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Development Direction of Muara Gembong Coastal Area Based on Abrasion Vulnerability Analysis

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Keywords

Abrasion,
Vulnerability,
Coastal Areas.

Abstract. Abrasion in Muara Gembong District has resulted in changes in the coastline, reaching 3,852 m. Abrasion causes physical, environmental, social, and economic changes, as well as changes in the lives of local people. This study aims to analyze the level of vulnerability due to abrasion in the coastal area of Muara Gembong. This study uses the AHP method to determine the weight of factors influencing vulnerability due to abrasion by involving stakeholders as respondents. Giving value weights to criteria and alternatives, then pairwise comparisons of each stakeholder's opinions. Using proximity analysis techniques, vulnerability zone analysis was carried out using kernel density analysis techniques and analysis regarding the distance from the coast to settlements. The analysis technique using Weighted Overlay is carried out to determine the vulnerability zone based on the results of the factor weight assessment. From the results of the analysis, the factor that has the greatest influence on the vulnerability of the Muara Gembong coastal area due to abrasion is the environmental factor; this shows that if there is environmental damage, especially damage to protected forests and mangrove forests, it will accelerate the process of coastal abrasion. The analysis results show that 85.10% of the coastal area of Muara Gembong is in the moderate vulnerability zone, 14.25% is in the high vulnerability zone, and 0.65% is in the low vulnerability zone. The results of the superimpose between the spatial pattern plan of Muara Gembong District and the Vulnerability Map show that the directions for developing activities for cultivation areas dominated by residential activities are in high and medium vulnerability zones. In contrast, low vulnerability zones are directed toward developing non-settlement cultivation areas.

1. INTRODUCTION

Coastal areas are transitional areas between land and marine ecosystems that are affected by changes on land and sea. Coastal areas are dynamic, with frequent changes in biological, chemical, and geological attributes, including productivity and biologically diverse ecosystems. Coastal areas consisting of coastal ecosystems such as coral reefs, mangroves, and beaches provide benefits as natural buffers against storms, floods, and erosion. On the other hand, coastal ecosystems feel the impact of pollution from activities on land and sea because many human activities live in coastal areas and carry out utilization activities such as fisheries, transportation, and tourism (Post & Lundin, 1996 in Witomo, 2019).

Coastal areas are important but vulnerable to disturbance. Because of this vulnerability, they are prone to change on a temporal and spatial scale. Changes in coastal areas are triggered by various activities such as industry, housing, transportation, ports, aquaculture, agriculture, and tourism. One vulnerability in coastal areas is the threat of abrasion that generally occurs on several beaches (Baun et al., 2008). Vulnerability has emerged as a central concept in understanding the consequences of natural disasters and developing disaster risk management strategies. The general definition of vulnerability is the degree to which a system is susceptible to or unable to cope with a disaster. The level of vulnerability can be viewed from physical, social, population, and economic aspects (Kasman et al., 2022; Westplat et al., 2017). Abrasion is the erosion of beach material by waves, and the eroded material is transported to another place by the current. Not only does coastal abrasion narrow coastlines, but it can become more dangerous (Pananrangi, 2011).

Vulnerability is an important factor in the social order that is at higher risk of disaster if it is not supported by capacities such as lack of education and knowledge, poverty, social conditions, vulnerable groups of the elderly, toddlers, pregnant women, physical or mental disabilities (Haryana et al., 2021). Muara Gembong sub-district has experienced changes in the coastline, which have been influenced by abrasion (erosion) and accretion (sedimentation). The calculation results show that Muara Gembong

Sub-district experienced a shift in coastline of 3,852 m from 2018 to 2019. Muara Gembong sub-district also experienced a change in coastline area (abrasion) of 328.50 ha and an increase in coastline area (accretion) of 112.67 ha (Wulandari, 2020). Muara Gembong sub-district often experiences coastal abrasion, which has been going on for a long time. The abrasion disaster resulted in the loss of part of the land, and sedimentation was present at the mouth of the river. The losses experienced by the community in the presence of abrasion disasters have affected social and economic life and environmental damage.

This research analyzes the vulnerability level due to abrasion disasters in the Muara Gembong coastal area. Vulnerability can be viewed from the aspects of physical vulnerability, environmental vulnerability, social vulnerability, and economic vulnerability. The research objectives are to analyze the level of influence of factors affecting vulnerability due to abrasion disasters in the Muara Gembong coastal area of Bekasi Regency, analyze the vulnerability zone due to abrasion disasters in the Muara Gembong coastal area of Bekasi Regency, and analyze space utilization in the vulnerability zone due to abrasion disasters in the Muara Gembong coastal area of Bekasi Regency. The research area includes coastal villages in Muara Gembong Sub-district, namely Harapan Jaya Beach Village, Jayasakti Village, Mekar Beach Village, Sederhana Beach Village, Pantai Bakti Village, and Bahagia Beach Village.

2. METHODS

Data collection methods were carried out through 2 (two) methods, namely primary and secondary data collection. Primary data is obtained using a questionnaire and field observation/documentation. While secondary data is sourced from agencies and is basic data or processed data from related agencies, such as the extent of geospatial data, the spatial data used are RBI Maps, Satellite Images of the region, population demographics, existing land use, boundaries, and other thematic maps in the Spatial Plan Document and Zoning Plan for Coastal Areas and Small Islands.

The analysis method used in vulnerability due to abrasion in coastal areas is carried out with several stages of analysis, such as the Analytical Hierarchy Process (AHP) method, kernel density method, proximity method, and Weighted Overlay. The first step of this analysis is to distribute questionnaires to experts in their fields as respondents. In this case, the respondents involved in the formulation of factor weights were 10 (ten) respondents selected through stakeholder analysis. Then, the respondents gave weighted values to the criteria and alternatives in the questionnaire and were assessed through pairwise comparisons of the opinions of each stakeholder. After that, a combination process is carried out to obtain the level of importance of each influential factor.

Furthermore, the Proximity method is a Geographical Information System (GIS) method found in the tools in the ArcGIS application based on the distance between layers (Zefri et al., 2022). In the proximity analysis, GIS uses buffering (building a supporting layer around a layer within a certain distance to determine the close relationship between the properties of existing parts). In this research, the proximity method is used to analyze the distance from the coastline to the settlement area so that the assessment weight can be given. The Weighted Overlay analysis method is one of the tools in the Arc. GIS application can be used to determine the effect of a variable on the variable that is the object of measurement by using weighting and scoring and integrating it into a grid map format with weighting factors from AHP. The superimposed method overlays the spatial pattern plan map into vulnerability zoning to identify land use designations by coastal vulnerability zones in coastal areas.

3. RESULTS AND DISCUSSION

The analysis results of the vulnerability level due to abrasion in coastal areas were reviewed by comparing all vulnerability factors, namely physical vulnerability factors, environmental vulnerability, social vulnerability, and economic vulnerability. The level of vulnerability due to abrasion in coastal areas is obtained from the results of perceptions given by experts/experts analyzed using the AHP method. The analysis found that the vulnerability factor that most affects the vulnerability due to abrasion in coastal areas is the environmental vulnerability factor, with an Eigenvalue of 0.462.

Furthermore, based on the order of vulnerability factors that affect vulnerability due to abrasion in coastal areas, namely physical vulnerability with Eigen Value 0.209, social vulnerability with Eigen Value 0.197, and economic vulnerability with Eigen Value 0.131. From the Eigenvalue of vulnerability due to abrasion in coastal areas, it has a consistency ratio (CR) in the weighting of vulnerability factors of 0.04.

The consistency requirement is that the CR value ≤ 0.1 has met the consistency requirements that have been determined. Furthermore, the weighting value of vulnerability factors can be used for the next analysis stage. Each factor is analyzed to determine the level of vulnerability due to abrasion in the coastal area. The Physical vulnerability factor that most affect vulnerability to abrasion disaster is the shoreline distance ratio variable, which has an Eigen Value of 0.354. Furthermore, based on the order of physical vulnerability factors that affect vulnerability to abrasion disasters, namely distance from the coastline with Eigen Value 0.354, availability of settlement infrastructure with Eigen Value 0.213, settlement facilities network with Eigen Value 0.190 and building density with Eigen Value 0.243. At the same time, the consistency ratio in weighting the physical vulnerability factor is 0.02. Environmental vulnerability factors, the variables that most affect vulnerability to abrasion disasters are mangrove forest area variables with an Eigen Value of 0.601 and forest areas with an Eigen Value of 0.399. At the same time, the consistency ratio in variable weighting in the environmental vulnerability factor is 0.00. The social vulnerability factor, the variable that most affects vulnerability to abrasion disaster, is the age variable, with the Eigen Value of 0.280. Furthermore, based on the order of social vulnerability factors that affect vulnerability to abrasion disasters, the disabled population has an Eigen Value of 0.270, the number of residents has an Eigen Value of 0.230, and the gender has an Eigen Value of 0.095. In comparison, the consistency ratio in weighting social vulnerability factors is 0.05. The economic vulnerability factor, the variables that most affect the vulnerability to abrasion disasters are the poor population variable with an Eigen Value of 0.547 and the employment of residents who work in vulnerable sectors with an Eigen Value of 0.453. At the same time, the consistency ratio in weighting the economic vulnerability factor is 0.00.

After determining the classification of factors, the weight of the influence of factors and variables is determined. The weight of the influence of factors and variables used is the weight of the results of AHP calculations using Weighted Overlay analysis. The weight of influence must be in the form of percent, so the weight of this influence will also be converted into percent. In the physical vulnerability factor, the weight that most affects the vulnerability to abrasion disasters is the variable distance from the coastline, with a weight value of 35.40%. Furthermore, based on the order of the weight value of physical vulnerability factors that affect vulnerability to abrasion disasters, namely building density with a weight of 24.30%, availability of settlement infrastructure with a weight value of 21.30%, and settlement facility networks with a weight value of 19.00%. Environmental vulnerability factors: The variables that most affect vulnerability to abrasion disasters are mangrove forest area variables with a weight value of 60.10% and forest areas with a weight value of 39.90%. The social vulnerability factor, the variable that most affects the vulnerability to abrasion disaster, is the age variable with a weight value of 28.00%. Furthermore, based on the order of the weight value of social vulnerability factors that affect vulnerability to abrasion disasters, namely the disabled population with a weight value of 27.00%, the number of residents with a weight value of 23.00%, and gender with a weight value of 9.50%. The economic vulnerability factor, the variable that most affects the vulnerability to abrasion disaster, is the poor population variable with a weight value of 54.70%, and the employment of people working in vulnerable sectors with a weight value of 45.30%.

From the calculation of factor weights and influence variables, a map of vulnerability due to abrasion in coastal areas can be made based on each factor. The influence weight used based on the results of AHP analysis for vulnerability factor groups, namely physical vulnerability, environmental vulnerability, social vulnerability, and economic vulnerability, namely:

1. Physical vulnerability: 0.209 or 20.90%;
2. Environmental vulnerability: 0.462 or 46.20%;
3. Social vulnerability: 0.197 or 19.70%; and

4. Economic vulnerability: 0.131 or 13.10%.

The formula used to determine the overall vulnerability zone in the Weight Overlay analysis is Vulnerability = {20.90* (physical_raster)+46.20* (environmental_raster) + 19.70* (social_raster) + 13.10* (economic_raster)}. In determining the vulnerability zone, three vulnerability classes were used with the following values:

1. Low vulnerability zone with a value of 1;
2. Medium vulnerability zone with a value of 2; and
3. High vulnerability zone with a value of 3.

The results of physical vulnerability show that Muara Gembong sub-district coastal villages have three physical vulnerability zones: low, moderate, and high. Villages with high physical vulnerability are located in Pantai Bahagia Village, Pantai Bakti Village, Pantai Mekar Village, and Pantai Sederhana Village, covering an area of 340.90 hectares. Villages with moderate physical vulnerability are located in all villages in Muara Gembong Sub-district, covering an area of 12,787.14 hectares. Villages with low physical vulnerability are located in Jayasakti Village and Harapan Jaya Beach Village, covering an area of 1,769.25 hectares. The results of environmental vulnerability are that coastal villages in Muara Gembong Sub-district have three zones of ecological vulnerability: low, medium, and high. Villages with high ecological vulnerability are located in all villages in the Muara Gembong Sub-district, with an area of 9,183.20 hectares. Villages with moderate environmental vulnerability are located in the Muara Gembong Sub-district, with an area of 5,392.73 hectares. Villages with low environmental vulnerability are located in Pantai Bahagia Village, Pantai Bakti Village, Pantai Harapan Jaya Village, Pantai Mekar Village, and Pantai Sederhana Village, covering an area of 321.73 hectares. The results of social vulnerability are that coastal villages in Muara Gembong Sub-district have two (2) social vulnerability zones: medium and high. Villages with high social vulnerability are located in Pantai Bahagia Village, Pantai Bakti Village, and Pantai Mekar Village, covering an area of 2,799.05 hectares. Villages with moderate social vulnerability are situated in all of Muara Gembong Sub-district, covering an area of 12,099.65 hectares.

The economic vulnerability results show that coastal villages in Muara Gembong Sub-district have two (2) financial vulnerability zones, namely medium and low vulnerability. Villages with moderate economic vulnerability are Pantai Bahagia Village, Pantai Bakti Village, Pantai Mekar Village, and Pantai Sederhana Village, covering an area of 6,943.35 hectares. Villages with low economic vulnerability are located in all towns in the Muara Gembong Sub-district, covering an area of 7,955.21 hectares. The results of the overall vulnerability analysis show that coastal villages in Muara Gembong Sub-district have three vulnerability zones: low vulnerability, medium vulnerability, and high vulnerability. Villages with low vulnerability are located in Harapan Jaya Beach Village and Mekar Beach Village, covering an area of 97.28 hectares. Villages with moderate vulnerability are located in all towns in Muara Gembong Sub-district, covering an area of 12,656.51 hectares. Villages with high vulnerability are located in Pantai Bahagia Village, Pantai Bakti Village, Pantai Mekar Village, and Pantai Sederhana Village, covering an area of 2,118.84 hectares.

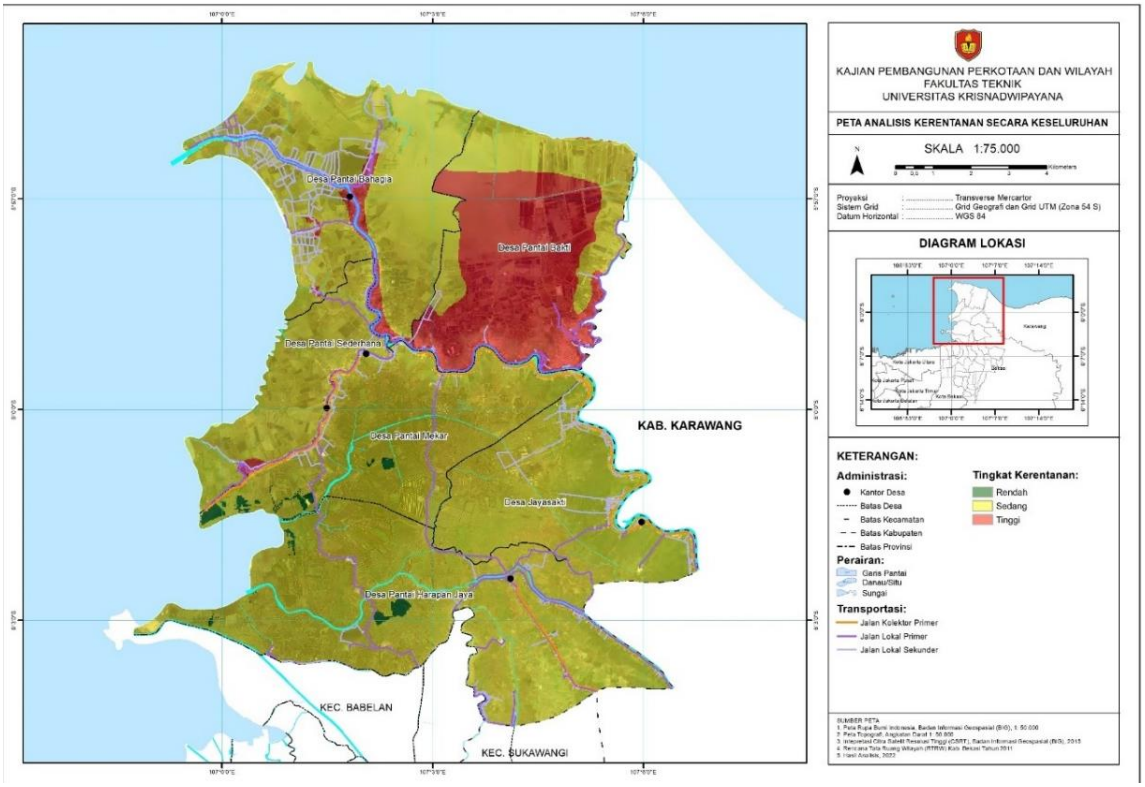

Figure 1: Overall Vulnerability Zone

From the results of superimposing the spatial pattern plan of Muara Gembong Sub-district with the vulnerability zoning of coastal areas, it can be identified that the direction of development of activities/allocations for cultivation areas, especially settlements, is in the high vulnerability zone and the medium vulnerability zone. Meanwhile, the low vulnerability zone is directed towards the development/allocation of non-settlement cultivation areas. In more detail, the spatial plan in the vulnerability zone, namely the high vulnerability zone, is directed towards development/allocation as a protected forest, limited production forest, tourism area, mining area, sub-district scale government, worship facilities, fishermen settlements, green belt, river border, sediment, urban village scale park, and regional scale park. Medium vulnerability zones are directed towards development/designation as protected forests, limited production forests, tourism areas, strategic mining areas, worship facilities, mixed scale commercial, sub-district scale government, regional scale government, fisheries, fishermen settlements, village settlements, dry land agriculture, green belts, coastal borders, river borders, sediments, village scale parks, and regional scale parks. The low vulnerability zone is directed for development/designation as a protected forest, limited production forest, tourism area, strategic mining area, coastal border, and river border.

4. CONCLUSION

Analysis of the vulnerability of coastal areas based on physical factors, environmental factors, social factors, and economic factors shows that the factor that has the greatest influence is ecological vulnerability. In contrast, the factor with the lowest influence level is the economic vulnerability factor. Villages with low vulnerability are located in Pantai Harapan Jaya Village and Pantai Mekar Village, covering an area of 97.28 hectares. Villages with medium vulnerability are located in all towns in Muara Gembong Sub-district, covering an area of 12,656.51 hectares. Villages with low vulnerability are located in Pantai Bahagia Village, Pantai Bakti Village, Pantai Mekar Village, and Pantai Sederhana Village, covering an area of 2,118.84 hectares. The results of the superimposed relationship between the Muara Gembong Sub-district spatial pattern plan and the Vulnerability Map show that the direction

of activity development for cultivation areas dominated by residential activities is in the high and medium vulnerability zones. In contrast, the low vulnerability zone is directed toward developing non-settlement cultivation areas. This certainly gives attention to the fact that the high and medium vulnerability zones in the direction of the spatial plan should be directed as protected areas.

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