

## Physical Vulnerability of Coastal Zone of Sidoarjo Distric to Potential Impact of Sea Level Rise due to Climate Change

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### Abstract

Climate change impact such as an increased on the intensity and the frequency of rainfall in the oceans cause sea level rise which then impacts the water surface in the river. This condition has an impact on fishery cultivation in coastal areas. People in Sidoarjo regency are increasingly affected by the alteration of water surface in coastal areas. Sidoarjo region is divided into 5 sub-development areas of one of the 5 sub-regional development units (SSWP V) which are a coastal area with aquaculture fisheries aquaculture economic center. Physical parameter indicators including secondary data and spatial map (GIS) were conducted. The result showed that 4 villages with the highest physical vulnerability of Sidoarjo Regency to the impact of climate change including Kalanganyar Village, Kupang, Tambak Kalisogo and Permisan.

**Keywords:** Coastal, Exposure, GIS, Sea level rise

### INTRODUCTION

Climate change resulted in sea level rise globally in the world, as well as the increased intensity and frequency of storms in the sea and coastal areas. The negative impacts of climate change include the inundation of coastal areas and the threat of sinking of the smallest islands due to rising sea levels, tropical storms, waves and coastal flood [1]. Global and regional assesments have been initiated to determine the vulnerability of country to various impacts of climate change Cities in Indonesia have a wide range of geographical characteristics nature of this country that includes mountains to coastal and archipelago [2]. Of the 94 autonomous cities in Indonesia, 47 of them have coastal areas.

Of the 47 coastal cities in Indonesia, there are 32 cities prone to flooding, there are 29 cities prone to tsunamis, and there are 15 cities prone to tidal waves [3]. Referring to the East Java provincial government regulation, Sidoarjo regency seeks to improve the planning process to protect and control and improve the welfare of society by issuing Local Government Regulation of Sidoarjo Distric No. 5 in 2011 about Protection and Supervision of Coastal Area and Small Island. In the regulation of the Government of Sidoarjo

Regency it is explained that coastal waters are sea bordering land covering waters as far as four nautical miles measured from coastline, waters connecting coast and islands, estuary, bay, shallow waters, swampy and lagoon [5].

Sidoarjo Distric in 2010 was in 133 which included in the high disaster vulnerable city [3], while in 2013 it was in 298 cities vulnerable to disaster which is still classified as high category [4], the government of Sidoarjo Distric attempts to reduce its risk index up to 30% in every year [4]. Where it is the center of "SSWP V" zoning in accordance with the spatial plan plan of Sidoarjo Distric where coastal development dominates the livelihood of the people are fishponds [8], and disasters the threat is the coastal flood [6].

The purpose of this research is to know the vulnerable villages in the coastal area of Sidoarjo regency using AHP methode and spatial map (GIS) through secondary data processing.

### MATERIAL AND METHOD

Quantitative method is used in this research analyze, Data collect from relevant agency/OPD and focus research analyzes on the physical vulnerability of coastal areas that are inundated with "SSWP V" area and coastal area boundary coastal that is four kilometers from beach in Sidoarjo [5]. Final identification there are have 8 sub-district consists of 20 villages.

The analyses of method processing data from each village to compared with total area/district, so as to get range of values between minimum (1) until maximum (5) [7], where each is

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determined its weight to then be displayed by spatial map so it can be known clearly which areas are not vulnerable, vulnerable and are highly vulnerable to physical parameters from indicators of land area, historical floods, elevation, rainfall, mangrove area, early warning system, pond area near to the river and water supply system from the study area.

**Data Collection**

Methods of data collection in this study analyze using secondary data where data obtained from several agencies in Sidoarjo Distric such as Regional Planning and Development Agencies, Regional Disaster Management Agency, Fisheries Agency and several other agencies involved. The data obtained with the village scale. Data acquisition by institution is as follows:

**Table 1.** Data Research and Processing

No	Data	Data Obtained
1	Villages land area	Village middle term of development plans
2	Historical disaster	RPB BPBD
3	Rainfall	Village middle term of development plans
4	Mangrove area	Google Earth analyze
5	Fishpond area	Subdistric data
6	Fishpond area near from the river supply	Google Earth analyze
7	Water supply fishpond	Village middle term of development plans

Source: Secondary data obtained

**RESULT AND DISCUSSION**

Vulnerability is the probable level of an object of disaster consisting of society, service structure or geographical area suffered damage or disruption due to impact of disaster. Although definitions can vary, vulnerability is generally considered to be the degree to which a system is susceptible to, and unable to cope from disaster [10].

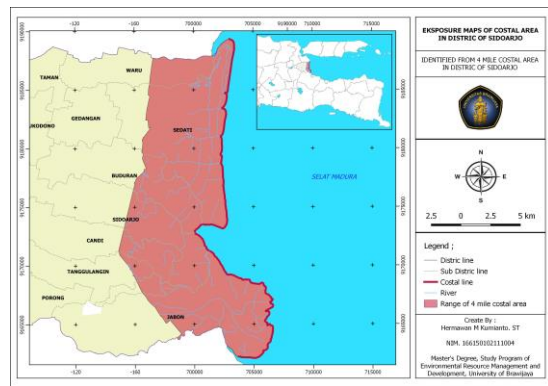
Some of the vulnerable builders include; the number of people, the place where a group is in a vulnerable position and the possessed assets of a territory. In this vulnerability study calculates the physical vulnerability (the place where a group is in a vulnerable position).

Physical vulnerability is a vulnerability indicator that is measured based on material condition, criteria of area and infrastructure including vulnerability in the event of coastal flood disaster.

Referring to Regional Regulation of East Java Province No. 6 of 2012 about Management and

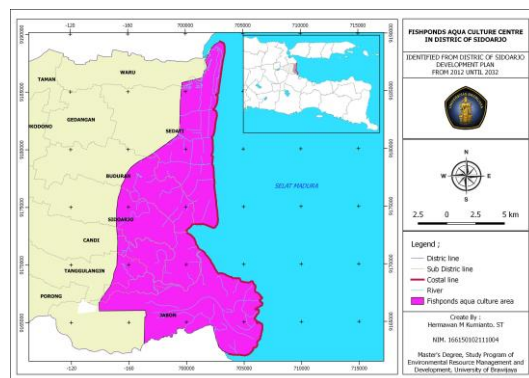
plan of zoning of coastal area and Small Island in year 2012 to 2032. Province coastal boundary is as far as 12 nautical miles in measuring from shoreline and coastal waters is sea bordering with mainland covering 12 miles connecting estuaries, bays, shallow waters, swamps and lagoons. But the district is entitled to manage the territory's resources within the 4 mile border of the shoreline [9].

Thus, based on the identification of the 4 mile area by using GIS application from Google Earth analyze, 26 exposed villages were used as the first basis for identifying vulnerability assessment sites. The coastal villages are shown in the figure 1.



**Figure 1.** The Proportion of 4 Mile Coastal Area for Fishery

Meanwhile, based on the zoning plan of coastal areas and small islands contained in the Regional Regulation of Sidoarjo Distric No. 5 of 2011 on the Protection and supervision of Coastal Zone and Small Island into coastal areas. SSWP V area obtained a number of 22 villages, while the village location is shown in the figure 2.



**Figure 2.** The Proportion of SSWP V area according to spatial plan of Sidoarjo Distric.

The result of coastal area overlay with 4 mile boundary of coastline with SSWP V area map in

Sidoarjo Regency using GIS application obtained by 18 study area villages that will be analyzed based on the physical vulnerability of the area. The villages analyzed are shown in the figure 3.

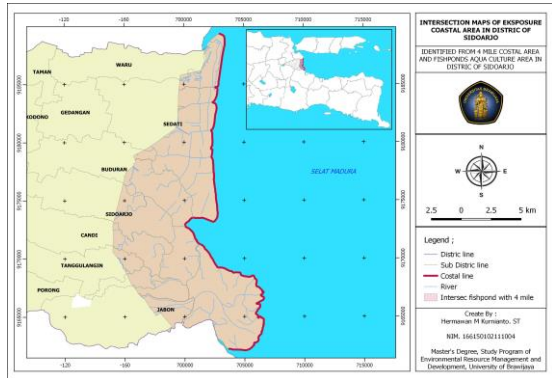


Figure 3. The Results of Intersection Coastal Areas of Fisheries with SSWP V in Sidoarjo.

Determination of vulnerability level of each unit analysis classifying the weights obtained in accordance with the clustering and then spatially overlaying the whole map to show the areas along the coast of the coastal vulnerability indexes in the high, medium and low category [15].

The result of physical vulnerability analysis in the above table is then incorporated into the GIS application format, so that it can be considered as a region / village that is vulnerable to the impact of the flood due to climate change in Sidoarjo distric. With the legend of green color for the area is not vulnerable to the red color for areas that are very vulnerable to disaster.

In the vulnerability map below it can be seen that the most vulnerable areas are Kalanganyar, Kupang, Tambak Kalisogo and Permisan villages. Based on the number of village locations analyzed, the input data acquisition is table 2.

Table 2. Data Processing and Result

Villages	Physicaly Category								
	Area	Disaster history	Elevation	Rainfall	Mangrove area	Early warning system	Fishpond area	Fishpond near the river	Water supply
	village area/sidoarjo area	historical disaster in village/all historical	0-3 ; upstream, 3-10 ; middle, 10-25 ; downstream	Rainfall in village/sidoarjo rainfall	mangrove in village/all mangrove identified	EWS in village/all EWS in sidoarjo	fishpond in village/fishpond in area analyze	fishpond near the river in village/all fishpond	1 = water bottle 2 = PDAM 3 = water pump 4 = water spring 5 = rainfall, river
Gebang	0.122	-	4.000	-	0.054	-	0.103	0.433	5.000
Pucanganom	0.027	-	4.000	-	-	-	0.028	0.331	5.000
Prasung	0.035	-	4.000	0.039	-	-	0.022	0.102	5.000
Sawohan	0.080	-	4.000	0.039	0.018	-	0.061	0.653	2.000
Damarsi	0.022	-	4.000	0.039	-	-	0.015	0.210	5.000
Pepe	0.021	-	4.000	0.037	-	-	0.024	0.044	5.000
Kalanganyar	0.138	5.000	4.000	0.037	0.198	-	0.144	0.401	5.000
Tambak cemandi	0.034	-	4.000	0.037	0.075	-	0.030	0.656	5.000
Segoro tambak	0.054	5.000	4.000	0.037	0.061	-	0.035	0.928	2.000
Banjar kemuning	0.025	-	4.000	0.037	0.020	-	0.028	0.314	2.000
Tambakoso	0.028	-	5.000	-	-	-	0.005	0.420	1.000
Kedung peluk	0.060	-	4.000	0.103	0.016	-	0.067	0.359	5.000
Plumbon	0.028	-	4.000	0.082	0.010	-	0.029	0.329	5.000
Kupang	0.179	5.000	2.000	0.030	0.493	-	0.068	1.203	5.000
Tambak kalisogo	0.074	5.000	2.000	0.030	0.044	-	0.055	0.429	5.000
Permisan	0.042	5.000	2.000	0.030	0.009	-	0.057	0.177	5.000
Banjarasri	0.011	-	4.000	-	-	-	0.006	0.168	5.000
Banjarpanji	0.020	-	4.000	-	-	-	0.022	0.237	5.000

Source: Secondary data obtained [11, 12, 13, 14]

Based on the number of village locations analyzed, as well as secondary data input, the value obtained for weighting as the basis for determining the vulnerability of coastal areas in the table 3.

**Table 3. Data Proceesing and Result**

No	Data	Weight		Range	Information
1	Land area	Very low	1	< 0,011	The area is proportional to vulnerability of coastal flood
		Low	2	0,011 - 0,067	
		Medium	3	0,067 - 0,123	
		High	4	0,123 - 0,179	
		Very high	5	> 0,179	
2	Historical disater	Very low	1	< 0,000	Historical disaster comparable with vulnerability of flood
		Low	2	0,000 - 1,667	
		Medium	3	1,667 - 3,333	
		High	4	3,333 - 5,000	
		Very high	5	> 5,000	
3	Rainfall	Very low	1	< 0,030	Rainfall area comparable with vulnerability of coastal flood
		Low	2	0,030 - 0,054	
		Medium	3	0,054 - 0,079	
		High	4	0,079 - 0,103	
		Very high	5	> 0,103	
4	Mangrove area	Very high	5	< 0,009	Mangrove area is inversely proportional to village vulnerability
		High	4	0,009 - 0,170	
		Medium	3	0,170 - 0,331	
		Low	2	0,331 - 0,493	
		Very low	1	> 0,493	
5	Fishponds area	Very low	1	< 0,005	Fishponds area comparable with vulnerability of coastal flood
		Low	2	0,005 - 0,051	
		Medium	3	0,051 - 0,098	
		High	4	0,098 - 0,144	
		Very high	5	> 0,144	
6	Fishponds near of river	Very low	1	< 0,044	Fishpond area near with the river are comparable with vulnerability of coastal flood
		Low	2	0,044 - 0,338	
		Medium	3	0,338 - 0,633	
		High	4	0,633 - 0,928	
		Very high	5	> 0,928	
7	Water supply system	Very high	5	Bottled water	Water supply for fishpond is inversely proportional to village vulnerability
		High	4	PDAM	
		Medium	3	Pumps wells	
		Low	2	Water springs	
		Very low	1	River/rainfall	

Source: Secondary data obtained

Based on the range of weight determined, then obtained a weight for each of indicators of the parameters of physical vulnerability in table 4.

**Table 4. Result of the Model**

Villages	Area	Disaster history	Elev.	Rainfall	Mangrove area	EWS	Fishpond area	Fishpond near the river	Water supply	Tot	Average (Total/9)
Gebang	3	1	3	1	4	5	4	3	1	25	2.8
Pucanganom	2	1	3	1	0	5	2	2	1	17	1.9
Prasung	2	1	3	2	0	5	2	2	1	18	2.0
Sawohan	3	1	3	2	4	5	3	4	1	26	2.9
Damarsi	2	1	3	2	0	5	2	2	1	18	2.0
Pepe	2	1	3	2	0	5	2	1	1	17	1.9
Kalanganyar	4	4	3	2	3	5	4	3	1	29	3.2
Tambak cemandi	2	1	3	2	4	5	2	4	1	24	2.7
Segoro tambak	2	4	3	2	4	5	2	4	1	27	3.0
Banjar kemuning	2	1	3	2	4	5	2	2	1	22	2.4

Villages	Area	Disaster history	Elev.	Rainfall	Mangrove area	EWS	Fishpond area	Fishpond near the river	Water supply	Tot	Average (Total/9)
Tambakoso	2	1	2	1	5	5	1	3	1	21	2.3
Kedung peluk	2	1	3	4	4	5	3	3	1	26	2.9
Plumbon	2	1	3	4	4	5	2	2	1	24	2.7
Kupang	4	4	5	1	2	5	3	5	1	30	3.3
Tambak kalisogo	3	4	5	1	4	5	3	3	1	29	3.2
Permisan	2	4	5	1	5	5	3	2	1	28	3.1
Banjarasri	1	1	3	1	0	5	2	2	1	16	1.8
Banjarpanji	2	1	3	1	0	5	2	2	1	17	1.9

Source: Secondary data obtained.

The results of the analysis of physical coastal vulnerability maps of Sidoarjo Distric described in figure 4.

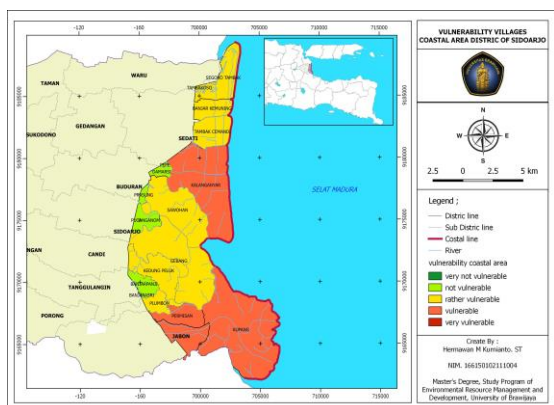


Figure 4. The Result of Physical Spatial map of the vulnerability coastal areas in Sidoarjo Distric.

**CONCLUSION**

Based on the results of the analysis, there have been identified 4 villages with very high physical vulnerability, among them Kalanganyar Village, Kupang, Tambak Kalisogo and Permisan Village.

The analysis of this research using 9 indicators of research due to data acquisition limitations in each agency and the limitations of data that can be compared to the village boundary, it is expected later in the day more and more indicators of parameters are compared so that obtained the maximum results, especially related to how far the intrusion sea water that has occurred in the coastal area of Sidoarjo Distric.

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