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Simulated Mitigation of Tsunami Disasters in the Coastal Area of Purworejo Regency, Central Java, Indonesia

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Abstract
The coastal area of Purworejo Regency has the potential to be hit by a mega-tsunami disaster because it includes the southern coast of Java Island which is faced with seismic gaps that may produce large earthquakes in the future. This study aims to simulate tsunami disaster mitigation in the coastal area of Purworejo Regency in an effort to raise awareness and increase the community capacity for dealing with potential tsunamis so that the level of loss can be minimized. The tsunami risk analysis is based on the Disaster Crunch model, which is a combination of vulnerability analysis based on the weighted overlay quantitative method and tsunami hazard analysis based on tsunami inundation reduction modeling and cost distance analysis. The planning of the tsunami evacuation route is based on the network analysis method. The tsunami-risk area with a run-up scenario of three meters in the coastal area of Purworejo Regency 126.29 square kilometers or about 72.52% of the total coastal area. There are five tsunami evacuation plan points, with five main tsunami evacuation routes that lead directly to each of these points.

Keywords: Tsunami mitigation simulation, Tsunami risk level, Tsunami evacuation route, Purworejo Regency.

1. Introduction

Mitigation is an attempt to minimize disaster risk, through both physical development as well as public awareness and capacity building, when dealing with disaster threats (BNPB, 2007). All categories of disasters, especially those caused by natural factors such as tsunamis, need to be mitigated to reduce the number of fatalities and the magnitude of the material losses (Solikhin, 2020). “Tsunami” comes from the Japanese words "Tsu" meaning harbor and "Nami" meaning a wave, so in general it can be interpreted as a big wave in a harbor. The tsunamis that occur in Indonesia are usually caused by earthquakes, because Indonesia is flanked by three large plates: namely, the Eurasian, Indo-Australian, and Pacific Plates (Widodo, *et al.*, 2017). These three plates are subduction zones between the continental and oceanic plates (Koshimura, 2018). An oceanic plate subducts under a continental plate, causing friction and pressure over time. Tsunamis occur when the accumulation of this pressure reaches its maximum limit, resulting in movement, such as the lifting or shifting of the plates. If the movement occurs at a shallow depth, it will potentially trigger tsunami energy (Koshimura, 2018).

The coastal area of Purworejo Regency forms part of the southern coastal area of Java Island which may potentially be affected by tsunamis in the future. A seismic gap was identified located in the southern subduction zone of Java Island, with the potential to cause a large earthquake (Widiyantoro, *et al.*, 2020). Therefore, mitigation planning efforts are needed as a response to a potential tsunami. Tsunami disaster mitigation planning can be carried out by determining which areas are likely to be affected by the tsunami disaster (Nahak, Djunaedi, & Wonlele, 2017). These areas can be identified by analyzing the level of tsunami risk through the integration of a vulnerability and tsunami hazard analysis (Santius, 2015). Another form of tsunami mitigation planning is tsunami evacuation route planning (Kultsum, Fuad, & Isdianto, 2017).

Jokowinarno (2011) examined tsunami disaster mitigation by formulating visions, missions, policies, programs, strategies, and activities to reduce the potential negative impacts of a tsunami based on a SWOT analysis (Strength, Weakness, Opportunity, Threats). He explained that, by paying attention to these strategic components, the keys to successful tsunami mitigation can be obtained, including understanding: 1) the characteristics of natural disasters and the damage they cause in coastal areas, 2) the risks and vulnerability of coastal areas to disasters, 3) the environmental, social, cultural, and local wisdom conditions, 4) the mitigation efforts, both structural and non-structural, 5) the institutional capacity building and law enforcement, and 6) the factors that ensure continuity. This study examines non-spatial tsunami mitigation using statistical data; for example, the distance from the coastline to the location of the tsunami generator due to the eruption of Mount Krakatau. The statistical data are analyzed so that disaster mitigation measures can be designed (Jokowinarno, 2011).

Non-spatial analysis cannot always explain the location of tsunami-prone areas that must be avoided, so this study attempts to design a tsunami mitigation simulation. Tsunami risk analysis and planning for tsunami evacuation routes utilize the integration of remote sensing technology and Geographic Information Systems (GIS) (Sambah, Miura, Guntur, & F, 2018). The data obtained from recording objects on the earth's surface by remote sensing satellites and the ability to operate spatial data via the Geographic Information System (GIS) can determine the vulnerable and hazardous zones, evacuation places, and tsunami evacuation routes (Johnson, 2000). This study aims to simulate tsunami disaster mitigation in the coastal area of Purworejo Regency in an effort to raise awareness and increase the community capacity for dealing with potential tsunamis, so that the level of loss can be minimized.

2. Research Method

This research is located in the coastal area of Purworejo Regency, Central Java Province, which consists of three sub-districts; namely, Grabag, Ngombol, and Purwodadi. The coastal area of Purworejo Regency covers 174.15 square kilometers. Kulonprogo Regency lies to the east, Kebumen Regency to the west, Butuh, Kutoarjo, Bayan, Banyuurip, and Bagelen to the north, and the Indian Ocean to the south. A map of the coastal area of Purworejo Regency can be seen in Figure 1.

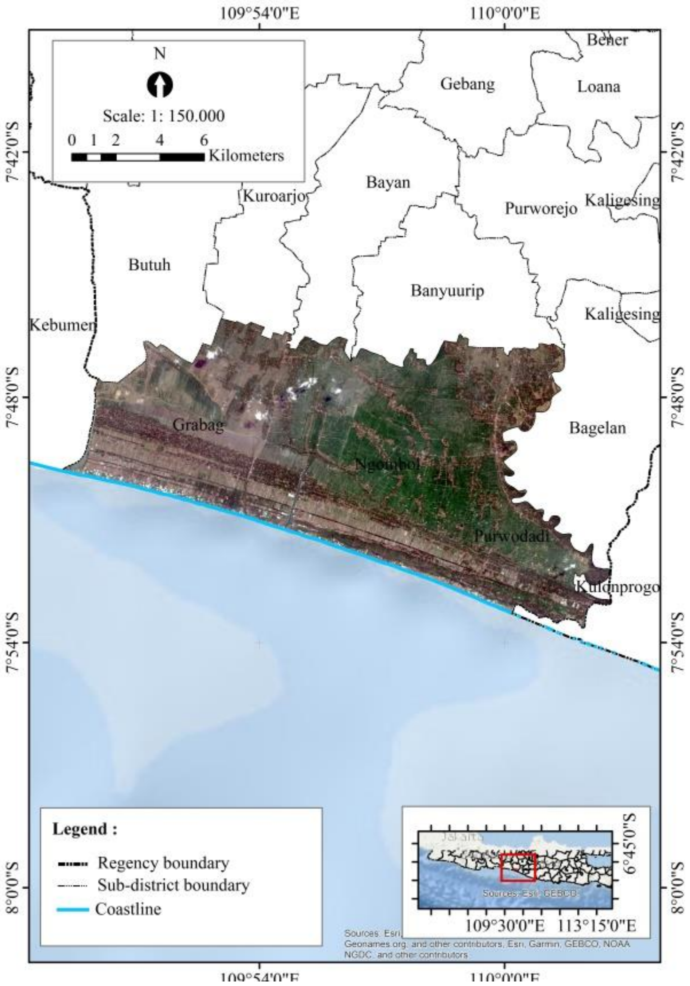

Figure 1. Map of the Coastal Area of Purworejo Regency.

The data used in this study can be seen in Table 1. Meanwhile, this research process was divided into four stages; namely, the tsunami vulnerability analysis, tsunami hazard analysis, tsunami risk analysis, and the planning of the tsunami evacuation routes.

Table 1. Research Data.

Data	Function	Source
Sentinel-2A image	Land use data	USGS Earth Explorer
Alos Palsar Digital Elevation Model Images	Land elevation data	ASF (Alaska Satellite Facility)
shapefiles of the coastal area of Purworejo Regency (administrative boundaries, road networks, and coastlines)	Mapping base data	Geospatial Information Agency (BIG)
Population density census data	Vulnerability parameters data	Central Bureau of Statistics (BPS)

2.1. Tsunami Vulnerability Analysis

Vulnerability is a characteristic of an area related to its geographical, geological, climatological, ecological, social, cultural, political, economic, and technological aspects, that can reduce the ability to face the adverse effects of a hazard at a certain time (BNPB, 2007). The tsunami vulnerability analysis uses a weighted overlay quantitative approach. The tsunami vulnerability parameters used include the evacuation speed obtained from the ratio of the population and the length of the road in each sub-district, the elevation extracted from the DEM ALOS PALSAR data, the distance from the shoreline obtained from the results of the buffer analysis to the shoreline, the population density obtained from the ratio of population and area per sub-district, and the settlement density obtained from the ratio of the population and the area of settlement per sub-district.

Each vulnerability parameter is classified into five classes, then given a score. The classification and scores for each vulnerability parameter are listed in Tables 2 to 5, respectively, while the weights for the five vulnerability parameters are listed in Table 7. The tsunami vulnerability raster, resulting from the scoring and weighting process, is then classified into five levels; namely, very low, low, moderately high, high, and very high vulnerability.

The tsunami vulnerability parameters in this study follow the research of Santius (2015), because there are areas that are mapped almost similarly; namely, the coastal area of a Regency in Indonesia, namely Bengkulu Regency. In addition, this tsunami mitigation simulation study in the coastal area of Purworejo Regency also considers the availability of the data that can be obtained and the parameters of tsunami vulnerability in the research of Santius (2015) can be easily obtained.

Table 2. Evacuation Speed Classification (Santius, 2015).

Speed Evacuation (People/ Kilometers)	Classification	Score
0-1,000	Very fast	0.1
1,000-2,000	Fast	0.2
2,000-3,000	Slightly fast	0.3
3,000-4,000	Slow	0.4

Table 3. Elevation Classification (Santius, 2015).

Elevation (Meters)	Classification	Score
0-10	Very low	0.333
10-20	Low	0.267
20-30	Slightly high	0.2
30-40	High	0.133
>40	Very high	0.067

Table 4. Distance from Coastline Classification (Santius, 2015).

Distance from coastline (Meters)	Classification	Score
0-500	Very close	0.333
500-1,000	Close	0.267
1,000-1,500	Slightly far	0.2
1,500-2,000	Far	0.133
>2,000	Very far	0.067

Table 5. Population Density Classification (Santius, 2015).

Population Density (People/Square Kilometers)	Classification	Score
0-1,500	Rarely	0.067
1,500-3,000	Slightly dense	0.133
3,000-4,500	Moderately dense	0.2
4,500-6,000	Dense	0.267
>60,000	Very dense	0.333

Table 6. Settlement Density Classification (Santius, 2015).

Settlement Classification (%)	Classification	Score
0-20	Rarely	0.067
20-40	Slightly dense	0.133
40-60	Moderately dense	0.2
60-80	Dense	0.267
80-100	Very dense	0.333

Table 7. Tsunami Vulnerability Parameter Weight (Santius, 2015).

Tsunami vulnerability parameter	Weight
Evacuation speed	0.399676
Elevation	0.103977
Distance from coastline	0.229936
Population density	0.218936
Settlement density	0.047475

2.2. Tsunami Hazard Analysis

The tsunami hazard analysis using the tsunami inundation reduction model refers to the Berryman inundation reduction equation (Equation 1) and the cost distance analysis. The value of tsunami inundation reduction when it reaches land (Hloss) using the parameters of the tsunami height when it arrives at the coastline or run-up (Ho), the coefficient of surface roughness (n) derived from the land cover, and the degree of slope were extracted from the Digital Elevation Model (DEM) image (S) (Qossam, Nugraha, & Sabri, 2020).

$$\mathbf{Hloss} = \frac{\mathbf{167n^2}}{\mathbf{Ho^{1/3}}} + \mathbf{5\ Sin\ S} \qquad (1)$$

The tsunami run-up scenario used in this study is three meters. The run-up scenario includes run-ups with a high hazard category and also considers the results of the run-up simulation at Keburuhan Beach, Purworejo Regency in Hartanto and Astriawati's research (Hartanto & Astriawati, 2020) whose results reached more than four meters, so a tsunami run-up as high as three meters is assumed to be possible. The three-meter high tsunami run-up used also considers the classification of the components of the tsunami hazard index which was decided in the Regulation of the Head of BNPB Number 02 of 2012 concerning the general guidelines for disaster risk assessment. The tsunami height index class included in the minimum height category is three meters.

The land cover information was obtained from Sentinel-2A images by following a supervised maximum likelihood classification process. Sentinel-2A imagery was chosen because it has a medium to high spatial resolution and can provide fast, up-to-date information (Mandala, Indarto, Arifin, & Hakim, 2020), so it is suitable for identifying land cover objects. The raster classification results are then tested for accuracy using a confusion matrix. The accuracy values in the confusion matrix accuracy test consist of the user's accuracy, producer's accuracy, and the overall accuracy. The formulae for the user's accuracy, producer's accuracy, and overall accuracy in equations 2, 3, and 4 (Danoedoro, Widayani, & Hidayati, 2017) are as follows:

$$\textbf{User's accuracy} = \left(\frac{Xkk}{Xk+}\right) \times 100\% \qquad (2)$$

$$\textbf{Producer's accuracy} == \left(\frac{Xkk}{X+k}\right) \times 100\% \qquad (3)$$

$$\textbf{Overall accuracy} = \frac{1}{N} \sum_{k}^{r} k = 1\, ni \times 100\% \qquad (4)$$

Where Xkk is the total pixel representation in column k, row k, Xk+ the total sample representation in row K, X+k the total sample representation in column k, N the total number of pixels, and R a representation of the number of classification classes. User's accuracy is the percentage of pixels that are correctly interpreted for each pixel per class. Producer's accuracy is a percentage that shows the object of the earth's surface that is represented at the time of the interpretation. Meanwhile, the overall accuracy is the percentage of accuracy of the interpretation results overall. An interpretation result is said to have good accuracy with strong classification accuracy, if the overall accuracy value is more than 85%. The land cover sampling method used random sampling (Danoedoro, Widayani, & Hidayati, 2017). Land use data that have passed the accuracy test and possess a good accuracy value can be used for the next analysis stage; namely, the conversion to surface roughness values. The relationship between the land cover class and the coefficient of the surface roughness is shown in Table 8.

Table 8. The Relationship Between Land Cover Class and the Coefficient of Surface Roughness (Qossam, Nugraha, & Sabri, 2020).

Land Cover Classification	Coefficient of Surface Roughness
Forest	0.07
Plantation	0.035
Field	0.015
Rice field	0.025
Bush	0.04
River	0.007
Empty land	0.015
Residential buildings	0.045

The slope information is extracted from the DEM image of Alos Palsar using the slope analysis method. DEM ALOS PALSAR has a medium-level spatial resolution of 25 meters, so it is fairly accurate in representing the condition of the coastal slopes of the Purworejo Regency. The slope gradient raster is expressed in degrees radians.

Furthermore, the cost distance analysis is carried out to measure the linear distance line from each cell to the nearest specified source (Qossam, Nugraha, & Sabri, 2020). The closest source in question is the coastline, while the measured cells are the pixels of the tsunami inundation reduction (Hloss) raster. The result of the cost distance analysis is a tsunami hazard raster, which is then classified into five levels using a fuzzy membership classifier; namely, very low, low, moderately high, high, and very high tsunami hazards.

2.3. Tsunami Risk Analysis

Disaster risk is the potential loss due to disasters occurring in an area at a certain time. These losses can relate to life, property, mental factors, and the disruption of community activities (BNPB, 2007). Based on this understanding, risk can be defined as a manifestation of hazard (H) that interacts with vulnerability (V). This is based on the concept of the Disaster Crunch Model (Qossam, Nugraha, & Sabri, 2020) (Equation 5). The tsunami hazard raster is classified into five levels; namely, very low, low, moderately high, high, and very high.

$$\mathbf{R = H \times V} \qquad (5)$$

2.4. Tsunami Evacuation Route Planning

The planning of a tsunami evacuation route is carried out using the network analysis method combined with the closest facility analysis technique. The concept of the analysis is to determine the closest facility and the best path to it. The starting points when planning tsunami evacuation routes are hazard points located in areas with high and very high tsunami hazard levels and at elevations of less than three meters. Meanwhile, the destination points are the planned tsunami evacuation points located in areas with low and very low tsunami hazard levels.

3. Results and Discussion

3.1. Tsunami Vulnerability Level

The level of tsunami vulnerability in the coastal area of Purworejo Regency is influenced by the conditions of the five determining parameters; namely, the evacuation speed, elevation, distance from the coastline population density, and settlement density. The tsunami vulnerability parameters are divided into two parts: namely, positive and negative vulnerability parameters. Negative vulnerability parameters are parameters whose value increases are followed by an increase in the level of tsunami vulnerability, including the population density and settlement density. Meanwhile, the positive vulnerability parameters are parameters whose value increases are followed by a decrease in the level of tsunami vulnerability, including the evacuation speed, elevation, and distance from the coastline.

The speed of tsunami evacuation in the coastal area of Purworejo Regency is around 216-262 people/kilometers: for Grabag Sub-district, it is 261 people/kilometers, for Ngombol Sub-district 217 people/kilometers, and for Purwodadi Sub-district 216 people/kilometers. The evacuation speed in these three Sub-Districts is categorized as very fast. The evacuation speed represents the ability of the existing road infrastructure to accommodate people during the tsunami evacuation process (Santius, 2015). An adequate road infrastructure capacity and a fast evacuation process will reduce the level of tsunami vulnerability.

The elevation in the coastal area of Purworejo Regency ranges from 0-13 meters and is included in the low to very low category. The difference in the elevation in the coastal area of Purworejo Regency is not very significant and the relief is relatively flat. Areas with low elevations will have a high level of tsunami vulnerability and suffer great damage.

The distance of an area from the coastline greatly affects its exposure to tsunami inundation. Areas that are situated closest to the coastline have a greater potential for high tsunami inundation. The height of the inundation will decrease as it moves away from the coastline because the inundation will be blocked by the slope and roughness of the surface through which it passes (Widodo, *et al*., 2017). The coastal area of Purworejo Regency which is included in the very close category (500 meters from the coastline) is 10.69 square kilometers, the close category (1000 meters from the coastline) is 11.70 square kilometers, the category is somewhat far (1500 meters from the coastline) is 11.86 square kilometers, the far category (2000 meters from the coastline) is 12.03 square kilometers, and the very far category (>2000 meters from the coastline) is 136.16 square kilometers. The area of the very close and close categories to the coastline in Grabag Sub-district is 9.97 square kilometers; in Ngombol Sub-district, it is 7.83 square kilometers; and in Purwodadi Sub-district, it is 4.59 square kilometers. This means that the residents of Grabag Sub-district must be more alert when a potential tsunami seems imminent because this sub-district has the largest area with characteristics that are very close and close to the coastline.

Vulnerability analysis will always relate to the population who is potentially exposed to the tsunami and their ability to deal with adverse conditions (Jelinek, *et al*., 2012). This study assumes that dense population conditions will increase the potential for fatalities. The condition of a densely populated area will narrow the space for people to evacuate so that the ability of the population to evacuate will be relatively slow. The population density value of Grabag Sub-district is 753 people/square kilometer, that of Ngombol Sub-district 629 people/square kilometer, and that of Purwodadi Sub-district 762 people/square kilometer. Overall, the population density values in the three sub-districts are in the rare category, so they tend to be safe from high vulnerability to tsunamis.

In addition to population density, another type of density that affects tsunami vulnerability is the density of the settlements. Buildings are one of the assets that may be exposed to tsunami inundation (Strunz *et al*., 2011). The threat of vulnerability will be higher if the buildings exposed to inundation are residential buildings occupied by the population. A large percentage of settlement density will increase the level of tsunami vulnerability (Santius, 2015). The value of settlement density in Grabag Sub-district is 5%, that in Ngombol Sub-district 62%, and that in Purwodadi Sub-district 9%. The population density values of Grabag and Purwodadi Sub-districts are in the rare category, while that of Ngombol Sub-district is in the dense category so that the population of Purwodadi Sub-District is more threatened with the greatest building damage when a potential tsunami occurs compared to the other sub-districts.

Figure 2 shows a map of the level of tsunami vulnerability in the coastal area of Purworejo Regency, which is weighted against the parameters of tsunami vulnerability. The area with a very high level of tsunami vulnerability is around 14.60 square kilometers, that with a high level of tsunami vulnerability is about 19.62 square kilometers, that with a rather high level of tsunami vulnerability is about 12.02 square kilometers, that with a low level of tsunami vulnerability is about 45.35 square kilometers, and that with a level of very low tsunami vulnerability is around 90.69 square kilometers. The sub-district which has the highest and very high tsunami vulnerability is the Grabag Sub-district, covering an area of approximately 14.79 square kilometers.

3.2. Tsunami Hazard Level

The provisional results for modeling tsunami inundation reduction are the land cover classification results (Figure 3) and the total accuracy value from the land cover classification results. Six land cover classes have been identified, including residential buildings, forests, gardens, open land, rice fields, and rivers. While the total accuracy of the land cover classification in the coastal area of Purworejo Regency is 79%, this accuracy value is still below the minimum acceptable limit, which is 85% (Danoedoro *et al*., 2017). The main factor causing this is the limited vision and experience of the interpreter in recognizing land cover objects during the training area process. The surface roughness raster value resulting from the conversion of land cover classification raster ranges from 0.007 to 0.07. A high surface roughness coefficient value indicates a rough surface. Rough surfaces can reduce tsunami inundation heights.

The next provisional result is information on the degree of slope. The degree of slope in the coastal area of Purworejo Regency ranges from 0-0.3871º. This value indicates that the slope conditions in the area are relatively flat. This is supported by low elevation conditions. The value of a high degree of the slope will increase the potential for reducing the height of the tsunami inundation.

The integration of scenarios of surface roughness, slope, and run-up of three meters resulting in a tsunami hazard level map for the coastal area of Purworejo Regency (Figure 4). The area that is included in the very high hazard category is the widest area of 65 square kilometers and the majority is in Grabag Sub-district. If the land cover information, slope, tsunami inundation reduction, and coastline buffer are integrated, it is known that the dominant land cover classes located at a distance of 0-2000 meters from the coastline are forest (mangrove forest), empty land (stretched sandy beach), and residential building. The three types of land cover are located on a low slope and the inundation in the area is classified as very high vulnerability. Areas located at a distance of >2000 meters from the coastline have a dominant type of land cover; namely, plantations with a higher degree of slope. In this area, the tsunami hazard level decreased to the high hazard category. Based on the modeling results, it is known that slope and land cover as a representation of land cover are very influential in terms of reducing the level of tsunami hazard in an area.

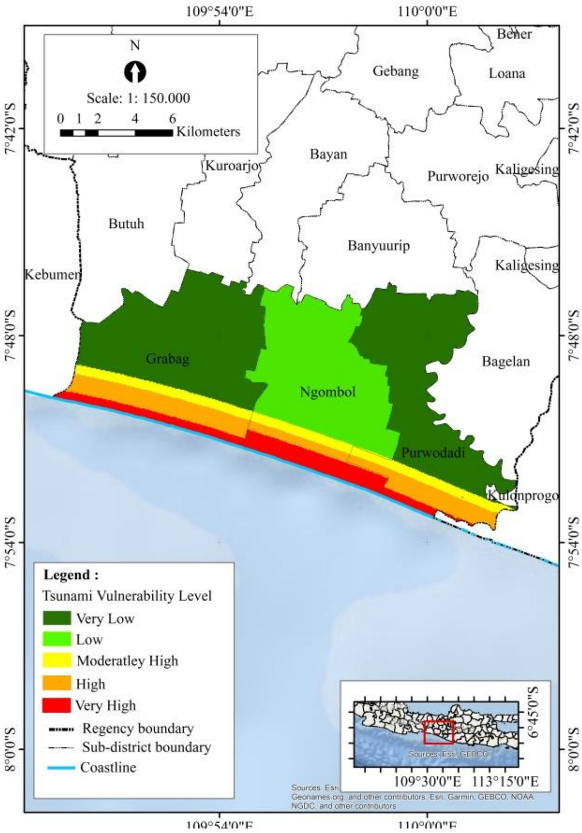

Figure 2. Map of the Tsunami Vulnerability Level of the Coastal Area of Purworejo Regency.

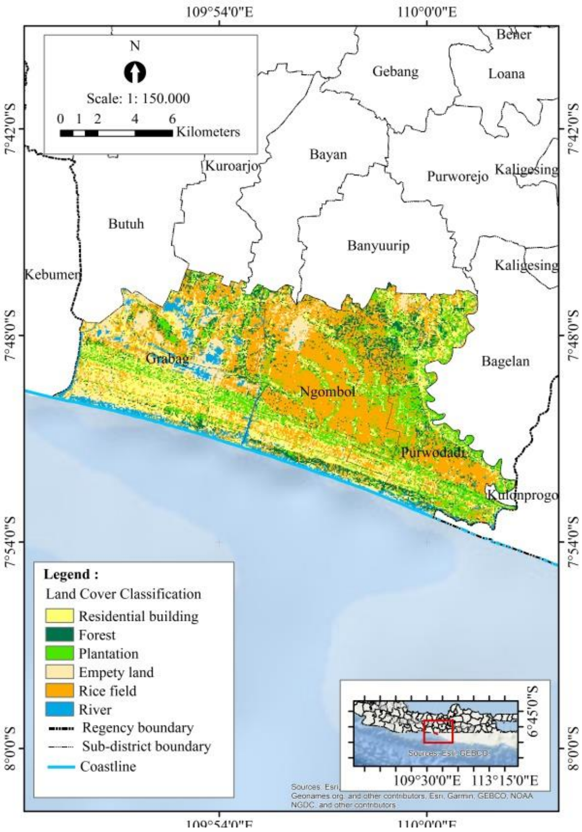

Figure 3. Map of Land Cover Classification of the Coastal Area of Purworejo Regency.

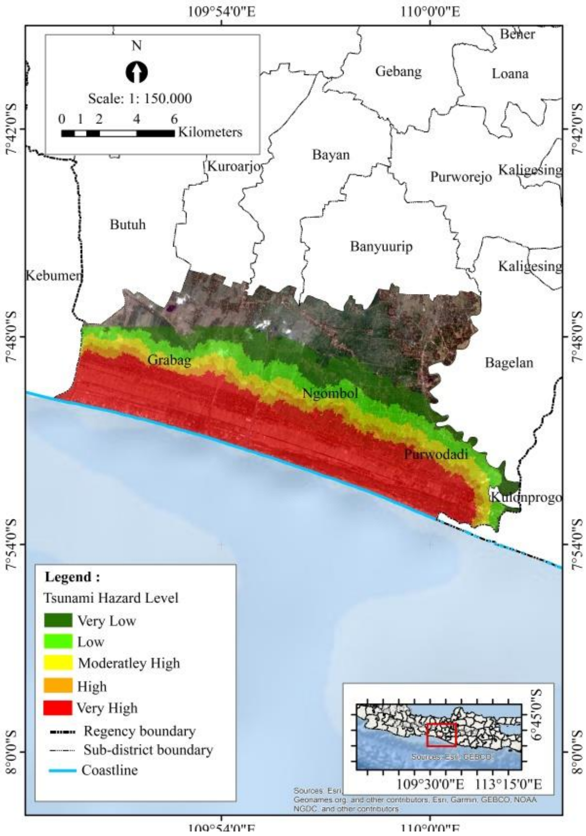

Figure 4. Map of Tsunami Hazard Level of the Coastal Area of Purworejo Regency.

3.3. Tsunami Risk Level

The tsunami hazard and vulnerability analysis made it possible to produce a tsunami risk level map (Figure 5). The coastal area of Purworejo Regency which is at risk of loss if a potential tsunami occurs is 126.29 square kilometers of the coastal area of Purworejo Regency. The area with a very high tsunami risk category is around 32.80 square kilometers, that with a high tsunami risk category around 32.09 square kilometers, that with a rather high tsunami risk category around 13.17 square kilometers, that with a low tsunami risk category around 20.65 square kilometers, and that with a very low tsunami risk category around 27.56 square kilometers.

Very high- and high-risk areas should be a priority area to be avoided. The areas with very high-risk areas in the Grabag Sub-district cover an area of 14.7 square kilometers, in the Ngombol Sub-district they cover an area of 10.54 square kilometers, and in the Purwodadi Sub-district they cover an area of 7.55 square kilometers. Meanwhile, the high-risk areas in the Grabag Sub-district cover an area of 13.96 square kilometers, in the Ngobol Sub-district cover an area of 11.44 square kilometers, and in the Purwodadi Sub-district cover an area of 6.69 square kilometers.

The Grabag sub-district has the widest category of very high and high tsunami risk areas, meaning that this sub-district has the potential to experience the greatest loss compared to the other sub-districts. This loss includes casualties, damage to residential buildings and infrastructure, and the paralysis of community activities. Overall, areas with a very high and high level of tsunami risk are spread over three sub-districts in the coastal area of Purworejo Regency, so that people living in these areas must be prioritized in the tsunami evacuation process in the future (Sambah, A. B., Miura, F., Guntur, 2018).

3.4. Tsunami Evacuation Route Planning

Planning a tsunami evacuation route involves establishing an effective route that allows access to a safe place should a tsunami disaster occur. There are five tsunami evacuation points planned in this study, the distribution of which is outside the area exposed to the tsunami inundation. Therefore, the determination of the location points for the planned evacuation site must be superimposed on the tsunami hazard level raster. In addition, it must be in a location that can be reached from various directions.

The starting point is that the hazard point must be determined to be in an area that has a very high level of tsunami disaster hazard and that the land height is below three meters. Figure 6 shows the result of the network analysis using the closest facility analysis technique to plan tsunami evacuation routes in the coastal area of Purworejo Regency. The total existing road network covers 1,221 roads, consisting of arterial roads, local roads, other roads, and footpaths. The number of road networks that are planned to serve as tsunami evacuation routes is 985 roads, with five roads being the main routes for tsunami evacuation. These five roads are perpendicular to the coastline of Purworejo Regency and lead directly to the planned evacuation sites.

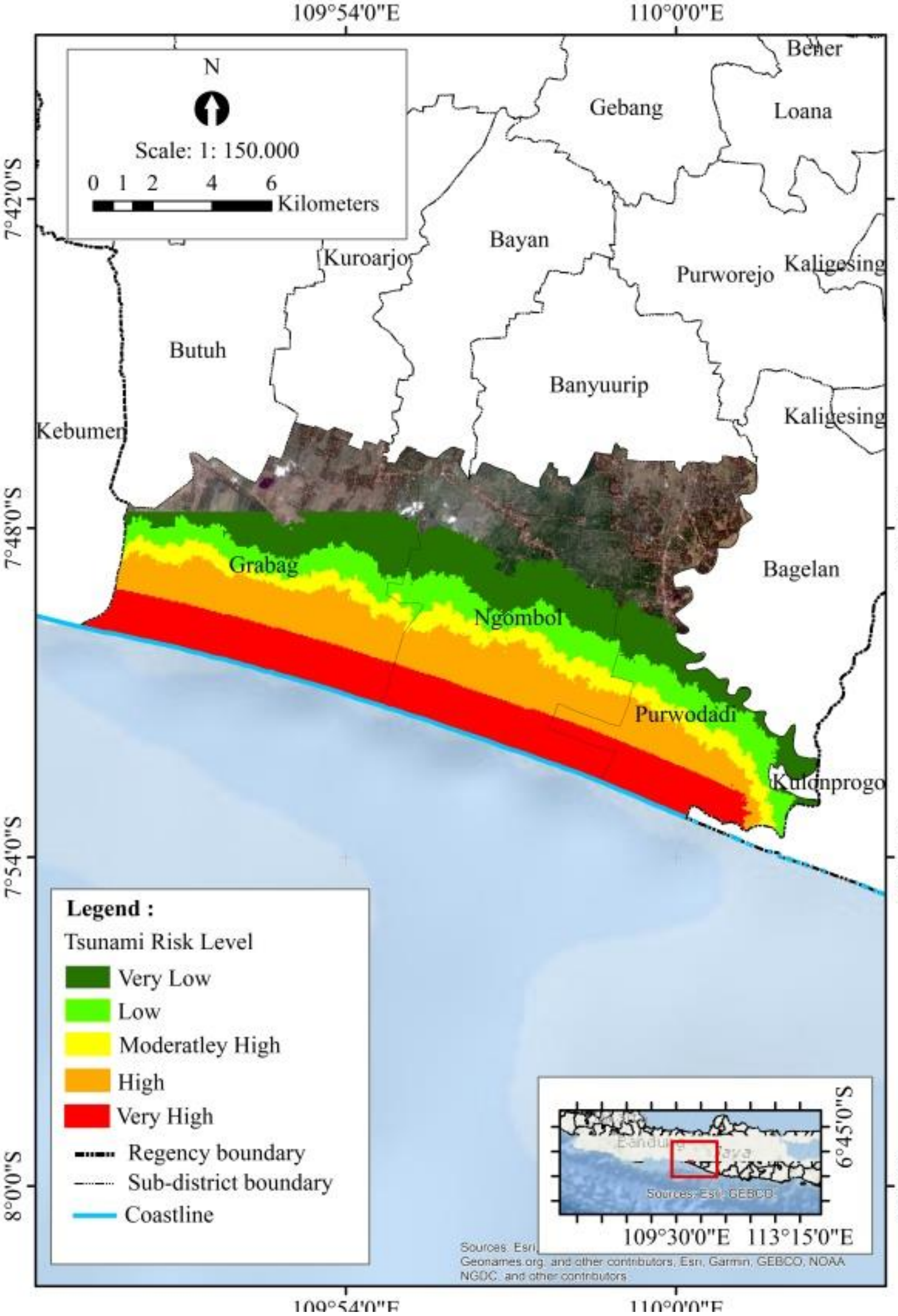

Figure 5. Map of Tsunami Risk Level of the Coastal Area of Purworejo Regency.

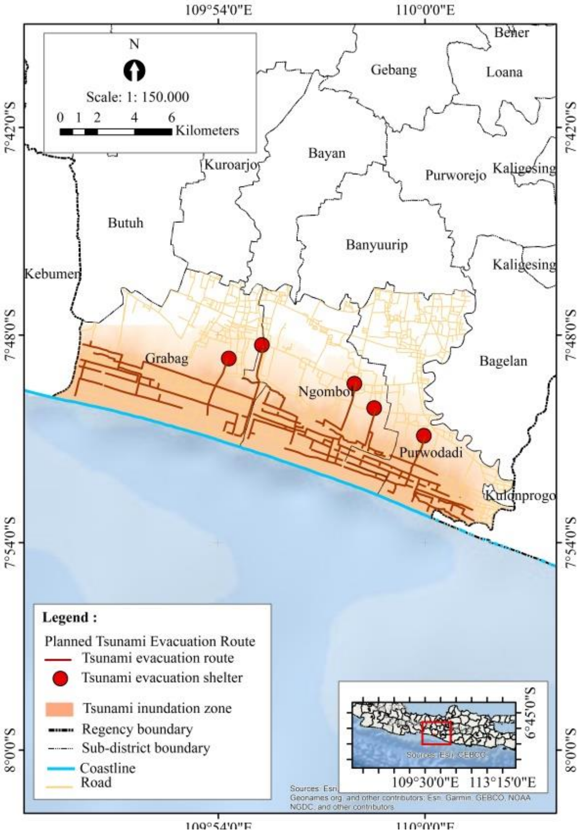

Figure 6. Map of Tsunami Evacuation Route Planning for the Coastal Area of Purworejo Regency.

The results of planning the tsunami evacuation route carried out in this study still have many limitations. This is because a lot of related data can only be gathered a direct check is made of each road network in the field. The following requirements must be met to plan a comprehensive tsunami evacuation route, including 1) The standard road width is six meters, but for conditions requiring it, a smaller capacity of four meters is allowed; 2) The maximum evacuation distance is 1 kilometer; 3) The evacuation capacity in the area of the evacuation route should be appropriate; 4) To reduce capacity, there should be a dividing line between the vehicle and pedestrian lanes; 5) Evacuation routes should not pass through other evacuation areas; 6) Evacuation routes for pedestrians should be as straight as possible with a minimal number of turns; 7) The evacuation route should not be busy and avoid congestion points; and 8) signs are required to indicate the direction to the evacuation site along each evacuation route (Mobarok, 2018).

4. Conclusion

The tsunami risk area with a run-up scenario of three meters in the coastal area of Purworejo Regency is 126.29 square kilometers or about 72.52% of the total coastal area of Purworejo Regency, which is 174.15 square kilometers. The Grabag Sub-district is a sub-district with very high and the widest tsunami risk categories, meaning that this sub-district has the potential to experience the greatest losses compared to the other sub-districts. These losses include casualties, damage to residential buildings and infrastructure, and the paralysis of community activities. Overall, the areas with a very high and high level of tsunami risk are spread over three sub-districts in the coastal area of Purworejo Regency, so the people living in these areas must be prioritized in the tsunami evacuation process in the future. The planning tsunami evacuation points are five points, with five main tsunami evacuation routes leading directly to each of these points. The location of the five main tsunami evacuation routes is perpendicular to the coastline of Purworejo Regency.

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