Coastal Vulnerability at Tanjung Pakis and Samudra Baru Beaches in Karawang District West Java Province

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Abstract. Coastal tourism is well renowned for the beaches of Tanjung Pakis and Samudra Baru in the Karawang District of West Java Province. Based on the idea of sustainable coastal tourism in Karawang, Samudra Baru Beach is a beach resort that is more sustainable than Tanjung Pakis Beach. One of the key strategies and concepts for developing sustainable coastal tourism is coastal management. One of the things that must be considered in managing coastal areas to maintain ecosystem sustainability is disaster mitigation by paying attention to the level of vulnerability. The substantial objectives are to examine coastal alterations and assess how susceptible the shoreline is in Samudra Baru and Tanjung Pakis coasts, Karawang District, West Java Province. Coastal vulnerability is influenced by six variables: visual observation, land use, wave height, coastline changes, visual observation, damage length and damage width. Tanjung Pakis's beach area experienced relatively minor damage. The coastline of Tanjung Pakis has been selected for the construction of a soft or hard coastal protection technique. However, Samudra Baru's coastal regions have only suffered little damage. This result also showed that Samudra Baru Beach is more sustainable coastal tourism than Tanjung Pakis Beach.

1. Introduction

In response to the Wonderful Indonesia 2014 program launched by the Minister of Tourism and Creative Economy of the Republic of Indonesia, the research examines the possibility of sustainable coastal tourism on Samudra Baru and Tanjung Pakis beaches in West Java, Indonesia [1]. Based on the idea of sustainable beach tourism in Karawang, this research demonstrates that Samudra Baru Beach is among the most environmentally friendly beach resorts when compared to Tanjung Pakis Beach. Tanjung Pakis Beach has all it takes to develop into a popular and long-lasting beach resort. Samudra Baru Beach has the potential to offer a more respectable beach tourism environment than Tanjung Pakis Beach if Pedes Regency is dedicated to concentrating more on realizing the potential of sustainable beach tourism by collaborating with stakeholders to protect the Samudra Baru coastal ecosystem. Both sides will profit monetarily from this, which will also boost the local economy of coastal towns. If Karawang Regency controls expansion and strikes a balance between the environmental effects of beach tourism and economic growth, Tanjung Pakis Beach will likewise offer sustainable beach tourism. Furthermore, Karawang Regency has the potential to collaborate with relevant parties in safeguarding Tanjung Pakis' coastal environment, hence promoting environmentally conscious beach tourism [1].

A research related to sustainable tourism and climate change is urgent due to the pressing global challenge of climate change and the need to mitigate its impacts on the tourism industry, the environment, and communities. It also encompasses a range of novel and innovative approaches, addressing the economic, environmental, social, and policy aspects of sustainable tourism. One of the

key strategies and concepts for growing sustainable coastal tourism is coastal management [2]. Coastal management refers to the methods and procedures used to develop and maintain coastal lands in a sustainable manner. These locations are significant for a variety of reasons, including recreational, environmental, and economic ones. Coastal management frequently necessitates a combination of actions to limit risks from both natural (such as erosion, floods, storms, and sea level rise) and human (such as urban development, pollution) processes [3]. One of the things that must be considered in managing coastal areas to maintain ecosystem sustainability is disaster mitigation by paying attention to the level of vulnerability. Spatial information related to vulnerability is crucial in sustainable tourism management to reduce disaster risk [4]. The Coastal Vulnerability Index (CVI) is useful for evaluating the degree of vulnerability of coastal areas to natural disasters [5]. This approach provides an assessment based on numbers about the possible risks and vulnerabilities that can occur in coastal areas in various situations. In implementing coastal adaptation and mitigation strategy policies, CVI can be used by researchers, planners and policy makers to identify and allocate required resources [6, 7]. The CVI considers of physical, biological and socio-economic aspects that determine the level of vulnerability of a coastal area.

The aim of this research is to evaluate the level of coastal vulnerability on the coasts of Samudra Baru and Tanjung Pakis, which are in Karawang District, West Java Province, Indonesia. This research also aims to determine a coastal management model based on the level of vulnerability found. There are six factors that influence damage, namely visual observations, land use, wave height, changes in coastline, length and width of damage. Furthermore, Karawang Regency in West Java Province focuses on beach management along the coast of Samudra Baru and Tanjung Pakis. Coastal management significantly prioritizes the construction of various types of coastal protection structures, including soft structures such as mangrove plantings, hard structures such as breakwaters and beach walls, or a combination of both.

2. Materials and Methods

2.1. Study Area

One of the districts with great natural potential for this highly prospective gold in the future and one with the notion of a democratic economy to maximize the potential of the allure of tourism in the area is Karawang District, which is located about 80 miles to the east of the capital Jakarta. Tanjung Pakis, a 7 km stretch of white sand beach with calm waves and lovely playing on, is located on the north path of Karawang's sides. Tanjung Pakis Bay is a peninsula that connects the Bekasi and Karawang districts. One of Karawang's most well-known tourist destinations is the Tanjung Pakis beachfront, which is known for its stunning beaches and crashing surf. Along with the Tanjung Pakis beach, Karawang offers other equally lovely tourist attractions along the Samudra Baru coast. Coastal visits are another popular activity. Tourists can enjoy the expansive view of the white sand beach as the surf beach and floated gently in Karawang district, on the coast, which has beaches available. Samudra Baru beach, located in the northern part of the Sungaibuntu, Pedes Sub district, offers further coastal tourism in the same area. The distance to Karawaci is roughly 40 kilometers. It deserves to be a popular tourist destination because of its unusual landscape. Samudra Baru and Tanjung Pakis beach in Karawang, which is the closest location to Jakarta, the capital city of Indonesia, are being investigated for possible coastal management. The distance between the two beaches and Jakarta, Indonesia's capital city and its hinterland, is only 80 kilometers. Figure 1 shows the location of Tanjung Pakis and Samudra Baru Beaches, Karawang District, West Java Province.

Figure l. Tanjung Pakis and Samudra Baru Beaches in Karawang District West Java Province

2.2. Data Collection

Data needed in this research include primary data and secondary data. Primary data is data obtained from the field or research sites. While secondary information is data that can be directly collected from the government agencies concerned. The secondary data acquisition method is done by by collecting, identifying and processing the data. In this study, six factors are utilized to assess coastal vulnerability, including visual observation, land use, wave height, changes in coastline, length and width of damage. The information for the six variables comes from field observations, satellite images of the shoreline from Google Earth Pro [8], and wave data from Indonesian Agency for Meteorological, Climatological and Geophysics (Badan Meteorologi, Klimatologi, dan Geofisika or simply BMKG). This method was chosen to find out and investigate the vulnerability of a coastal area.

The first stage carried out was visual identification by carrying out a field survey. The survey locations were Tanjung Pakis beach and Samudra Baru Beach in Karawang District, West Java Province. Visual observations detected on the condition of the beach. Investigation of the areas surrounding the beach demonstrating its state and condition, including the presence of land use, human activities, and beach damage.

The next analysis is to process the wind and wave data obtained from the BMKG station for the years 2012 to 2021. The wind data obtained is wind direction, average wind speed and maximum wind speed. A wind rose can be produced using the wind speed and direction information from BMKG. The WRPLOT VIEW application was used to build the wind rose [9]. A wind rose is a graphical tool used to provide a concise overview of how wind speed and direction are typically distributed at a location. The wind speed, wind duration, and wind distance generate wave. Wave data obtained from BMKG is the direction wave and maximum wave.

Data coastlines were used which were obtained from mapping satellite images sourced from the software via the Google Earth Pro application [8]. Samudra Baru Beach coastline data is used for 2001, 2003, 2013, 2015, 2016, and 2017, while Tanjung Pakis Beach coastline data is used for 2012-2016. The multi-temporal satellite imagery is the acquisition of remotely sensed data from more than one period. The multi-temporal imageries detected the shoreline positions and manually delineated using the path line to map shoreline positions. The multi-temporal of coastlines was simply imported from Google Earth Pro engine to AutoCAD application [10]. The advantages of AutoCAD are that it allows user to show complex group drawing for clear understanding, has an auto dimensioning that helps in designing easy and accurate drawings, and helps in a digital tracing such as coastline. Changes in the coastline each year can be evaluated using the AutoCAD application.

2.3. Coastal Vulnerability Index

The Coastal Vulnerability Index (CVI) is a valuable tool for understanding the vulnerability of coastal areas and plays a crucial role in guiding sustainable practices. By identifying and addressing vulnerabilities, it helps to protect coastal communities, ecosystems, and economies from climate change and natural hazards, ensuring their long-term sustainability. The CVI is used to assess how susceptible coastline regions are to natural disasters [11, 12]. The CVI considers the visual observation, the land use, the wave height, the rate of coastline change, the width and length of damage. Data has been gathered for each of the parameters. Remote sensing and Geographic Information Systems (GIS) are commonly used in data gathering and processing [13, 14, 15, 16]. A thorough assessment is produced by integrating hydrological data, topographic maps, satellite photography, and demographic data [17]. To ensure that the data for each factor is on the same scale, normalization of the data is frequently used. This is significant because different units or ranges may apply to certain aspects. Following normalization, weights are given to each element according to how important they are in creating vulnerability. The ranking of the Coastal Vulnerability Index variables [5] is shown in Table 1.

Table 1. Ranking of coastal vulnerability index parameters

Parameter	Ranking of Coastal Vulnerability Index				
	Very Low	Low	Moderate	High	Very High
	1	2	3	4	5
Observations visual damage	Visible symptoms of damage	Looks scours but still stable	Scours occurs and will happen collapse	Scour and debris occur but not jeopardize facilities or infrastructures	Scour and debris occur and endangering facilities or infrastructure
Land use	Moor, mangrove forests, vacant land and bogs	Domestic tourist areas and traditional farms	Rice fields and intensive ponds	Settlements, ports, offices, schools and provincial roads	Cultural heritage, international tourist areas, industry, country roads, and national defense
Wave height (m)	<0.5	0.5-1	1-1.5	1.5-2	>2
Shoreline change rate (m/year)	0	0-1	1-5	5-10	>10
Length of damage (km)	<0.5	0.5-2	2-5	5-10	>10
Width of damage (m)	0	1-10	10-50	50-100	>100

The six (6) physical relationships are quantified by the index. After giving each coastline a risk value based on each distinct data characteristic, the coastal vulnerability index is constructed [18] as follows:

$$CVI = \left(\frac{axbxcxdxexf}{6}\right)^{1;2} \quad (1)$$

where a represents the recorded visual damage, b is the use of land, c is the wave height, d represents the rate of shoreline change, e is the length of damage, and f is the width of damage. Table 2 classifies various degrees of coastal vulnerability based on the value of the coastal vulnerability index [19].

Table 2. Classification of coastal vulnerability level

CVI	0-25	25-50	50-75	>75
Level of Damage	Low	Medium	High	Very High

3. Results and Discussions

The results of field observations showed that at Samudra Baru Beach, there was no visible damage to the coast at Samudra Baru Beach. The damage was not visible but, according to residents, the beach was in deterioration. The beach has a gentle slope, making it possible for high tide to easily reach residential areas around the beach. There is a structure with a height of approximately 3 m which can be seen in Figure 2. This structure is useful as a place to guard the safety of beach visitors. Figure 3 shows a drainage pipe containing household waste from surrounding settlements and ponds. The drainpipe is supported using bamboo. Figure 3 also illustrates the presence of organic and inorganic waste carried by the current and stranded on the beach. Samudra Baru Beach is bounded by a barrier and the Buntu River estuary, as Figure 4 illustrates. In addition, Figure 5 shows fishing operations, which are the main source of income for people who reside close to the coast.

Figure 2. Coast guard structure at Samudra Baru Beach

Figure 3. Drainpipe at Samudra Baru Beach

Figure 4. Breakwater at Samudra Baru Beach

Figure 5. Buntu River estuary at coast of Samudra Baru

According to field observation data, there is abrasion on Tanjung Pakis' coast, and this abrasion may cause changes in the coastline's position. Tanjung Pakis Beach experiences progressive changes in the coastline's position. Beach areas affected by abrasion have been filled or dammed with tree branches. At Tanjung Pakis Beach there is coastal damage, namely abrasion close to settlements as in Figure 6. Figure 7 illustrates the delineated tree planting and business premises use for land use and human activities in Tanjung Pakis Beach area.

Figure 6. Abrasion close to settlements at Tanjung Pakis Beach

Figure 7. Land use at Tanjung Pakis Beach

The use of the beaches studied is as a tourism destination for tourists from surrounding cities, such as: Bogor City, Karawang City, Jakarta City, and others. There are designated areas for tree planting and the usage of commercial properties for land use and human activities in the Tanjung Pakis Beach region. On Samudra Baru beach, several cultural activities are also held, such as: sea parties and earth almsgiving. The main income of residents is selling seafood and some as fishermen. On the Buntu River, which is located at the end of the Samudra Baru beach, there are many fishing boats anchored.

The highest wind speed is calculated using BMKG's data on the average maximum speed for each month over a period of ten years. At Tanjung Pakis' coastal region and Samudra Baru's coastal area, the greatest wind speeds are 17.68 knots and 17.51 knots, respectively. For each of the investigated coastal locations, January is when the winds are at their strongest. According to the wind rose that has been made, most of the wind blows in the east, while the most wind blows in the west. Figures 8 and 9 show wind roses on the examined coastal area.

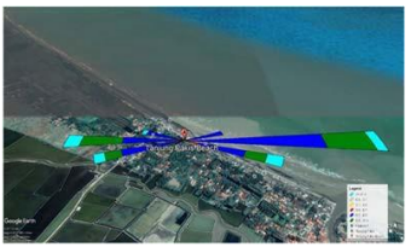

Figure 8. Wind rose on Tanjung Pakis Beach

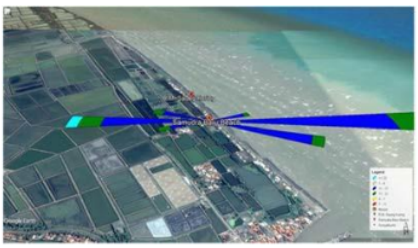

Figure 9. Wind rose on Samudera Baru Beach

The maximum wave height is calculated using BMKG's average maximum wave height for each month over a period of ten years. The highest waves occur in January. It was discovered that the highest wave heights in Tanjung Pakis and Samudra Baru beaches are 2.76 and 2.91 meters, respectively.

The results of combining coastline tracing can be seen in Figures 10 and 11. Figures 10 and 11 show the coastline change at Tanjung Pakis beach and Samudra Baru beach, respectively. Tanjung Pakis beach

in Figure 10 experiences an annual change in coastline of 16.64 m. Due to the lack of embankments constructed from tree branches in abrasion-prone coastal areas, the shoreline had its largest change in the year of 2012-2013. Based on Figure 11, the change in coastline at Samudra Baru beach is obtained at 8.08m/year. Progressive changes in coastlines (sedimentation) are the result of reclamation by the government and residents around the coast.

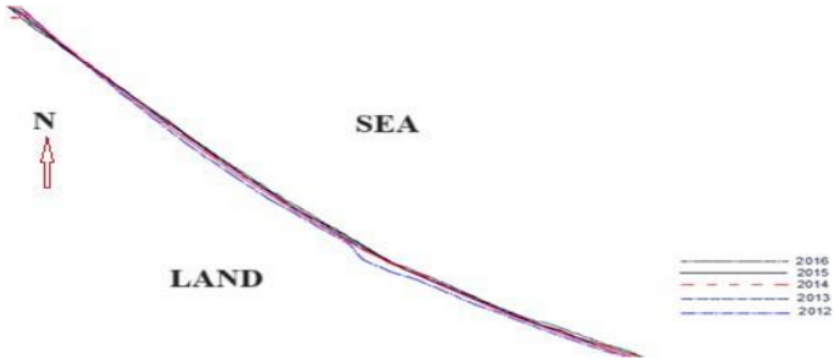

Figure l0. Coastline change at the coast of Tanjung Pakis

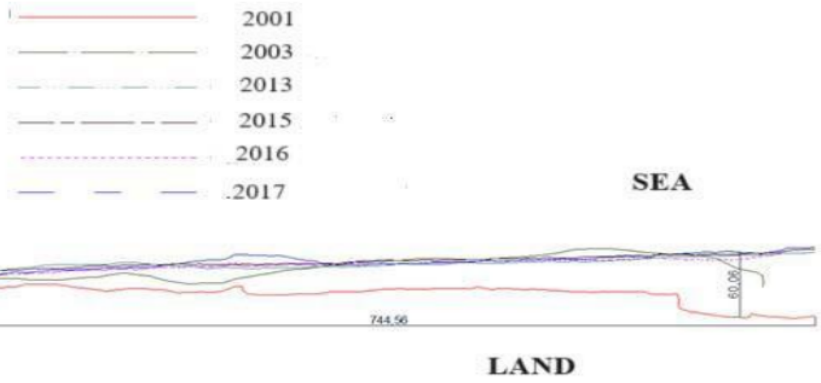

Figure ll. Coastline change at the coast of Samudra Baru

The length and width of damage were calculated using tracing images and measured using AutoCAD. The size that has been measured is then multiplied by the scale that has been calculated. The length of the damage that occurred at Tanjung Pakis beach and Samudra Baru beach are 0.7 km and 1.6 km, respectively. The width of damage at Tanjung Pakis and Samudra Baru beaches are 696.32 m and 129.23 m, respectively.

The CVI rating is determined from the study's findings and observations of the CVI characteristics listed in Table 3. Table 3 illustrates the ranking of CVI variables in Tanjung Pakis and Samudra Baru's coastal areas. Table 4 shows the level of damage based on CVI.

Table 3. Result and Rank of CVI variables at Tanjung Pakis and Samudra Baru Beaches in Karawang District

Variable	Coastal Area			
	Tanjung Pakis		Samudra Baru	
	Result	Rank	Result	Rank
Observations visual damage	damage to the pier on the beach and coastal erosion	5	beach degraded, and construction remnants on the shore that have fallen into the water.	1
Land use	marine tourism destination, settlements, and roads	4	marine tourism destination	2
Wave height (m)	2.76	5	2.91	5
Shoreline change rate (m/year)	16.64	5	8.8	4
Length of damage (km)	0.06	2	1.6	2
Width of damage (m)	62.14	4	129.23	5

Table 4. Damage assessment based on CVI in Tanjung Pakis and Samudra Baru Beaches

Coastal Area	CVI	Level of damage
Tanjung Pakis	25.82	Medium
Samudera Baru	8.17	Low

The coastal area of Tanjung Pakis had moderate damage. Tanjung Pakis's coastline has been chosen for the development of a soft or hard coastal protection structure. Natural protection methods, such as planting mangroves near the shore or constructing embankments for erosion-prone coastal areas, can be used to lessen the degree of coastal vulnerability. The coastal areas of Samudera Baru have sustained low damage.

4. Conclusions

The coastal vulnerability index is used to evaluate coastal vulnerability at Tanjung Pakis and Samudra Baru's coastal tourism in Indonesia's West Java Province's Karawang District. The factors determining the coastal vulnerability index value in Tanjung Pakis and Samudra Baru beaches are the observed visual damage, the land use, the wave height, the coastline change rate, the length damage, and the width damage. Tanjung Pakis's beachfront region sustained moderate damage. The coastline of Tanjung Pakis has been selected for the construction of a soft or hard coastal protection system. To minimize the degree of coastal vulnerability, natural protection techniques can be implemented, such as planting mangroves close to the coastline or building embankments for erosion-prone coastal areas. Samudra Baru's coastal regions have largely avoided damage. The coastal vulnerability of Samudra Baru Beach showed more sustainable coastal tourism than Tanjung Pakis Beach. Further research is required to calculate the coastal vulnerability index with the variable coastal green belt, tidal range, lithology, and beach slope. More investigation can be conducted to determine the ideal location for coastal protection structures in order to reduce coastal risk.

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9