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ANALYSIS OF TIDAL INUNDATION AND THE AGGLOMERATION OF LOSSES IN THE COASTAL AREA OF BONANG SUB-DISTRICT, DEMAK DISTRICT

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Abstrak

Rob (banjir air laut) adalah bencana yang dampaknya semakin parah akibat penggunaan dan pengelolaan lahan yang tidak tepat di wilayah pesisir, membahayakan kawasan pantai Jawa yang panjangnya sekitar 1.000 km dan lebarnya lebih dari 250 km, sehingga total area lebih dari 80.000 km pantai Indonesia akan terancam (Triatmodjo, 1999; Bird dan Ongkosongo, 2005).

Kabupaten Demak merupakan salah satu kabupaten di Jawa Tengah yang terletak di pesisir utara (Pantura). Menurut Badan Pusat Statistik Kabupaten Demak, permukiman di Kabupaten Demak merupakan permukiman pesisir yang rawan bencana banjir rob, khususnya di wilayah Kecamatan Bonang. Permasalahan kerusakan akibat rob di Kabupaten Demak disebabkan oleh letak geografisnya di daerah pesisir dan berbatasan dengan sungai dengan kemiringan lahan yang hampir datar, serta diperparah oleh berkurangnya daerah aliran sungai (DAS) akibat alih fungsi lahan. Jika kenaikan permukaan laut diprediksi akan terus meningkat dalam jangka panjang, dikhawatirkan banjir akibat badai akan meluas. Dampak yang ditimbulkan berbanding lurus dengan luas wilayah yang tergenang banjir.

Metode yang digunakan adalah metode kuantitatif dengan pendekatan spasial. Hasil penelitian menunjukkan bahwa kondisi fisiografis Kecamatan Bonang yang cenderung datar dan memiliki elevasi lahan yang rendah berpengaruh signifikan terhadap luas wilayah yang terkena banjir rob, mencapai 71,04% dari total luas wilayah. Dengan karakteristik Kecamatan Bonang sebagai daerah padat penduduk, perkiraan kerugian yang dihasilkan pun semakin besar. Jarak bulan dari bumi juga berperan dalam menentukan tinggi pasang air laut, yang pada gilirannya mempengaruhi tinggi genangan.

Abstract

Rob is a disaster whose impact is getting worse due to inappropriate use and management of land in coastal areas, endangering Java's coastal areas which are around 1,000 km long and more than 250 km wide, so that the total area will be threatened. more than 80,000 km of Indonesian coast (Triatmodjo, 1999; Bird and Ongkosongo, 2005). Demak Regency is one of the districts in Central Java which is located on the north coast (Pantura). According to the Demak Regency Central Statistics Agency, settlements in Demak Regency are coastal settlements that are prone to flood disasters, especially in the Bonang District area. The problem of damage due to tides in Demak Province is caused by its geographical location in coastal areas and bordering rivers with almost flat land slopes, and is exacerbated by the reduction in river watersheds due to land conversion. If sea level rise is expected to continue to increase in the long term, there are concerns that flooding due to storms will become more widespread. The impact caused is directly proportional to the area covered by the flood.The method used is a quantitative method with a spatial approach. The research results show that the physiographic conditions of Bonang District, which tend to be flat and have low land elevations, have a significant effect on the area covered by tidal flooding, reaching 71.04% of the total area. With the characteristics of Bonang District as a densely populated area, the resulting estimated losses are even greater. The distance of the moon from the earth also plays a role in determining the height of sea tides, which in turn influences the height of inundation

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INTRODUCTION

The phenomenon of global warming has several impacts, including rising sea levels around the world. Another impact of rising sea levels is to cause serious problems, especially in coastal areas. Rising sea levels cause various losses, including erosion and abrasion of coastal areas, storm surges, and damage due to tides. Robs are expected to continue to increase in both frequency and extent (Marfai, 2013).

Demak Regency is one of the regencies in Central Java located on the north coast (Pantura). According to the Demak Regency Central Bureau of Statistics, settlements in Demak Regency are coastal settlements that are prone to flooding, especially in the BonangSubdistrict area. The problem of tidal damage in Demak Province is due to its geographical location on the coast and bordering rivers with almost flat land slopes, and is exacerbated by the reduction of watersheds due to land use change.

It is predicted that in the next few decades the impact of economic sector losses due to tidal inundation will increase based on environmental and socio-economic changes.(Ward et al., 2011). Bonang sub-district is one of the sub-districts that is often affected by Rob. Waters in Demak Regency have the characteristics of an open ocean in direct contact with the Java Sea, and are strongly influenced by external conditions such as wind, rainy season, and open sea tides outside Java Island. There are settlements, ponds and agricultural land that are affected by the phenomenon of flooding and rob. In addition, tides also play a role in increasing the water level in coastal areas. If high rainfall occurs along with tides, the risk of flooding and tidal flooding will be higher.

This research is important to help analyze the distribution of tidal floods and analyze the distribution of losses in the coastal area of BonangSubdistrict, Demak Regency. The form of mapping in this study will be studied through the calculation of loss value based on indicators of tidal inundation area, and tidal inundation height which are then combined with land use data and land economic value data to carry out the assessment stage. After the overlay stage, the loss value calculation will be carried out and the results of the description of the value of material losses received in each region can be obtained. After knowing the value of material losses received by each region, it is hoped that it can make mitigation efforts and tidal inundation management more effective and efficient so that the value of losses can be minimized.

METHOD

The research site is located in Demak Regency, Central Java, focusing on Margolinduk Village, Morodemak and Purworejo Village, Bonang Sub-district. Bonang sub-district ranks second with the largest area with an area of 8,324 ha. Astronomically, Bonang sub-district is located between 110º 31' 18" to 110º 39' 55" East longitude and 6º 47' 40" to 6º 54' 42" South latitude.

The population in this study is tidal inundation as well as land use and people who experience losses due to inundation on the north coast of BonangSubdistrict, Demak Regency.

The method used is a quantitative research method with a spatial approach. quantitative research is a method for obtaining knowledge by utilizing data in the form of numbers to analyze what you want to study.

RESULT AND DISCUSSION

Land use in Bonang Sub-district, Demak Regency

Land use in Margolinduk, Morodemak and Purworejo Villages in BonangSubdistrict used as the basis for calculating the loss estimate in this study was obtained through the interpretation of satellite image data. The satellite image used is the Sentinel-2 L2A image with a recording time of August 1, 2023 at 23:59 WIB. Sentinel imagery was chosen because it has a spectral resolution of 10 meters, making it easier for researchers in the process of interpreting the use contained in the research location. The recording time of satellite imagery is taken into account because it affects the determination of the coastline during the land use digitization process. Based on the results of Satellite Image Interpretation, land use in Bonang Sub-district is divided into 3 classifications, namely Settlements, Ponds and Open Land. Land use in Margolinduk, Morodemak and Purworejo Villages in Bonang Sub-district in 2023 is dominated by Pond Land amounting to 1106,334 Ha and Settlement Land amounting to 61,400 Ha. More detailed results can be seen in the following table 1.

Table 1. Land Use of the Study Site

No.	Land Use	Area (Ha)	Percentage (%)
1	Settlements	61.400	5.254
2	Pond	1106.334	94.685
3	Open Land	0.698	0.059
Total		1168.432	100

Source: Data Processing Results 2023

Judging from the percentage proportion of each land use to the area of Margolinduk, Morodemak and Purworejo Villages, BonangSubdistrict when sorted starting from the largest is Tambak at 94.685%, Settlement 5.254%, and Open Land at 0.059%.

The results of the interpretation of land use classification in this study have been carried out accuracy test using confusion matrix and calculation of kappa value test. Based on the results of the accuracy test using the confusion matrix, the overall accuracy value is 94%, while the kappa coefficient (T) value is 90.48%, which falls into the very good category. The calculation of the accuracy test and land use is presented in the data below:

Table 2. Research Site Land Use Accuracy Test 2023

2023 LAND USE CLASSIFICATION ACCURACY TEST					
	1	2	3	Total Sample	User Accuracy
1	14	2	1	17	87,5
2		22		22	100
3			11	11	100
Total	14	24	12	50	
Producer Accuracy	100	95, 24	100		94

Source: Data Processing Results

Land Use Description:
1 : Settlement
2 : Pond
3 : Open Land

Kappa Value Coefficient Calculation:

$$Kappa\ Coefficient = \frac{(\mathrm{TS} \times \mathrm{TCS}) - \sum(Column\ Total \times Row\ Total)}{TS^2 \times \sum(Column\ Total \times Row\ Total)} \times 100$$

$$Kappa\ Coefficient = \frac{(50 \times 43) - 2350}{50^2 \times 2350} \times 100$$

$$Kappa\ Coefficient = 90{,}4$$

Figure 1. Land Use Map
Source: Data Processing Results

Tidal Characteristics of Bonang Sub-district, Demak Regency

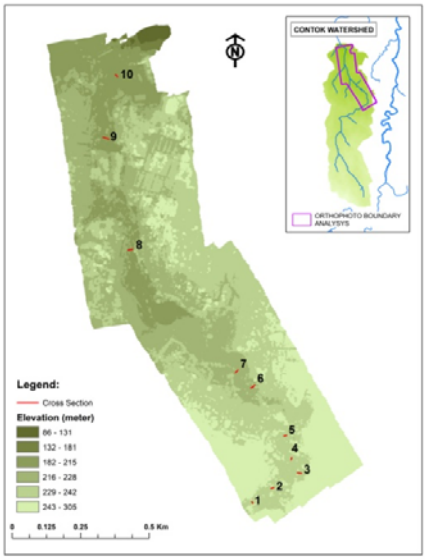


Figure 2 map layout example

Tidal analysis in the Morodemak Harbor area is intended to determine the type of tides and determine the sea level that can be used as a vertical reference for Rob Flood Modeling in the Bonang Sub-district area of Demak Regency which produces Mean Sea level values (sitting midway from sea level), and average water levels. For this reason, a harmonic analysis will first be carried out to obtain the amplitude and phase of each harmonic component. The data analyzed is tidal data for 29 days with a data range of August 2 to 30, 2023.

Based on the tidal data and the results of the Admiralty calculation above , the tides that occur in the coastal area of Demak are included in the type of single daily tides with the average height of sea level in the waters of Morodemak harbor is 60.5 cm. The highest high water level for the August period is 98.5 and the lowest low water level for August is 12.4. In the observation of tides, water level elevation data is needed as one of the parameters for the Rob flood modeling that occurs in Bonang District, Demak Regency. The tidal data graph can be seen in Figure 9 below.

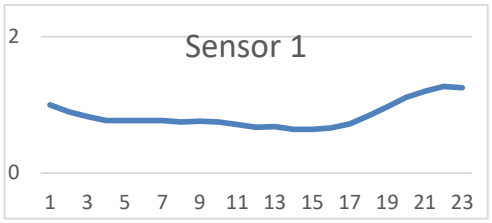


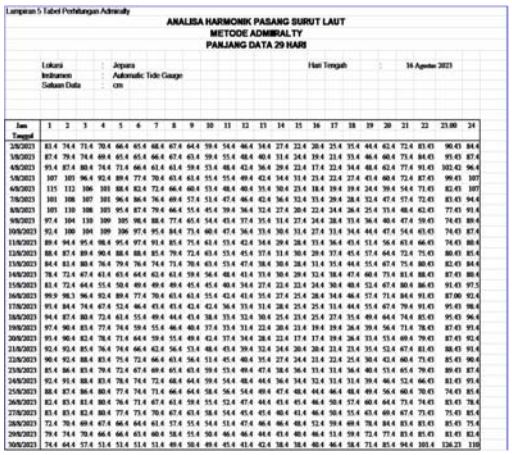
Figure 3. Tidal data of jepara station sensor 1
Source: Geospatial Information Agencey

Table 3. Calculation Results Admiralty tides Jepara

HASIL TERAKHIR

	So	M2	S2	N2	K2	K1	O1	P1	M4	MS4
A cm	60,5	5,6	8,7	2,8	2,0	20,4	8,6	6,7	0,2	0,7
g		28,6	291,5	52,1	291,5	20,8	36,6	20,8	191,4	204,1

Zo	=	55,68	MSL=	60,5	FORMZA HL=	2,034475
			HHWL=	98,9	MHWL=	69,9
			LLWL=	12,4	MLWL=	41,4



Source: Data Processing Results

Rob inundation in Bonang Subdistrict, Demak Regency

In this study, data on the extent of tidal inundation in Bonang Sub-district was obtained through the development of inundation scenarios using DEMNAS as elevation data and tidal data to determine the height of inundation scenarios. In the preparation of inundation scenarios, two tidal height data were used, with the lunar cycle considered as the most influential factor on the tidal height. Two events in August 2023 were selected. On August 30, 2023, the moon is at its closest position to the earth (perige) with a distance of 357.7182 km and on August 16, 2023, the moon is at its farthest position to the earth (apoge) with a distance of 406.635 km. Calculation data Tidal inundations based on the perige and apoge lunar cycles are detailed in the following table 4

Table 4. Tidal Scenario

Moon Position	Date	Time	Hhwl (cm)	Msl (cm)	Inundation (cm)
(Perige)	30/08/2023	23:51	126	60	66
(Apoge)	16/08/2023	00:55	100	60	40

Source: BIG and BMKG (2023)

The results of the above calculations show that the inundation height is 66 cm and 40 cm. This height is then used as input for the tidal inundation depth scenario so that the following inundation results are obtained:

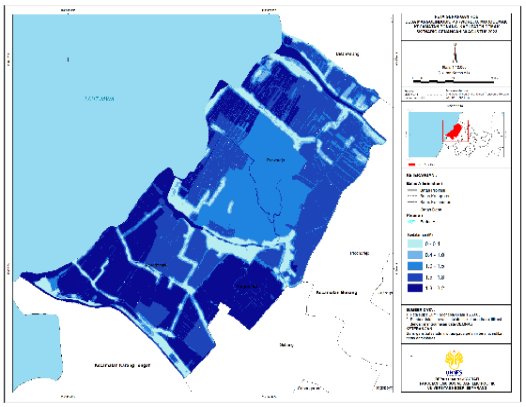


Figure 4.ROB Inundation Scenario August 30, 2023

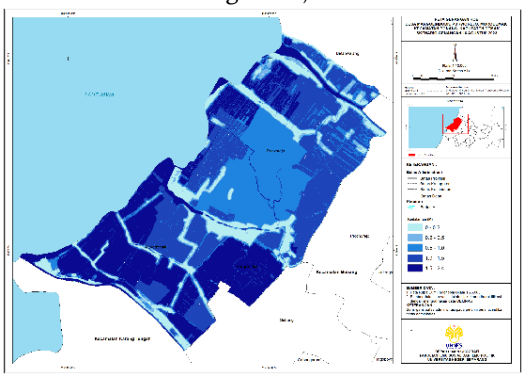


Figure 5.ROB Inundation Scenario August 16, 2023

Distribution of losses due to ROB inundation

In calculating the estimated value of losses in this study, the economic value of land is required and calculated through various considerations rather than the market value or the actual value of land use. The economic value of each land use was obtained from interviews with residents in the coastal area of Bonang Subdistrict.

To obtain more relevant results at the time of scenario development, the economic value of land was adjusted to the inflation rate so that the actual value of the approach taken was obtained as shown in the following table.

Table 5. Loss Estimation Value per Land Use

Land Use	Estimated Loss/Ha
Settlements	Rp.2,080,000,000
Pond	Rp.1,248,000,000
Open Land	RP.832,000,000

Source: Data Processing Results

The value in rupiah of the losses incurred was calculated by summing up the result of multiplying the area of each land use affected by tidal floods with the economic value of each land use in the study location.

In the scenario of loss distribution in Bonang Sub-district, the loss value per pixel has been calculated and then the total sum is done for each village. This aims to identify the losses experienced by each village. The following are the results of the distribution of losses due to tidal inundation by kelurahan in BonangSubdistrict in the form of a map in table 6 below.

Table 6. Distribution of Losses due to Rob Inundation

Village	Estimated Loss Value (IDR)	
	August 16, 2023	**August 30, 2023**
Margolinduk	IDR 76,780,000	IDR 77,070,000
Morodemak	IDR 246,520,000	IDR 256,180,000
Purworejo	IDR 4,481,260,000	IDR 4,534,460,000
Total	IDR 4,804,560,000	IDR 4,867,710,000
Average	IDR 1,601,520,000	IDR 1,622,570,000

Source: Data Processing Results

Based on the table presented above, the total estimated loss is IDR 4,804,560,000 in the August 16, 2023 scenario. The average loss per kelurahanwas recorded at IDR 1,601,520,000, with two villages, namely Margolinduk and Morodemak, falling below this average.

On the other hand, KelurahanPurworejo showed losses that exceeded the average.

The largest loss was experienced by KelurahanPurworejo with an estimated loss of Rp. 4,481,260,000, while the smallest loss was in KelurahanMargolinduk with an estimated value of Rp. 76,780,000.

CONCLUSIONS

The physiographic condition of Bonang Sub-district, which tends to be flat and has a low land elevation, has a significant effect on the area inundated by tidal inundation, reaching 71.04% of the total area. With the characteristics of Bonang Sub-district as a densely populated area, the estimated losses generated are even greater. The distance of the moon from the earth also plays a role in determining the height of the tide, which in turn affects the height of the inundation. This research resulted in the following conclusions:

1. Identification of land use through satellite imagery shows that ponds cover 94.685%, settlements 5.254%, and open land 0.059% of the total study area of 1168.432 ha.
2. From the data processing, the estimated loss due to tidal inundation in North Semarang Sub-district in the inundation scenario of August 16, 2023 is Rp 4,804,560,000, while for the inundation scenario of August 30, 2023, the estimated loss increases to Rp 4,867,710,000.
3. The inundation and land use scenarios are the main factors influencing the magnitude of estimated losses in each neighborhood.
4. The inundation scenario results in this study do not fully reflect accurate field conditions. Various factors, such as the presence of dykes and other natural barriers, were not taken into account, so the actual height and extent of inundation may differ from the mapping results.

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