Chapter 72
Spatial Modeling of Tidal Flood Due to the Fishpond to Tidal Waves in Bengkalis, Indonesia

Giant Amor, Muhammad Hanif, Arie Yulfa, Rizki Athorik Hidayat, and Poppy Indrayani

Abstract Almost 99% of the reported disasters are hydrometeorological types [11]. tidal flooding is one of the potentials that has recently become a frightening specter in the coastal area of Bengkalis. tidal flooding is an annual disaster that occurs in the coastal region of the Bengkalis Regency. (BPBD Bengkalis, 2020). it often happens and it has a serious problem for people living around coastal and tidal flats. This condition aggravated In 2020, most of the coastal areas in Bengkalis Island by the conversion of mangrove land into Fishponds, which is a classic problem in the research area for support the economy of the Bengkalis community. Moreover, The Sea level rise reported by IPCC (2007) increases by 15–90 cm with a definite increase of 48 cm in 2100. The method in this research is the spatial analysis model of coastal flooding use scenario optimum high tidal and estimation impact of conversion mangrove to become fishpond. All parameter data from the geospatial information agency (BIG), as land cover, coastal line, digital elevation model, and tides is analyzed using Cost Distance analysis with a geographic information system (GIS) in Arcgis. The aim of this research is to model the coastal flooding and the impact of the fishpond on tidal floods. For the final decision, we use the extreme scenario using the highest tidal discharge, which is 3.4 m to result in the Spatial Modeling Of Tidal Flood In Bengkalis. The results of this spatial modeling succeeded in showing the coastal flooding area, with the highest to lowest inundation range This model is suitable for representing the worst scenario of high tides in the coastal area of Bengkalis.

G. Amor (✉) · A. Yulfa · R. A. Hidayat
Department of Geography, Universitas Negeri Padang, Padang 25163, Indonesia
e-mail: giantamor84@gmail.com

P. Indrayani
Department Architecture, University of Fajar, Makassar, Indonesia

M. Hanif
Department of Geo-Informatics, Khon Kaen University, Khon Kaen 40002, Thailand

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72.1   Introduction

Sumatra is the second largest area of mangrove land. Where: "Indonesia has more than 4 million hectares": 15.46% in Sumatra, 2.35% in Sulawesi, 2.35% in Maluku, 9.02% in Kalimantan, 1.03% in Java, 0.18 Bali and Nusa Tenggara, and 69.43% in Irian Jaya. The conversion of mangrove forests into fish ponds strongly supports the community's economy is being empowered by the business sector in Bengkalis. From an economic perspective, the fishery business is profitable and it could increase people's income. However, this activity might lead to environmental degradation. On the other hand, Bengkalis is an area that is vulnerable to tidal flooding. Based on the latest news, flood conditions have occurred again since December 2019 until early 2020. The height of the sea water that rises to the land varies from 15 cm to 30 cm. High tide floods like this are subscribed every year. (Riaupos.com. 2021).

Based on information from the local community, this tidal flood has begun to be felt in the last 10 years, this tidal event mainly occurs in coastal areas that are prone to flooding, including Teluk Latak Village, Pedekik, Damon, Senggoro, Wonosari, Sebauk, Simpang Ayam, Meskom, Deluk, Jangkang, Bantan Sari, Bantan Air, Ulu Pulau, Pambang Baru, and Batu Panjang Village on Rupat Island. (Coverage 6. 2018). The tidal flood incident also occurred on October 30, 2019, the activities of residents in Bandar Jaya Village, Siak Kecil District, Bengkalis Regency were paralyzed because the main road in the area was flooded and water reached a height of 20 cm inundating a number of local residents' houses (Antarariau.com. 2019).

Geospatial technology such as geographic information systems is very effective for representing and analyzing spatial information, and very effective for calculating spatial data, and also for modeling as a basis for analysis and policy making, especially in disaster analysis and estimation of disaster slopes in settlements. Seeing the problem of the disaster which is very clearly a strategic issue in Bengkalis Regency, the author is interested in conducting research with the title "Spatial Modeling Of Tidal Flood Due To The Fishpond To Tidal Waves In Bengkalis, Indonesia".

Thus, carrying out The mapping of coastal flood hazards in Bengkalis is a tool used to determine flood area limits inland and in other areas exposed to coastal floods due to different risks such as storms, surge waves, sea-level rise caused by climate change. So far there has been no research that discusses flooding in Bengkalis. In fact, flood modeling in Bengkalis is not only useful for disaster mitigation, but also in the context of saving environmental degradation in coastal areas.

Therefore, this study aims to identify the spatial distribution of the Rob flood inundation on the Bengkalis Island coast due to high tides using spatial modeling by using the method Cost Distance.

72.2   Materials and Methods

72.2.1   Land Surface Roughness Design and Cost Distance Analysis

Modeling potential vulnerability of coastal areas assisted by GIS technology in interpreting constituent variables such as digital elevation model, slope, coastal line, land cover, and tides. The data as a roughness coefficient map is obtained from the land use map resulting from the extraction of land cover Digital Elevation Model. It is a product of the Geospatial Information Agency to serve the availability of elevation data in Indonesia. This data is needed in the analysis process that will design a spatial model that is the topic of this research, such as data on land cover, shoreline, the slope of the research area, and others. Type data: 32 bits Float. Spatial Resolution: 10 m (bands 1 Panchromatic). This Research Aims To Simulate Or Predict The Inundation Of Rob Flood That Runs On The Land When Tide Occurs As A Mathematically Measurable Energy Release.

Cost distance mapping and spatial analysis often involve more than calculating distances and elevations. Distance costs can also be a variety of variables, ranging from economic, social, cultural, environmental, or other barriers that can create this type of 'cost' in travel or movement [1]. Based on the suitability for analyzing between variables, this study is suitable for calculating the reduced surface reduction power due to being a pond that can inhibit the movement of tides.

72.2.2   Damage of Mangrove Forests and Fish Pond Status in Bengkalis Regency

No	District	Land Area	Mangroves	Large of fish ponds	
		(Ha)	Damaged	Total	Activities
1	Rupat Utara	12,784	25.3	3.32	0.06
2	Rupat	5806	1.5	3.38	0.45
3	Bantan	5804	20.7	62.63	61.29
4	Bengkalis	4254	0.5	23.33	15.34
5	Pinggir	2125	5.3	3.32	0.06
6	Siak Kecil	3452	7.8	0.05	0.05
7	Bukit Batu	898	7.8	3.23	1.37

(continued)

(continued)

No	District	Land Area	Mangroves	Large of fish ponds	
		(Ha)	Damaged	Total	Activities
Total		**41,718**	**64.1**		
2018				92.94	78.56
2017				61.28	44.59
2016				64.12	33.08
2015				64.49	32.65
2014				50.25	31.90

Source Department of Forestry Service Reg Riau. Source Fishery Service of Bengkalis Regency
Notes Condition December 2018

Mangroves are found at the forefront in terms of their position relative to many coastal hazards. The fact that they thrive in many coastal settings provides some indication of their ability to overcome the danger, or at least to recover from big impact [2]. Mangroves may contribute to reducing loss of life and damage to property from storms and cyclones as they reduce the impacts of waves, storm surges, and high winds.

Figure 72.1 reveals the fact that changes in field existence of the mangrove ecosystem is highly threatened by the conversion of mangroves become fishponds carried out by the community for business opportunities. Waves are most rapidly reduced when they pass through a greater density of obstacles [2]. This Means The structure of the mangrove forest is important in determining the potentialrisk reduction by mangrove.

Fig. 72.1 Damage of mangrove forests to become fishpond.on Coastal Bengkalis, 2021

Table 72.1 Coefficient land surface roughness

Roughness	Land cover	Coefficient value
R1	Water body	0.007
R2	Shrub	0.04
R3	Forest	0.07
R4	Plantation	0.035
R5	Bare land	0.015
R6	Agricultural area	0.025
R7	Built-Up	0.045
R8	**Mangroves**	0.025
R9	**Fish pond**	0.01

Source Barryman (2006)

72.2.3 *Analytical Methods*

At this stage, Geographic Information Systems (GIS) can be developed in urban hydrology applications, especially making a model [3]. In tidal flood modeling, the data used include surface feature data (Digital Elevation Model), topographic maps, land use maps, flow discharge models, runoff coefficients. The modeling technique uses cost distance modeling [4]. Data in the form of contours showing the elevation lines of the area are processed to become DEM, and modeling to look for runoff, accumulation of flow, and concentration of water flow (Table 72.1).

The following is a mathematical process for making data on the coefficient of land surface roughness [5].

$$H_{loss} = ((167n2/H01/3) + 5\sin S)$$

Description:

H$_{loss}$: Reduction of water level and energy in the interval of shoreline
n: Coefficient of land surface roughness
H0: Maximum scenario of high water level of the tidal wave
S: Slope of the land surface.

72.2.3.1   Coastal Flooding Innundation Design

The basic principle of calculating the cost distance is to calculate the cost of each cell that is passed, the fundamental equation of the cost distance behind the ArcGIS software [1] (Fig. 72.2).

$$Cost\,Distance = cds + \frac{crs + cra}{2}$$
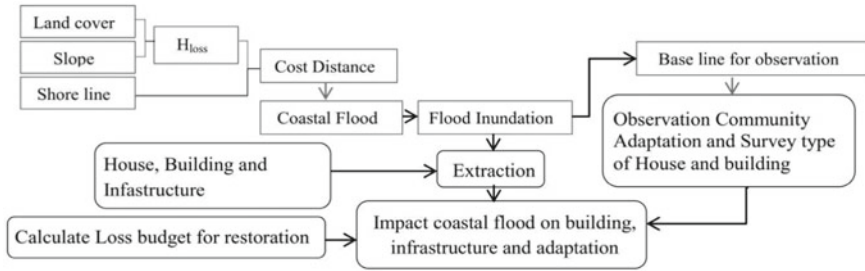
Fig. 72.2 Research procedure

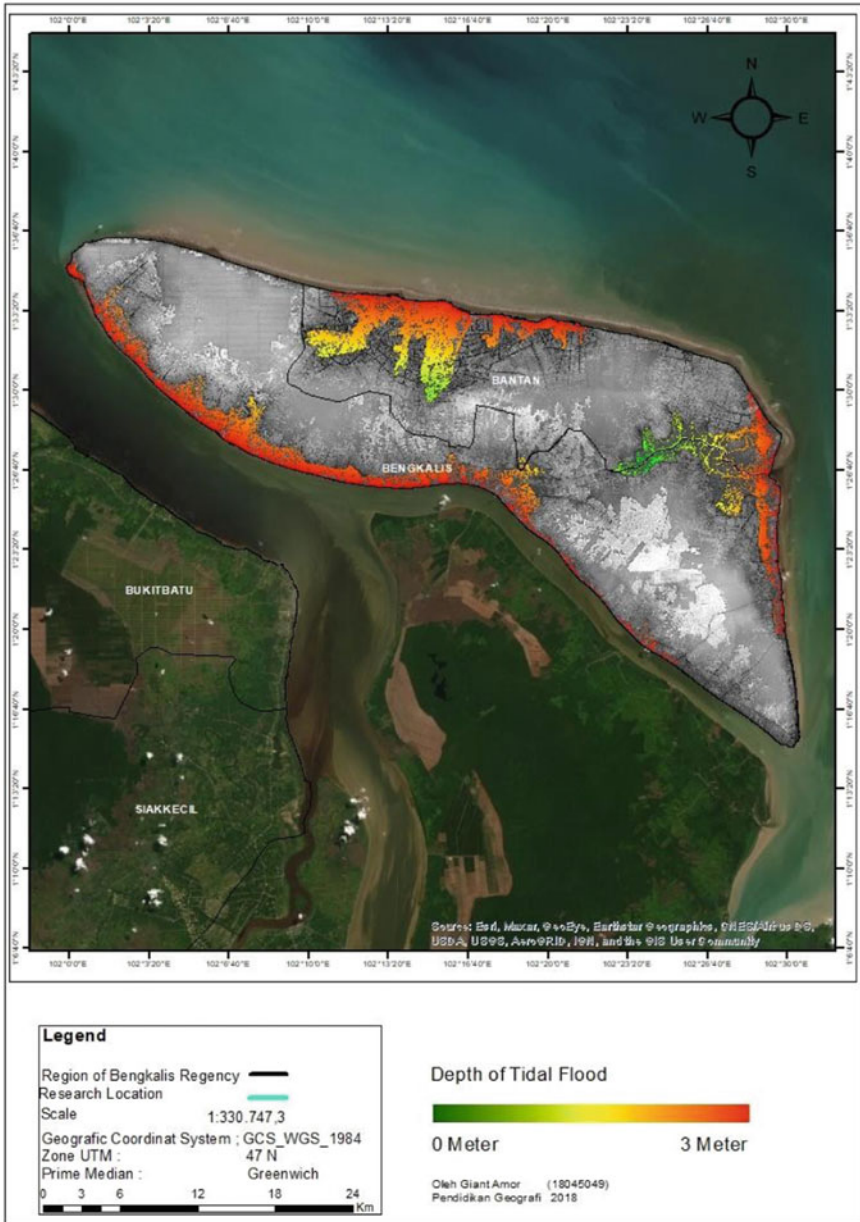where:

> $Cds =$ is cost distance sources
> $Crs =$ raster cost

$$CoastalFlood = cd - Maxcd$$

where: cd = cost distance and Max cd = Maximum value of cost distance. After the results of the coastal flood analysis are obtained. These results must be subtracted from the flood height data that occurred at the research location [11]. As in the location of this study, coastal flooding has a height of up to 100 cm above sea level, so data extraction is carried out at the height of 1 m. In this study, the land elevation was extracted from DEM images with a resolution of 10 m.

72.3   Results and Discussions

72.3.1   Spatial Modeling Tidal Flood Map in Coastal Bengkalis

We found the topography of the Bengkalis area is generally a flat and low area, as is the characteristic of the sloping landscape of the east coast of Sumatra. And it is dominated by peatland, making this research area vulnerable to tidal floods that hit coastal areas. The distribution of tidal inundation on the Bengkalis coast by an inundation map that has been modeled with mathematical calculations in Arcgis 10.4 software using Cost Distance Analysis.

Legend

Region of Bengkalis Regency	——
Research Location	——
Scale	1:330.747,3
Geografic Coordinat System ;	GCS_WGS_1984
Zone UTM :	47 N
Prime Median :	Greenwich

0   3   6   12   18   24
Km

Depth of Tidal Flood

0 Meter   3 Meter

Oleh Giant Amor   (18045049)
Pendidikan Geografi 2018

From this modeling, it can be seen that the zone of exposure of the area to tidal inundation is modeled with a maximum tide scenario of 3 m. This is achieved by considering the variation in the distribution of tides along the coastline which is generally gentle and not more than 3 m high from land to sea (Fig. 72.3).
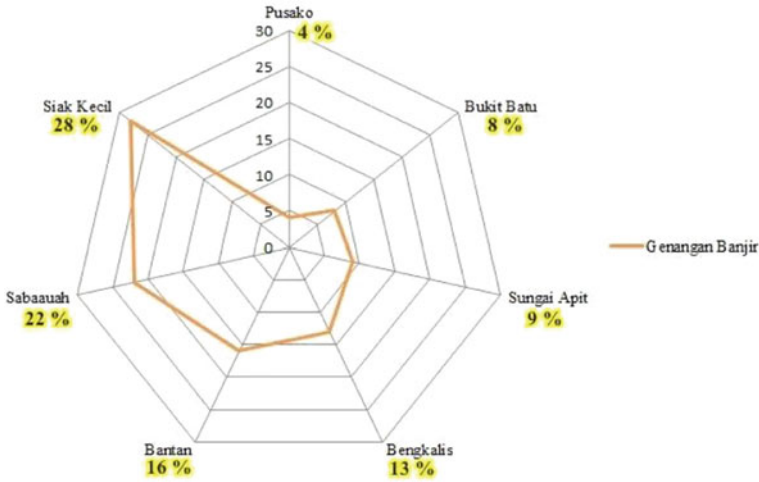
Fig. 72.3 Percentage areas impact of tidal flood inundation in coastal Bengkalis

From the picture above, it is clear that the administrative areas are affected by the tidal flood disaster. So for the prevention of choice of other places in the event of a greater tidal flood disaster. The flood vulnerability is relatively high for the major coastal cities. The values of all three assessment components together are more significant. Directions for city development, especially residential areas, also need to be reviewed and accommodate disaster zones as a disaster mitigation strategy in the form of developing development policies. The limitation of this research is which not use high- resolution data. For better coastal flood modeling, we should use the multiscale, multi- physics aspects of this study are considerable and highly informationally provocative. Coastal storm surges are on the order of a meter or more in the vertical and extend alongshore for coastal distances of several kilometers, with persistence of over several hours to several days

72.4   Conclusions

Tidal flood inundation mapping model with an approach to the condition of the basin/surface elevation and ground surface roughness, so that it can provide information on the area of the tidal flood inundation from the estimated tidal overflow, as well as calculate the settlements affected by the flood. puddle model. This method is appropriate in spatial modeling of flood inundation because with a very dynamic land cover, it calculates the coefficient of surface roughness based on the land cover can reduce the energy of the incoming waves. Currently, in Bengkalis, the Mangrove Land Cover has turned into a fish Pond which will have an impact on the amount of energy carried by the land waves.

Authors Contribution All authors contributed equally as the main contributors to this work.

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