Tsunami-affected areas in Tanjung Lesung – Banten - Indonesia

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Abstract: The West Coast of Banten is one of the tsunami-affected areas in Indonesia. People living in this region have to be aware of the possible tsunami occurrence anytime. PUSGEN 2017 research result indicated that Megathrust of Sunda Strait has the potential to trigger an earthquake up to magnitude 8.8 generated in the seismic gap zone and strengthened the issue of tsunami threats. Therefore, we need a more detail study of these areas. In this study, we use the mathematical model of tsunamis from ComMIT software by NOAA and overlay it with the coastal population density. The outputs of ComMIT software are heights of run-up, inundation areas, and estimated time arrivals. The population density is determined by the housing population density method and the total number of populations divided by the area of settlements. The result is the number of people affected by tsunami obtained from the intersection between the area of inundation and the field of settlements. In Tanjung Lesung, there are up to 134 people affected by the tsunami.

1. Introduction
IndoAustralia – Eurasia subduction zone is the megathrust area that has a declivous plate moving slip [1]. Megathrust area with a normal or thrust fault mechanism is one of the triggered of a tsunami. The area along the western Sumatera and southern Java is a vulnerable area of a tsunami. According to PUSGEN, 2017, who mapping the segment of the subduction zone, the Sunda Strait segment has a big earthquake potentially up to 8.8 in magnitude moment caused by plate movement up to 40 mm/year [2]. There that three big earthquakes that occurred in this area that is in 1840, 1867, dan 1875. In the last three hundred years, there isn’t a big earthquake that happened in this area, and it called the seismic gap [3]. The researcher interpreted that the area along the seismic gap has significant potential to trigger a tsunami.

Four regions in Indonesia have a high risk of tsunami probability. One of the areas is the megathrust Sunda Strait region [4]. Historically, there are many tsunamis recorded in the Sunda Strait region. As recorded by Tsunami Catalog from BMKG, tsunamis in Sunda Strait occurred in 1722, 1863, 1883, 1889, 1928, 1930, 1963, and 2018 [5]. Sunda Strait segment appears right to the western coast of Banten, which is this area is significant to developing Banten. Tanjung Lesung is located right in front of the Sunda Strait megathrust segment, in which one of the regions of Banten was always busy with tourism activity. Some researchers have examined the Sunda Strait and concluded that the Sunda Strait is very potential for the tsunami disaster [6].

The model has been created to identify run up and height of tsunamis. In Cilegon, the inundation map shows broader distribution results up to 1 km to the mainland for a thrust fault scenario [6]. In Pandeglang, the maximum potential height at Pandeglang is 9 m, with a tsunami arrival time of about 20 minutes [7]. Therefore it is essential to conduct further research in the Tanjung Lesung area which
faces directly to the Sunda Strait and must be anticipated in terms of disaster mitigation. This research aims to know how the exposure by a tsunami in Tanjung Lesung - Banten.

2. Method
In this research, tsunami propagation has been modeled by software ComMIT (Community Model Interface for Tsunami), the product by NOAA (National Oceanic and Atmospheric Administration) [8]. ComMIT is numerical simulation modeling using a leapfrog numerical scheme to solve basic equations of wave propagations. ComMIT using linear wave theorem in the deep ocean and using shallow water theorem in shallow water to simulate run-up and inundation. The result of this modeling is run-up, estimated time arrival, and inundation [8]. In this research, we use earthquake parameters scenario as the trigger of tsunami shown in this description bellow based on PUSGEN 2017 study [2].

The scenario location of the earthquake epicenter by longitude and latitude. It shows the depth of the earthquake is 14 km under the mean sea level. The strike, dip, and slip are representing the source mechanism of an earthquake — the lengthwise of fault from northwest to southeast represented by the 309 degrees of fault strike; the sloping fault (dip) is 9 degrees. The thrust fault (slip) is 90 degrees. The wide of the fault is 40,000 km squares. BATNAS data from the Geospatial Information Agency of Indonesia run in ComMIT is National DEM built by IFSAR data (5 meters in resolutions), TERRASAR X data (5 meters in resolutions), and ALOS PALSAR (11.5 meters in resolutions). DEMNAS data resolutions are 0,27 arc second with vertical datum EGM 2008. This data then processed to be coastal slope by ArcGIS software.

Populations density is calculated by the housing population density method, as stated by Yunus, 2005 [9]. This method calculates the total number of populations divided by the area of settlements. This concept used to fix the population density based on the administration area in which many areas are not the settlement area. The analysis in this research is overlaying inundation’s area with the settlement area and get the intersections. The result is a settlement area affected by tsunami inundations. Furthermore, that area multiplied by population density then obtained the number of people destroyed by a tsunami. To simplify the result, we mapped on google earth.

3. Result and Discussion
From DEMNAS data, we make a cross-section in the Tanjung Lesung area and get the slope of coastal regions shown in Figure 1 below. From Figure 1, the Y-axis is the height (meter) and X-axis is the radius from the coastline (km). We can assume that Tanjung Lesung has low coastal topography because it is the cape. From the statistics, we can get the average height is about 10 meters above sea level. Tanjung Lesung is surrounded by the sea, that’s why Tanjung Lesung does not have height altitude.
Figure 1. Cross Section in Tanjung Lesung. Left, Position of Vertically cross-section. Right, Vertically cross-section in Tanjung Lesung

Figure 2. Initial Commit Model

The locations of the megathrust and the initial of the ComMIT running model shown in Figure 2 below. The fault’s width is approximately 400 km square right in southern Banten. From Figure 2, then the software is running to get the propagation figure shown in Figure 3. Tsunami propagates in all directions. In the south-west direction of the earthquake source is the ocean, otherwise in north-east direction is Java mainland. Tsunami propagates in high velocity in the ocean but it has a low amplitude. When a tsunami approaches the mainland, it decreases the velocity but increases the height. In Figure 2, we can see the rectangle that represents a grid of the model as a calculating base of this software.
Figure 3 explains to us that the tsunami destroys the mainland in 60 minutes after the earthquake. In the early minute, running models show us that the first is recede wave, which shows in blue color.
From the first time of earthquake to 50 minutes, we can see that tsunami come as a receding wave. After 1 hour, tsunami begins to enter and destroy the mainland. From the color of Figure 3, we know that a tsunami enters the mainland more than 5 meters in height. After 70 minutes, tsunami waves in the ocean begin to recede but not in the mainland. That is because tsunami water restrained by debris from the mainland. In 120 minutes, seawater recedes.

Figure 4 is the time series of tsunami propagation in Tanjung Lesung up to more than two hours after the earthquake accrue. Time 0 means the first time of the earthquake. From Figures 3 and 4, we can know that in Tanjung Lesung, the first wave is receding wave. The wave starts to destruct the mainland at 55 minutes after an earthquake occurs. The height of the run-up is 966 cm in height. The area of inundation is up to 2.54 km square.

For the simulation, we only calculate in Tanjung Lesung area, so the model used the population density calculated in the Panimbang Sub-district [10]. We use the latest data from BPS in 2018 which shows the total population of 51,583 people and the settlement area of 19.21 km square. So we can calculate the population density is 2.685 persons per km square. Inundations area from the software then overlaying by settlement area’s map. In Tanjung Lesung Area, the inundations area concerning the settlement area is up to 0.05 km squares. Thus, based on mathematically calculating, the population exposed by the tsunami is 134 persons. The result of overlaying to google earth to simplify interpreted, as shown in Figure 5.

From Figure 5, we can see that the tsunami significantly destroyed the mainland as yellow and red color. The areas not affected by tsunami can be caused by several factors including the height of the land is higher than the run-up, the presence of rivers in other parts so the water is concentrated into the area and there is vegetation that covers the land surface. The coastline area behind Tanjung Lesung is not significantly destroyed by the tsunami because the location is in the back of the earthquake source.

The number of 134 people is only a registered population, and we must remember that the area is a tourist area where visitors are not registered as residents. So the possibility of real victims will be higher. The calculation of the number of people affected by the tsunami will be even better if we consider the capacity of people in hotels or resorts.
4. Conclusion

From the modeling of a tsunami in the Tanjung Lesung region, we know that the tsunami began to destroy the mainland in 55 minutes with a receding wave onset first. The maximum run-up is 966 cm in height. The total population exposed is 134 people. However, the number of tourists who are not residents is unknown, so the further recording of non-population exposure in the Tanjung Lesung area is needed.

5. Reference

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