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Mapping Vulnerability Level Tsunami Coastal Parangtritis Subdistrict, Kretek, Bantul, Yogyakarta

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Abstract: Tsunamis often hit the Southern coast of Java, where Parangtritis is located in the area, this is due to the meeting of the Indo-Australian plate with the Eurasian plate in Southern Java which produced a tectonic earthquake as the main source of the tsunami. Tsunami waves from this area take 50-100 min to reach the coast. Considering the short period for the process of self-preservation, this study is necessary to draw up a map of the vulnerability of the region to the tsunami evacuation route to design and place a Temporary Evacuation (TES) tsunami in the coastal village of Parangtritis. The material used as the object of study in this study is tsunami hazard, tsunami runoff based on run-up height, proposed evacuation routes and Tsunami Evacuation Sites (TES). the results are that Parangtritis is included in tsunami-prone areas with a percentage of the tsunami-prone area of 66.45%. At the time of the tsunami run-up as high as 16 m, the total area of the runoff was 788.07 ha. There are three proposed evacuation routes via. Parangtritis, Depok and Depok-Parangtritis roads. There are 12 proposed temporary evacuation sites scattered in Parangtritis village.

INTRODUCTION

Tsunamis are large ocean waves, usually due to the sudden movement of oceanic plates causing vertical dislocations, i.e., decreases or shifts, so that, the water mass above will move in response to plate changes[1]. Tsunamis can be interpreted as an ocean wave with a long period caused by disorders such impulse if tectonic earthquakes, volcanic eruptions or avalanches on the seabed[2-4]. Tsunami events often hit the South Coast of Java where Parangtritis is located in the area, this is due to the meeting between the Indo-Australian Plate with the Eurasian Plate in South Java which has high earthquake activity. The plate meeting results in a subduction zone which is the main source of Earthquakes that cause tsunamis that can hit Parangtritis. It is estimated that the tsunami waves that occur from this area takes 50-100 min to reach the beach. The important thing is that the tsunami is not seen in the form of a single wave but a series of waves[5]. The impact of the tsunami on the coast was very large and rapid. In shallow waters, the amplitude of tsunami waves grows to the extent that undulation usually occurs in long waves which develop into progressives. Studies relating to tsunamis or other coastal disasters can depend on a combination of hydrological modeling and Geographic Information Systems (GIS). GIS can be used to make a vulnerability simulation of various natural hazards[6-8].

Parangtritis is a coastal tourist destinations most visited tourist in Yogyakarta, thereby revitalize the economy in the area. Parangtritis dealing directly with the subduction zone in the South of Java, at high risk of earthquake and tsunami hazard areas where N has been experiencing in the past tsunami events in 1840 and 1859. Because of the proximity to subduction zones and the history of earthquakes, scientists can predict tsunamis occur again in the future with an interval of recurrence of between 30-50 years or even 200-300 years that can affect Parangtritis, although, precise predictions are not yet possible. Preparatory steps are key to reducing tsunami hazards and the development of local preparedness strategies is essential. This requires a good understanding of the hazard. Tsunami vulnerability maps provide important references for the development of preparedness strategies.

The one of the real disaster threats in Indonesia is geological hazards in the form of Earthquake and tsunami. Geographically, the territory of the Indonesian archipelago is located in the four-plate boundary zone, namely: the Eurasian Plate, the Indo-Australian Plate, the Pacific Plate and the Philippine Plate. In addition, to the deformation of plate boundaries, the tectonic movement of earth plates causes the formation of many active faults both in land area and on the seabed, these plate boundaries and active faults are the source of tectonic earthquakes[9]. A tsunami hazard map is needed as a basic reference and the most important planning tool for developing evacuation strategies. The role of vulnerability is also required for land use planning and development of medium-term measures to mitigate the possible impact of a tsunami[9]. The effective route recommendation is made with network analyst based on the evaluation of existing evacuation assembly points and then determined new evacuation points[10].

Simple summary: Studies relating to tsunamis or other coastal disasters can depend on a combination of hydrological modeling and Geographic Information Systems (GIS). This study is necessary to draw up a map of the vulnerability of the region to the tsunami evacuation route to design and place a Temporary Evacuation (TES) tsunami in the coastal village of Parangtritis. The map of tsunami hazard level consisting of five classes, namely very vulnerable class, vulnerable class, somewhat vulnerable class, safe class and very safe class can be considered for tsunami disaster mitigation activities in Parangtritis village. Tsunami waves reach the most heavily affected densely populated coastal areas and are considered tsunami prone zones.

MATERIALS AND METHODS

Research material: The research material used is primary and secondary data. Primary data in the form of main or principal data that is used as input of a model or calculation while secondary data is additional data that is used as a support of the research, namely as verification material. Primary data in this study are: IKONOS Satellite imagery Parangtritis village area, ASTER data GDEM Bantul, Desa Parangtritis. In addition, bathymetry and topographic data of southern Java waters from GEBCO, Bantul Regency earth map, Parangtritis village scale 1: 25,000 Bakosurtanal publications in 2001, Earthquake position data in the Indian Ocean on July 17, 2006 sourced from the US Geological Survey (USGS) and Parangtritis sand dune sediments.

This research was conducted on 17-20 December, 2013. The research area was in Parangtritis village, Kretek District, Bantul Regency, D I Yogyakarta. Geographically the area is located at coordinates 7°59’15 “- 8°1’58” South Latitude and 110°16’52” -110°20’ 37” East Longitude (Fig. 1). The research material used is primary and secondary data. Primary data in the form of main or principal data that is used as input of a model or calculation, while secondary data is additional data that is used as a support of the research, namely as verification material. Primary data in this study are: IKONOS Satellite imagery Parangtritis Village area, ASTER data GDEM Bantul, Desa Parangtritis. In addition, bathymetry and topographic data of Southern Java waters from GEBCO, Bantul Regency earth map, Parangtritis village scale 1: 25,000 Bakosurtanal publications in 2001, Earthquake position data in the Indian Ocean on July 17, 2006 sourced from the US Geological Survey (USGS) and Parangtritis sand dune sediments.

Data analysis: Descriptive analysis in this study is that the ASTER GDEM data is carried out spatial analysis with extraction to obtain information about the height of the study area, followed by analyzing the slope of the study area to obtain location information with steep slopes that can withstand tsunami waves with the help of slope in the spatial analysis tools. DEM is an important and significant topographic product that can be applied in various fields one of them is assessing tsunami hazard[8, 11].

IKONOS satellite imagery was analyzed to obtain land cover information at the study site. Recently analyzed within the study area of the beach, the river to obtain information about a dangerous area affected by the tsunami where the tsunami in through the beach and the

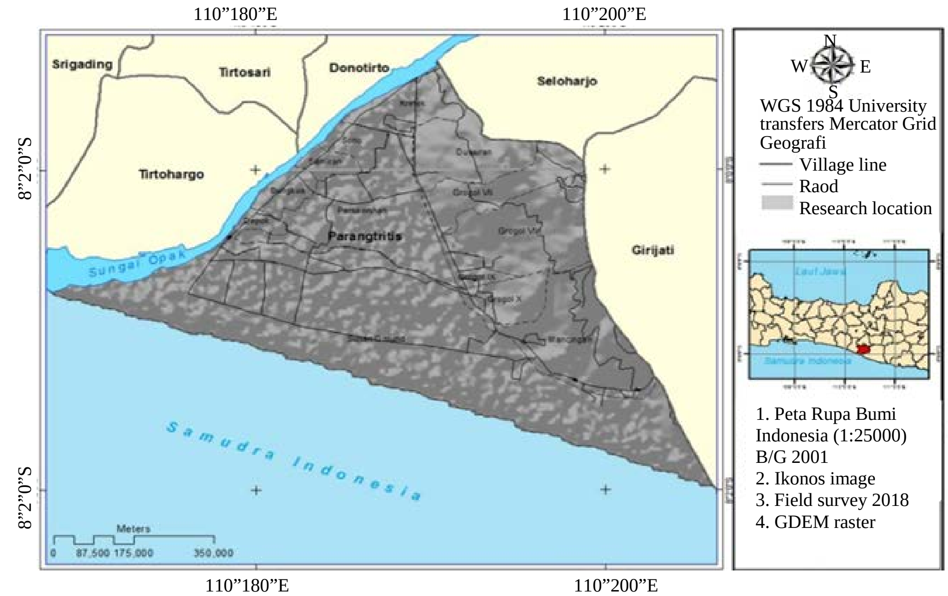

Fig. 1: Research location map

river and the distance from the center of the tsunami in the analysis to obtain the distance information coast to the epicenter to decided how far away and can be analyzed tsunami wave arrival time to the coast. After a descriptive analysis of the factors that influence the tsunami, the thematic map produced in the form of a map of the height of the study area, slope map of the study area, distance map from the river, distance map from the coastline. All thematic maps are overlayed to produce new information in the form of tsunami hazard maps with the help of a spatial calculator in ArcGIS software.

Quantitative analysis method was used to analyze the data presented in the form of numbers that are systematically using a scoring system. The scoring system is a system whose function is to analyze some very influential factor in determining the potential and constraints in an analysis region. Before overlay, the factors that influence vulnerability to tsunamis in the classification. Where each class is given a score, classes that have a high influence on tsunamis are given a large score and classes less affected by the tsunami are given a small score.

Hazards from tsunamis are assessed quantitatively and characteristics such as (run-up height, tsunami magnitude, wave height, damage observed from historical tsunamis, coastlines) are considered to produce tsunami hazard maps and potential future tsunami inundation. Tsunami hazard analysis includes both the tsunami occurrence and its frequency[12].

Sampling analysis methods: Determination of sample points for field testing needs to pay attention to the system or way of carrying out field tests so that each class can be represented. In ground check is used stratified random sampling is sampling based on the class of the results of the interpretation of satellite imagery, each class were randomly sampled. This ground check is used as a test of accuracy of the interpretation of satellite imagery. With the stratified random sampling method, the accuracy test is carried out by: field checking of selected sample points from each class. Each class was taken several samples of the homogeneity of their appearance and tested the truth in the field. Checking elevation, slope, distance from the river and the distance from the beach is done by randomly choosing a location and in doing manual measurements with water pass, measuring sticks, roll-meter and GPS. Assess the compatibility of the results of the interpretation of satellite imagery with the actual conditions on the ground. The results of field checking at several points of the next research location are matched with the results of spatial processing where the location checked is the same as the results of spatial analysis.

Data processing in this research was carried out with the help of computers and ArcGIS 10.0 Software. Data processing (IKONOS imagery, ASTER GDEM and Indonesian landscape maps) to compile tsunami prone areas consists of several stages. Damage to buildings and seawater areas can be evaluated using IKONOS data processing and object-based change detection, this aims to get an initial idea of the damage caused by the tsunami[13].

Broadly speaking, the steps used in this study include the following stages: Extraction of spatial data from satellite imagery, maps of the Earth, DEM and other supporting data. Distance from Earthquake sources in the Indian Ocean on July, 17, 2006 obtained from the US Geological Survey (USGS) were processed with the help of Global Mapper 10.0 Software and ArcGIS 10.0 for obtain information such as the distance from the epicenter, the distance from the shoreline, the distance from the river, the height and slope. Runoff tsunami with a scenario of high run-up of tsunami waves, process modeling of spatial runoff tsunami preceded by entering a value run-up of tsunami waves in the DEM (Digital Elevation Model) with software ArcGIS 10.0, height values are under high run-up is runoff region. Runoff produced in the raster format is stored in vector form to calculate the estimated area of the pool formed. The process of calculating the area of land lost and modeling runoff are carried out at each step interval of the model (Run-up of 8 and 16 m) which refers to the Sokolive classification.

Determination of tsunami prone areas, In determining areas of tsunami hazard, carried out by using the overlay method and data modeling. The overlay method is carried out by combining graphical data of parameters that affect tsunamis to produce tsunami-prone areas. Data modeling is carried out with the aim of planning procedures and analysis. Determination of evacuation routes and temporary evacuation sites, proposed evacuation routes and temporary evacuation sites are determined based on criteria established by BNPB in 2012 regarding the terms of the tsunami evacuation path and temporary conditions.

RESULTS AND DISCUSSION

Tsunami hazard parameters: Low-altitude region will be more prone to tsunamis than the high-lying areas. Almost along the coast in the village of Parangtritis has a low altitude that is prone to tsunamis. In Fig. 2, shows the distance classification from the coastline, where tsunami waves enter through the coast and based on the results of this classification it can be seen the range of tsunamis for each height of tsunami run-up. The farther an area by the tsunami sources will cause the region to have a level of vulnerability that is getting smaller and tsunami travel time creeping towards it longer to the area parangtritis have 366.23 km distance from Pangandaran tsunami source July 17, 2006. For Parangtritis area, there is only one class of coast distance from the source of the Earthquake. This is due to the position of the research location close to the plate meeting.

Conditions morphology of the seabed in the area Parangtritis steep with the basic conditions of a steep, bumpy and hilly affect the propagation of tsunami waves while in the coastal areas in Desa Parangtritis has a slope of <2% or flat and between 3-6% or landau and slope steep> 20% located in the Eastern village of Parangtritis. The existence of the Opak river in Parangtritis village resulted in an area with a distance of <250 m into an area that was threatened by tsunami runoff. Based on the analysis and modeling of GIS, a tsunami hazard map was obtained in Parangtritis Village consisting of five classes. The area and percentage of area in the level of tsunami hazard can be seen in Table 1. For more details, it can be seen on the map of tsunami disaster vulnerability in

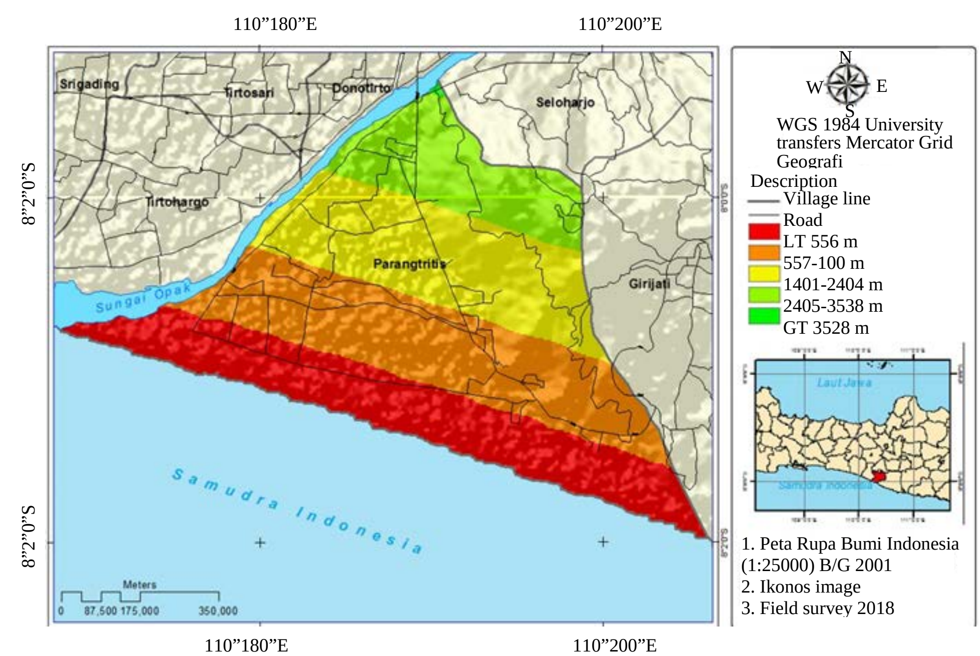

Fig. 2: Distance map from the coastline of Parangtritis village, Kretek, Bantul, DI Yogyakarta

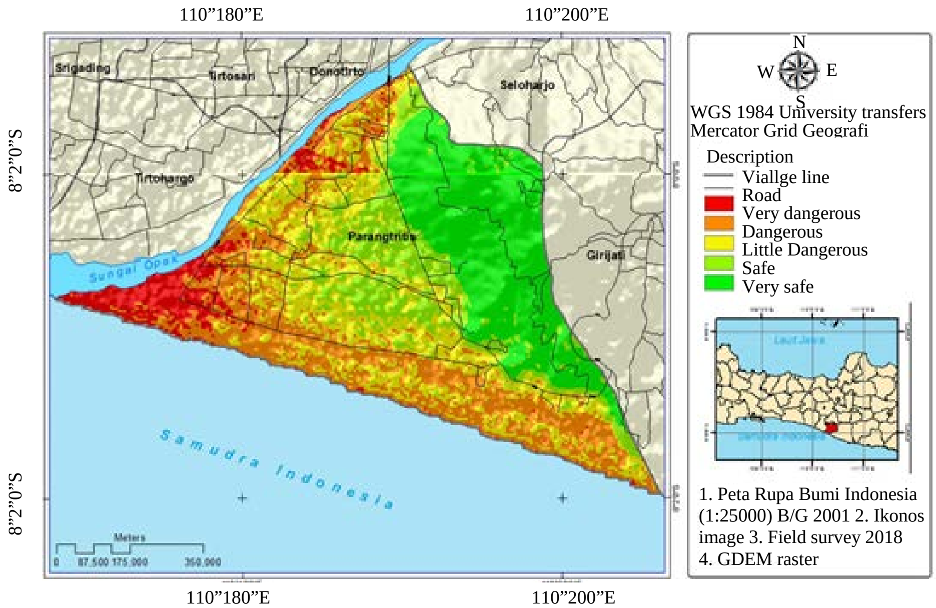

Fig. 3: Tsunami Hazard of Parangtritis village, Kretek, Bantul, D.I. Yogyakarta

Table 1: Area in Tsunami hazard in Parangtritis village

Class classification	Area (ha)	Percentage area
Very vulnerable	139.96	10.09
Vulnerable	380.14	27.39
Rather vulnerable	401.93	28.97
Safe	198.18	14.27
Very safe	267.65	19.28

Table 2: Run-up Tsunami Runoff area of 8 and 16 m in Parangtritis village

	Run-up 8 m (ha)		Run-up 16 m (ha)	
Land use	Run over	Flooded	Run over	Flooded
Moor	14.24	379.13	105.34	288.03
Bush	0	87.28	22.83	6.45
Grass	0	124.35	107.36	16,99
Sand beach	110.03	180.04	289.25	0.82
Rain filled rice dield	0	14.76	11.27	3.49
Settlement	0.35	264.11	72.87	191.59
Irrigated fields	4.39	178.45	179.15	3.69

Fig. 3. Tsunami waves reach the most heavily affected densely populated coastal areas and are considered tsunami prone zones[14]. Based on morphological conditions, Hamlets in coastal areas that have high levels of tsunami hazard are Hamlet Depok, Hamlet Bungkus, Hamlet Mancingan and Hamlet Grogol X. Areas categorized by tsunami prone areas are Mancingan Hamlet, Grogol Hamlet X, Grogol IX Hamlet and Grogol Hamlet X. For hamlets which are categorized rather tsunami-prone are Hamlet Bungkus, Hamlet Samiran, Hamlet Soso, Hamlet Kretek, Hamlet Grogol X, Hamlet Grogol IX, Hamlet Grogol VIII. For safe class categories, there are Grogol IX Hamlet, Grogol VIII Hamlet, Grogol VII Hamlet. For very safe classes, there are in Some Kretek Hamlet, Duwuran Hamlet, Grogol VII Hamlet and some Grogol VIII Hamlet.

Tsunami run-off analysis: Tsunami waves caused by seabed Earthquakes will spread in all directions. Due to differences in water depth, there will be a change in the direction and height of the tsunami waves. Topography is an important factor in showing runoff based on tsunami wave run-up. Below 2 tsunami wave run-up scenarios are used, namely 8 and 16 m run-up. Land use is an important factor to consider in tsunami runoff analysis. This is due to classes of land use that are very important and very vulnerable if a tsunami suffers which can result in flooding of the area. For more details about tsunami runoff with a 1 m tsunami wave run-up on land topology and land use can be seen in Fig. 4 (run-up 8 m) and Fig. 5 (run-up 16 m). The extent of tsunami runoff can be seen in Table 2.

The best location for placement of tsunami height observation points is at a depth of 10 m. A good observation location is at a distance of 500-3000 m from the coastline[15, 16].

Evacuation and Temporary Evacuation Route (TER) Tsunami: Evacuation routes are important to be arranged to avoid the loss of mass death during the tsunami. Evacuation points are considered from vulnerability analysis. The lowest vulnerable area can be determined as a potential evacuation point. criteria in determining evacuation routes[17]:

- The fastest route to the evacuation point
- Evacuation routes must be distributed and socialized equally to avoid crowds of residents during an emergency

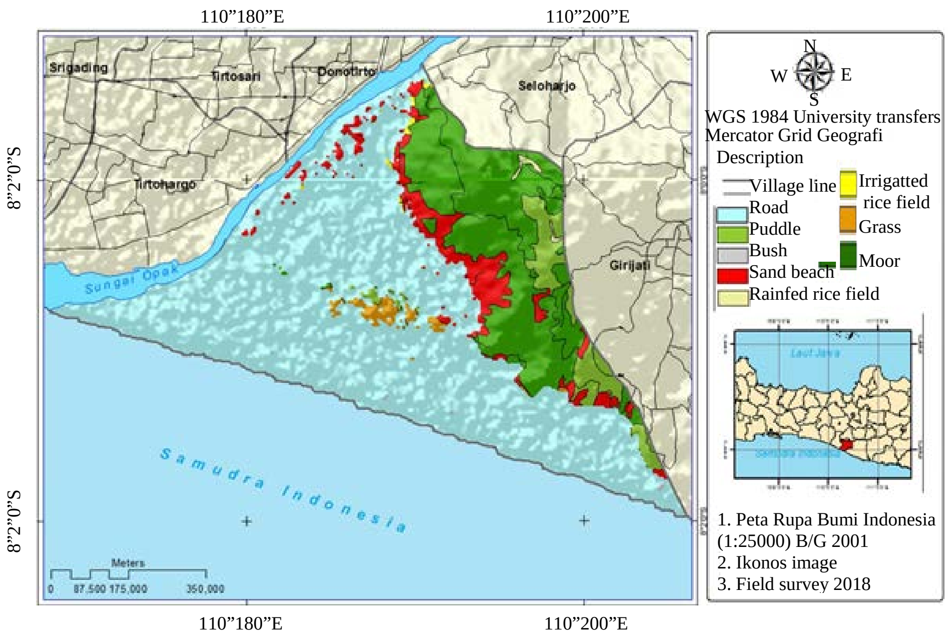

Fig. 4: Run-up Tsunami runoff map 8 m of Parangtritis village, Kretek, Bantul, DI Yogyakarta

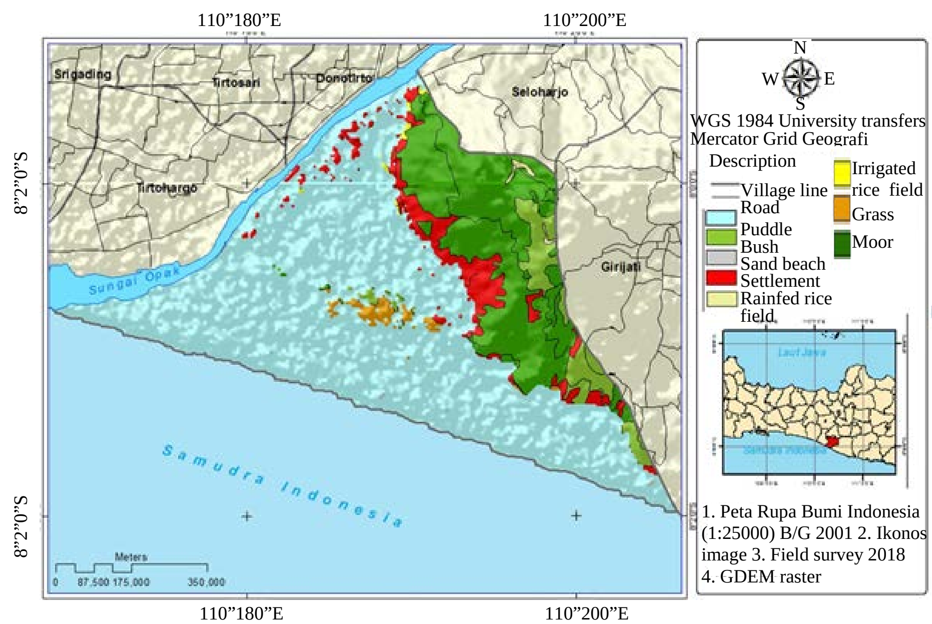

Fig. 5: Run-up Tsunami run-off Map 16 m of Parangtritis village, Kretek, Bantul, DI Yogyakarta

The main route for evacuation of Parangtritis billage is Jalan Parangtritis, Jalan Parangtris-Depok and Jalan Depok. In some locations there is also control of traffic flow to the coast and bridges during tsunami emergencies. This evacuation route is based on the tsunami hazard map of Parangtritis village and is equipped with an evacuation sign for the safe zone or TER tsunami. The proposed tsunami follows the rules set by BNPB[9]. So, that selected 12 TER tsunamis suitable for evacuation during emergencies. The proposed TER has two types, namely, the horizontal TER in the safe zone located in the hills of Parangtritis village and the vertical TER in the tsunami-prone zone in the form of a large floor building (Fig. 6).

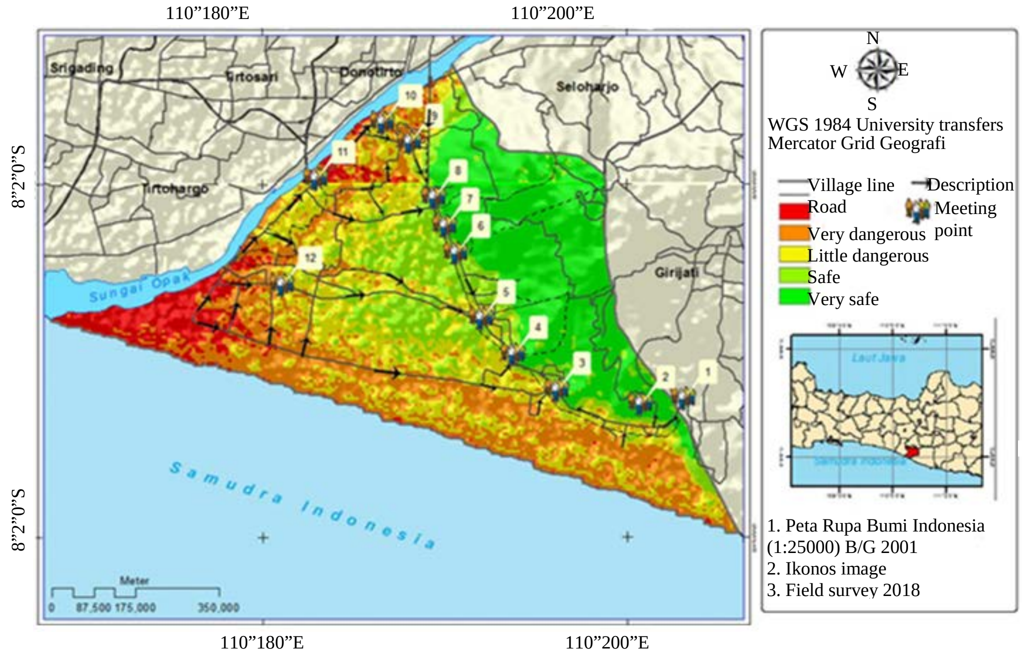

Fig. 6: Path map and evacuation Sute of Parangtritis village, Kretek, Bantul, DI Yogyakarta

Table 3: Proposed location of Temporary Evacuation Route (TER) Tsunami in Parangtritis village

Location	Priority
Desa Girijati	1
Bulak Mabul	1
Makam Syeakh Maulana Magribi	1
Makam Syeakh Bela Belu	1
Masjid Maulana Magribi	2
Klinik Rusi Husada	2
Kelurahan Parangtritis	1
Masjid Al A'laa	1
SMP 2 Kretek	3
Masjid Al Ma’un	3
Masjid Al Mukhlisin	3
Laboratorium Geospasial Parangtritis	3

Based on tsunami vulnerability maps, maps of runoff scenario tsunami ru-nup Parangtritis village and TER requirement, the proposed tsunami TER can be prioritized to be used as the main reference of citizens in the escape.

The requirements of the BNPB[9] regarding the TER tsunami are that buildings that are proposed to be Earthquake resistant have a sufficient number of safe floors and in normal conditions (no tsunami disaster) the building can function as a public building, so that, it meets the sustainability aspect. For more details regarding the TER tsunami and location can be seen in Table 3.

These places are scattered in all hamlets in Parangtritis village so that people can quickly arrive at the tsunami TES before the tsunami reaches the land. Evacuation sites are arranged, spreading close to vulnerable areas easily accessible to people during a tsunami attack[17]. The location that is easily accessible, tall buildings, spacious and close to the location of the activities of the citizens of Parangtritis village is a safe place for rescue when the tsunami comes quickly, so that, losses from the tsunami can be minimized. Self-rescue measures will be more effective if the community understands tsunami hazards, so, training, education, public awareness of tsunami hazards and simulation of evacuation actions should occur.

CONCLUSION

Based on the results of the study, it can be concluded that the map of tsunami hazard level consisting of five classes, namely very vulnerable class, vulnerable class, somewhat vulnerable class, safe class and very safe class can be considered for tsunami disaster mitigation activities in Parangtritis village. The main evacuation routes that can be used by the community are Jalan Parangtritis, Jalan Depok and Jalan Parangtritis-Depok through dukuh in Parangtritis village. The evacuation route also go directly to the 12 TER tsunami proposed. The success of the evacuation route and the tsunami TER proposal for evacuation during the tsuanami must be accompanied by a fast and appropriate early warning system.

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