621.

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