ISSN 2349-6193
Impact Factor: 2.805

IJESMR

International Journal OF Engineering Sciences & Management Research

VULNERABILITY ANALYSIS FOR SMALL ISLANDS: THE CASE OF DULLAH ISLANDS TUAL CITY MOLLUCCAS

Henny Fitrinawati*[1], Daniel Djokosetiyanto[2], Machfud[3] & Achmad Fahrudin[4]

*[1]Natural Resources and Environmental Management Program, Bogor Agricultural University, Graduate School Building 2nd Floor, Campus of IPB Baranangsiang, Bogor 16141, West Java, Indonesia.

[2]Department of Aquaculture, Faculty of Fisheries and Marine Science Technology, Bogor Agricultural University, Campus of IPB Darmaga, Bogor 16680, West Java, Indonesia.

[3]Department of Agroindustrial Technology, Faculty of Agricultural Technology Bogor Agricultural University, Campus of IPB Darmaga, Bogor 16680, West Java, Indonesia.

[4]Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science Technology, Bogor Agricultural University, Campus of IPB Darmaga, Bogor 16680, West Java, Indonesia.

Keywords: *vulnerability index, Dullah Bay, small island.*

ABSTRACT

Dullah Island is the largest island of the 66 islands located in the city of Tual. The island Dullah approximately 94 km2 that included into the category of very small and outer islands of Indonesia. Potential Island Dullah very large as the potential of fisheries and marine tourism potential which should improve the welfare of local residents but faced pressure as complex as an ecological aspect that global climate change is triggering natural instability, tsunamis and social aspects namely population growth.The purpose of this study is to calculate the vulnerability index Dullah Island, Kota Tual.This research was conducted in Dullah Islands, Tual City, Molluccas Province Indonesia. Data were collected through observation, measurement and interview with the respondent (primary data) and secondary data collection from various sources such as AVISO, ECMWF, and the Department Hidrooseanografi consisting of geophysical data such as the average riding tide, wave height, elevation and slope typology beach, spacious island, sea level rise; ecobiolgy data such as mangrove ecosystems, coral reefs, seagrass beds; and socioeconomic and cultural conditions such as population, land use and the presence of marine conservation.

This study refers to the concept of vulnerability (V) Turner et al (2003) which is an overlay function of exposure/ exposure (E), sensitivity / sensitivity (S) and the adaptive capacity / adaptive capacity (AC). Dullah Island has environmental vulnerability index which is still in the category of low vulnerability.where the value of the environmental vulnerability index for Island Dullah ranged between 1.16 - 4.71.

INTRODUCTION

The small island is defined as the island which has less than 2,000 km² (Act No. 27 of 2007) and the following characteristics: apart from the main island or large island that is insular, has limited fresh water resources both surface water and groundwater, has limited carrying capacity, its uninhabited population has socio-cultural conditions depending on local economy developments and outside the island, has lowterrestrial and high marine biodiversity, climatic variations are small but potential changes occur quickly, sensitive and susceptible to external influences whether natural such as sea level rise, especially oceanographic conditions and tidal waves or due to human activities such as the level of land use, population growth and pollution (Pelling and Uitto 2001; Cherian 2007; Kusumartono et al 2016; Ozyurt et al, 2010). The various specific characteristics, management of small islands require a more systemic approach and specific to each island.Dullah Island is the largest island of the 66 islands located in the city of Tual. The island Dullah approximately 94 km2 that included into the category of very small and outer islands of Indonesia because typically no greater than 100 km2 (Farhan and Lim 2012). Potential Island Dullah very large as the potential of fisheries and marine tourism potential which should improve the welfare of local residents but faced pressure as complex as an ecological aspect that global climate change is triggering natural instability, tsunamis and social aspects namely population growth.Vulnerability is a tendency of an entity suffered damage (SOPAC 2005). The vulnerability of small island can be interpreted as a convenience systems / small island were damaged so the more vulnerable an island the more easily the island were damaged. Framework vulnerability expressed Turner et al 2003 consists of three elements of exposure, sensitivity and durability. Exposures derived from variability and change in the human condition and the environment / nature. Sensitivity linked with socio-economic diversity and biophysical

ISSN 2349-6193
Impact Factor: 2.805

IJESMR
International Journal OF Engineering Sciences & Management Research

conditions of the island. Durability relates to the response of small islands that rely on the ability to adopt impact and at the same time manage the resulting risks.The above description can be used as a basis in environmental management Dullah Island so it takes a vulnerability assessment environment that would be beneficial to the development strategy plan Dullah Island precise and accurate. The purpose of this study is to calculate the vulnerability index Dullah Island, Kota Tual.

MATERIALS AND METHODS

Study Area

This research was conducted in Dullah Islands, TualCity,Molluccas Province, Indonesia on December 2016 to June 2017 which consisted of initial data collection, processing of the initial data, field surveys and advanced data processing. Dullah islands consist of two districts North Dullah and South Dullah.The location of research shown in Figure 1.

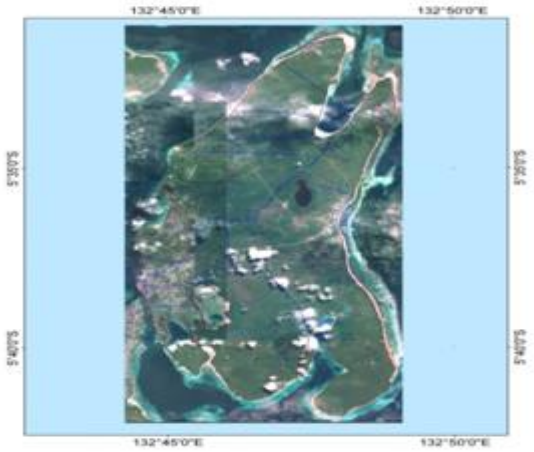

Fig 1: Study Area

RESEARCH PROCEDURE

The data were collected through observation, measurement and interview with the respondent to obtain primary data.The secondary data were collected from various sources such as AVISO, ECMWF, and the Department Hidrooseanografi consisting of geophysical data such as the average riding tide, wave height, elevation and slope typology beach, spacious island, sea level rise; ecobiology data such as mangrove ecosystems, coral reefs, seagrass beds; and socioeconomic and cultural conditions such as population, land use and the presence of marine conservation.This study referred to the concept of vulnerability (V) Turner et al (2003) which is an overlay function of exposure / exposure (E), sensitivity / sensitivity (S) and the adaptive capacity / adaptive capacity (AC). The parameters of each dimensionin these vulnerabilities using the approach of vulnerability scoping diagram (Polsky et al 2007) that sea level rise (SR), coastal erosion (ER), wave height (GL), the average riding pairs (PS), tsunami (TS), growth (PD) and population density (KP), elevation (EL) and slope (SL), the typology of the beach (TP), land use (PL), the typology of settlements (PP), habitat pesisr (HP), the mangrove ecosystem (MR), the coral reef ecosystem (TK), seagrass ecosystems (LM) and marine conservation (KL). Function vulnerability developed into a mathematical equation by UHU-EHS (2006)

$$V = (EXS) / AC \quad (1)$$

The formula of each dimension of vulnerability adopted from Polsky et al. (2007) as follows:

Exposure dimension

$$IE = 0,41(SRxER)+0,21GL+0,14PS+0,14TS+0,10(PDxKP) \quad (2)$$

Sensivity Dimension

$$IS=0,43EL+0,21TP+0,14SL+0,11PL+0,11PP \quad (3)$$

Adaptive Capacity Dimension

$$IAC=0,40HP+0,20TK+0,20MR+0,10LM+0,10KL \quad (4)$$

ISSN 2349-6193
Impact Factor: 2.805

IJESMR
International Journal OF Engineering Sciences & Management Research

2,3,4 Equation 2 is substituted into the equation in order to obtain the equation vulnerability index for small island (IK-PK) as follows:
IK-PK=(IExIS)/IAC

Categories of vulnerability values (Doukakis 2005)
0,20-6,04 = low vulnerabilty
6,05-18,18 = moderate vulnerability
18,19-40,48 = high vulnerabilty
40,49-76,00 = very high vulnerability

RESULTS AND DISCUSSION

Total vulnerability assessment parameters of Dullah Island consisted of 17 parameters, seven parameters were components of exposure, five parameters for component sensitivity and adaptive capacity. Geophysical characteristics, ecosystems, and natural resources and economic and social transformation have been done that value become a value score for each parameter vulnerabilities as in Table 1. As shown in Table 1, there were some differences between districts parameters contained in both Dullah island of component exposure , sensitivity, and adaptive capacity. Differences in these values of course would also determine the difference in value between the environmental vulnerability indexDullahwillayah Island which were being used as a case study in this research.

Table 1: The value score of each parameter vulnerability Dullah Island

No	Parameter	Score	
		North Dullah	South Dullah
A Exposure			
1	Sea level rise	1	1
2	High waves	5	5
3	The average riding tide	3	3
4	The ride of erosion	2	5
5	Tsunami	1	1
6	Population growth	4	5
7	Population density	2	4
B Sensitivity			
8	Typology beach	4	2
9	Elevation	3	2
10	Slope	4	3
11	Land use	1	5
12	Location settlement	2	3
C Adaptive capacity			
13	Coastal habitat	3	2
14	Coral reef (%)	5	5
15	Mangrove(tress/ha)	1	1
16	Seagrass (%)	1	1
17	Marine conservation	1	2

Exposure parameter values in the district dimension North Dullahand South Dullahhad differences on some parameters. This could be seen in parameter erosion/shoreline change (ER), population growth (PD) and population density (KP) in the district of South Dullah had a score greater than North Dullah. Meanwhile, four other parameters such as sea level rise (SR), wave height (GL), the average riding pairs (PS) and tsunami (TS)had a value score that was the same for both districts.Sensitivity parameter value both districts studied also showed a significant difference. Five different parameters relative sensitivity between the two districts. Typology beach (TP), elevation (EL) and slope (SL) in the district of North Dullah has a higher sensitivity than South Dullah. Land use (PL) and settlements (PP) in the district of South Dullah has a sensitivity that was higherthan the North Dullah because the land was dominated by settlements.Of the five parameter values adaptive capacity, two relatively different parameters namely coastal habitat parameters (HP) and the presence of marine conservation areas (KL). A larger proportion of coastal habitats in the district of North Dullah than Dullah South but South Dullah districts had marine protected areas,. Mangrove and seagrass dominated districts

ISSN 2349-6193
Impact Factor: 2.805

IJESMR

International Journal OF Engineering Sciences & Management Research

of South Dullah while North Dullah dominated by coral reef ecosystems.The results of the analysis of environmental vulnerability index Dullah Island presented in Figure 2. Dullah Island had environmental vulnerability index which was still in the category of low vulnerability because it was smaller than 6.04 (Doukakis 2005) where the value of the environmental vulnerability index for Island Dullah ranged between 1.16 - 4.71

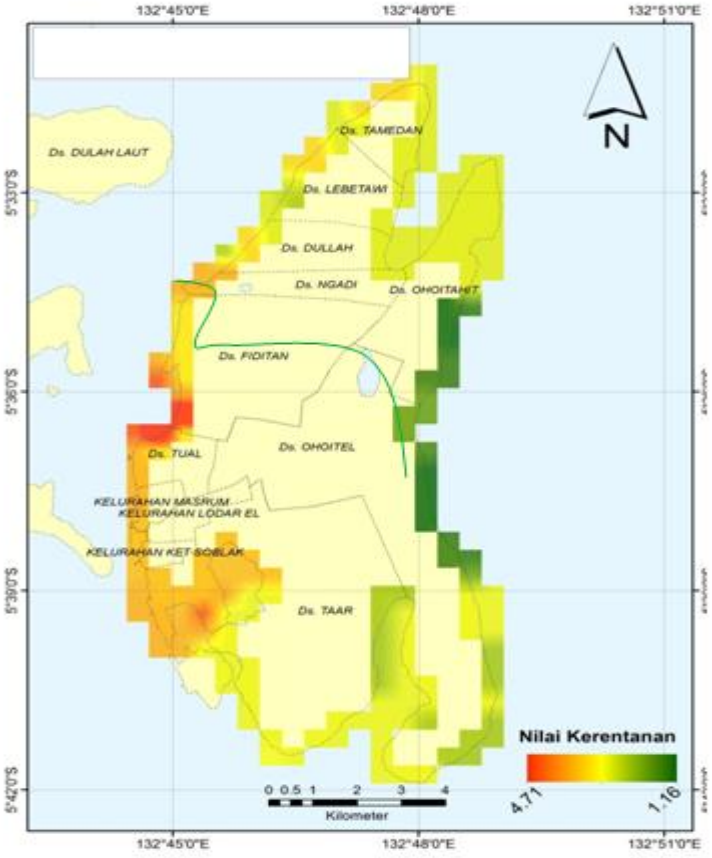

Figure 2: Environmental vulnerability index of Dullah Islands

The range of values vulnerability index Dullah Island neighborhood were included Dullah districts of North and South Dullah. Environmental vulnerability index values districts South Dullah slightly were higher than North Dullah. If it was seen from the characteristic dimensions of exposure, environmental vulnerability parameters which had a high value in the district of South Dullah were the wave height, the rate of coastal erosion, population growth and density so that the value of the exposure was slightly higher than the North Dullah districts. Characteristic dimensions of the specific sensitivity South Dullah districts is the use of land. Dullah south was dominated by residential areas that were more vulnerable than any other land use. Characteristic dimensions of adaptive capacity South Dullah districts were relatively similar to North Dullah such as coastal habitats, coral reefs, mangroves and seagrass. Different parameters was the existence of a regionalmarine conservation area, especially Un Bay in the District of South Dullah.

Differences in the rate of erosion / alteration Dullah coastline between North and South Dullah expected due to external influences or human intervention activities include fisheries, ports, mining and settlement (Hedge and Reju 2007). This was supported by the existence of the harbor between islands and between provinces were also found in South Dullah.In addition, the parameters of population growth and overcrowding in South Dullahparticipate increasing use of land for residential locations (Mimura et al 2007) so that the dimension of South Dullah sensitivity to parameter land use and settlements was higher than the North Dullah. Population growth was determined by two factors: 1) the birth and death and 2) migration (entry and exit) of the population of an area. Large population growth rate in South Dullah caused by a factor of two, while the population growth of North Dullah only influenced by factors of birth and death. Implications of the population growth rate was the population density would be high with the area available for limited residential areas and large population.

ISSN 2349-6193
Impact Factor: 2.805

IJESMR

International Journal OF Engineering Sciences & Management Research

North coast Typology Dullah was more sensitive because it was dominated by sandy beaches compared to the South Dullah with rocky beach typology. Similarly, the parameters of altitude or elevation which was owned by North Dullah was lower than South Dullah although overall Dullah Island is a coral island, which generally have a low elevation (Woodroffe 2008).Coastal habitats were formed by the combination of three ecosystems, namely mangrove, seagrass and coral reef which had adaptability to a variety of outside interference. The wider the coastal ecosystems of small islands, the greater the adaptive capacity of the island. Moreover, the existence of a marine conservation area could also be scaling up the adaptability of a small island (McClanahan et al 2008). Habitat Dullah coastal districts of North and South Dullah dominated by coral reef ecosystems due typology Dullah Island was a coral island that has the ability to adapt to various disorders. The existence of regional marine conservation areas had been on the island, especially in the Gulf Dullah Un, South Dullah districts so as to prevent damage to coastal habitats and enhance adaptation capabilities Dullah Island.

CONCLUSION

From the study, it concludes that the environmental vulnerability index of Dullah Island was ranged from 1.16 to 4.71, and it wascategorized as low vulnerability. If observing each sub-district, district South Dullah dimensional parameter had higher exposure than North Dullah such as erosion, population growth and overcrowding while dimensional parameter sensitivity North Dullah was higher than South Dullah includes beach typology, elevation and slope. The parameters of the dimensions of adaptive capacity, the two districts were not so different as to the parameters of coastal habitats, coral reefs, mangroves and seagrass. The parameters whichwere quite different was the existence of regional marine conservation areas located in the Gulf Un, South Dullah.

REFERENCES

1. *Act No. 27 Tahun 2007tentangPengelolaan Wilayah PesisirdanPulau-Pulau Kecil.*
2. *PellingM, Uitto JI. Small island developing states: natural disaster vulnerability and global change. Environmental Hazard3, 2001.49-63.*
3. *Cherian A.Linkages between biodiversity conservation and global climate change in small island developing states (SIDS). Natural Resources Forum 31(2), 2007.128-131.*
4. *Kusumartono FX, Sapei A, Dharmawan AH, Anna S.Integrated vulnerability assessment: A decision tool for water scarcity in small islands. International Journal of Sciences: Basic and Applied Research (IJSBAR) 28(1), 2016.16-32.*
5. *OzyurtG and Ergin A. Improving coastal vulnerability assessments to sea level rise: A new indicator-based methodology for decision makers. J. Coast Res 26 (2), 2010.265-273.*
6. *FarhanAR and Lim S. Vulnerability assessment of ecological condition in Seribu Islands, Indonesia. Ocean and Coastal Management 65, 2012.1-14.*
7. *SOPAC (South of Pasific Islands Applied Geoscience Comission). Environmental vulnerability index, EVI: description of indicators. UNEP-SOPAC.2005.*
8. *Turner BL, Kasperson RE, Matsone PA, McCarthy JJ, CorellRW,Christensen L, Eckley N, Kasperson JX, Luers A, Martello ML, Polsky C, Pulsipher A, Schiller A. A framework for vulnerability analysis in sustainaibility science. Proc. Natl. Acad. Sci. U.S.A. 100, 2003.8074-8079.*
9. *Polsky C, Neff R, Yarnal B. Building comparable global change vulnerability assessment: the vulnerability scoping diagram. Global Environmental Change 17, 2007.472-485.*
10. *UHU-EHS (United Nation University). Vulnerability: A conceptual and methodological review. Source No.3/2006.2006.*
11. *Doukakis E. Coastal vulnerability and risk parameter. European Water 11(12), 2005. 3-7.*
12. *Hedge AV and Reju VR. Development of coastal vulnerability index for Mangalore Coast, India. Journal of Coastal Research 23(5), 2007.1106-1111.*
13. *Mimura N, Nurse L. Small island in IPCC 2007. Climate change 2007. Cambridge University Press, New York. 2007.1032.*
14. *Woodroffe CD. Reef-island topography and the vulnerability of atoll to sea level rise. Global and andPlanetay Change 62, 2008.77-96.*
15. *McClanahan TR, Cinner JE, Maina J, Graham NAJ, Daw TM, Stead SM, Wamukota A, Brown K, Ateweberhan M, Venus V, Pulonon NVC. Conservation action in a changing climate. Conservation Letter1, 2008. 53-59.*