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Earthquake and Tsunami Threat in Lombok

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Abstract

Lombok, the alternative tourism destination beside Bali, has beautiful sight and culture, but it also includes the vulnerability area in Indonesia. There are subduction zone and the Flores Fault in the south and north of Lombok. Both of them are a source of the earthquake. Based on the BMKG historical disaster, in 1992, there was an earthquake and tsunami comes from Flores Fault. In 2018, there was an earthquake coming from the Flores Fault. The earthquake is unique; it started from foreshock and followed by mainshock seven days later. It rarely happened in Indonesia. However, it is a difficult way to predict the earthquake is include in foreshock or not. Besides that, the tsunami potential that can occur from Flores Fault activity still become a mystery to some geoscientist.

Keywords: Lombok, Flores Fault, earthquake and tsunami

I. INTRODUCTION

Lombok is a famous tourism destination in Indonesia besides Bali. There are several destinations like Senggigi beach, Gili Air, Gili Trawangan, Gili Meno, Gili Gede, and Rinjani volcano. Besides that, the culture in Lombok is also interested, like Perang Topat, a friendship symbol between the Hindu and Muslim communities (Rismayadi, 2016). As a tourism destination, the Government of Indonesia built some facilities to support it.

In 2018, there was an earthquake in Lombok that started from July 29th to August. It was started by foreshock allowed by mainshock on August 5th and aftershock. However, it rarely happened in Indonesia. The earthquake is coming from Flores Fault activity in the north of Lombok, and it destroyed some facilities. The earthquake also can trigger tsunami-like in 1992; there was a tsunami in Lombok with the height of tsunami waves reach to 15 m (Katalog Tsunami di Indonesia Tahun 416 – 2017, Kedeputian Bidang Geofisika BMKG, 2018).

Based on the exposure above, the purpose of this research is to analyze the earthquake and tsunami potential around Lombok from a geophysical way. The research is started with literature data from several earthquakes and tsunami events in Indonesia, like Aceh, Banten, and Palukoro. First, the deformation effect of the earthquake triggered the tsunami should be calculated. It includes the length, wide, and large area. The deformation will cause the displacement of some volume of water from the

source to the mainland. Then, the height and the velocity are calculated to get the description of the potential to destroy.

II. RESEARCH METHODOLOGY

The research started from literature studies about earthquake and tsunami disasters around Lombok. Earthquake is earth energy release on the surface. More energy release in some places, then the seismicity is higher too. The energy of an earthquake usually causes the deformation, and if it happened in the ocean, it would cause the tsunami. The deformation will move the water in a certain volume. As it reaches the shoreline, the height will increase while the velocity will decrease. Figure 1 describes the tectonic setting of Lombok

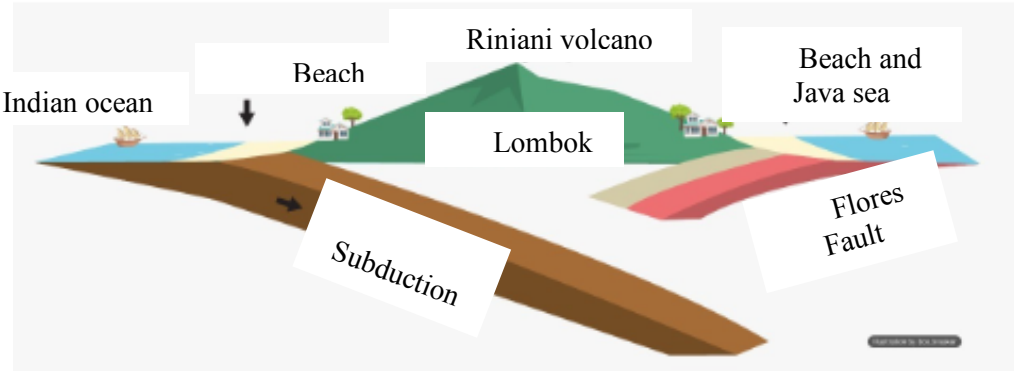

Figure 1. Subduction zone and Flores Fault illustration around Lombok (Box Breaker from PusGen team, PusGen, 2018)

Based on Figure 1, Lombok is located between two potential earthquake sources, they are the subduction in the south and the Flores Fault in the north. Both of them are the result of a tectonic setting where the Australian plate (Indian ocean) moves relative to the Eurasian plate. Earthquake source or hypocenter that is coming from the subduction zone usually includes a deep earthquake. Different from the Flores Fault, various earthquakes depth can occur. Rinjani volcano is one sample product of the subduction zone. The subduction zone and the Flores Fault crash under the Lombok island because they have bigger densities.

The facility's damage is usually caused by the tsunami wave lacing. The law of conservation of energy applies to a tsunami. Around the hypocenter, with the big enough value of bathymetry, the kinetics energy will big enough too, and the velocity of tsunami waves can reach hundreds. As the tsunami wave reaches the shoreline, the bathymetry depth is shallower, and the velocity will decrease. The kinetic energy will change into potential energy, and the height of the tsunami wave becomes higher. Then it will destroy the facilities that are hit by the tsunami (Sugito, 2008).

To analyze the earthquake and tsunami potential, the bathymetry data is needed besides the information about earthquakes. The data downloaded from USGS and Topex website. In the Topex, there are topography data include beneath the ocean, and it is assumed as bathymetry data.

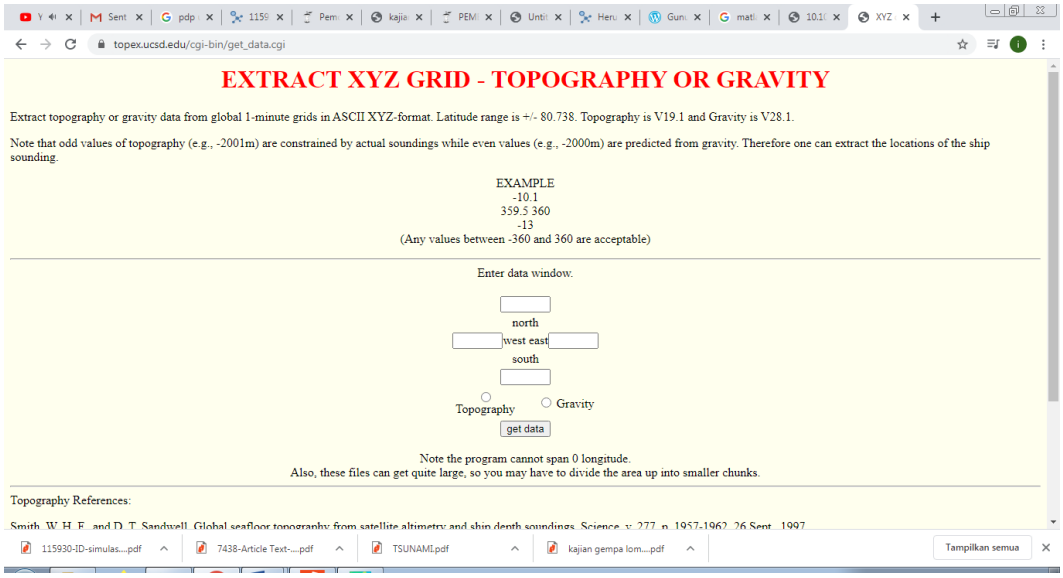

Figure 2. Topex Website (https://topex.ucsd.edu/cgi-bin/get_data.cgi)

In tsunami modeling, the conservation law of energy is used. There are two kinds of energy; they are kinetic and potential energy. The summary of them is then called mechanic energy. The kinetic energy is based on the velocity value of the tsunami, while the potential is based on the height of the tsunami. The velocity then depends on the bathymetry data. The deeper bathymetry data, the bigger velocity of tsunami waves will occur. Otherwise, the height of the tsunami reaches low. After the earthquake happened, and some water volume is move closer to the mainland, the bathymetry will be shallower. Automatically, the velocity will decrease while the height of the tsunami wave will increase. In the mainland, the velocity reaches zero, and the effect is the height of the tsunami will chaos if it hit the buildings, home, bridge, and the other facilities.

III. RESULT AND DISCUSSION

Based on the data and the concept of the law of conservation of the energy, the tsunami's height around Lombok profile caused by Flores Fault activity can be seen in Figure 4. The concept of the law of conservation energy can be seen in equation (1)

$$EM = EK + EP \quad (1)$$

$$EM = \frac{1}{2}mv^2 + mgh \quad (2)$$

Where EM, EK, and EP are Mechanics, Kinetics, and Potential Energy. Based on equation 2, the kinetic energy depends on the power of velocity value. So it is no wonder that the velocity of a tsunami can reach hundreds. The data then processed by using Matlab language Programming. Matlab language programming is chosen because it is simple and very easy. It also has a good visualization of the graph or contour.

Figure 3. Research location (Google Earth)

The research location can be seen in Figure 3. It can be known that Lombok island is part of West Nusa Tenggara Province. It is located next to Bali. The Redline is the location of the Tsunami wave and velocity. Assumed, there is an earthquake in Flores Fault with magnitude 7.8 marked by the star sign. Then by the Well and Coppersmith (1994) equation, the deformation will be calculated, and the result showed in Figure 4.

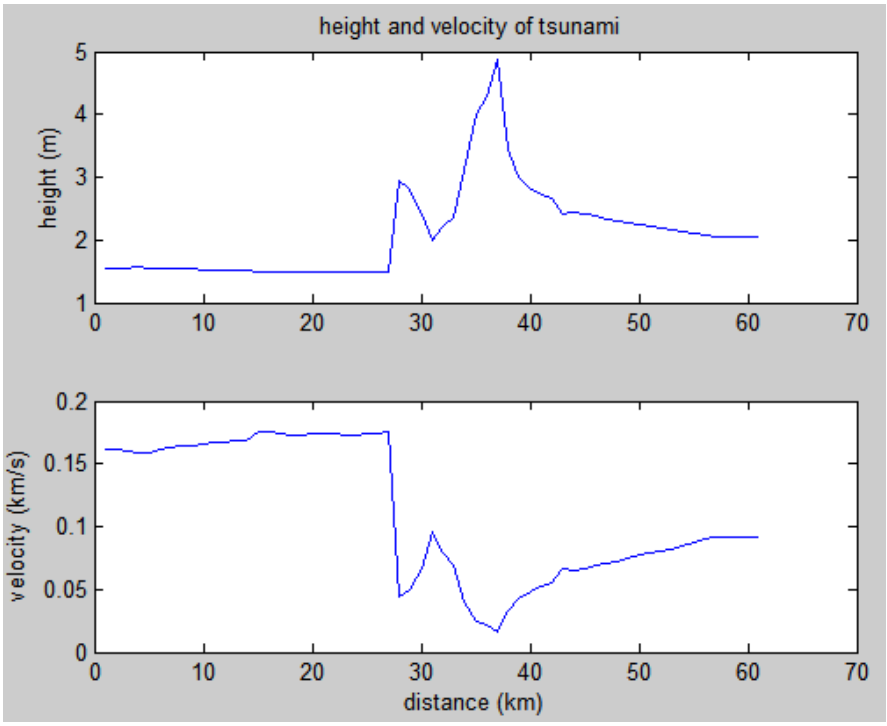

Figure 4. Height and velocity of the tsunami

Figure 4 is a profile of the height and velocity of the tsunami around Lombok. The earthquake assumed to come from Flores Fault activity with magnitude is about 7.8. It can be seen that the height of the tsunami reaches to 5 m, and the velocity reach 100 m/s reach to the shoreline. The velocity is big enough to destroy some facilities through it. Based on Figure 3, it also describes how the energy changed from kinetics to the potential in the distance around 30 km from the hypocenter.

As a comparison, the height of the tsunami in Aceh with a magnitude 9.2 reach to 30 m, and the Palukoro tsunami reach to 5 m with 7 magnitudes of the earthquake. In Aceh, the magnitude is the biggest in the earthquake history in Indonesia. Almost off the facilities is distributed and the victim reaches thousands of peoples. Different from Palukoro, the magnitude is 5, and it triggered tsunami height reach to 5 m plus the liquefaction. Liquefaction is mixed between the soil and the water in enormous numbers, so the soil loses the density. Even though the tourism in Aceh and Palukoro is not like in Lombok, but the disadvantages of the tsunami is very big.

Lombok, as the main tourism destination in Indonesia, should be completed by various facilities developed by the local government. In Rismayadi (2016), there was an increase in tourists visiting Lombok from 2010 to 2014 (Table 1).

Table 1. The increase of tourists visiting in Lombok from 2010 to 2014 (Tourism Department of Lombok Barat, 2014 op cit Rismayadi, 2016)

No	Year	Tourist		
		Foreign	Domestic	Total
1	2010	70.294	159.774	230.068
2	2011	85.008	184.792	269.980
3	2012	110.457	196.763	307.220
4	2013	132.693	240.352	373.045
5	2014	194.863	183.248	378.101

The increase in tourism will give an increased income to the local government, so the treatment of the facilities around Lombok is very important. The tsunami height and its velocity could destroy the facilities moreover if the facilities were built without regard to the hazard potential. The shape of the buildings is also influenced by the damage potential. The buildings with a lot of corners more potential in destroyed than the curved buildings. It can be a warning to the developer to build the facilities to adapt to the geological condition.

The tsunami also can be triggered by a volcano eruption. Like the tsunami because of the Krakatoa eruption, it caused the big tsunami. But it has specific criteria; the volcano should be located in the ocean. But it is little possibility that happened in Lombok. The tsunami in Lombok is a little possibility that comes from the volcano eruption.

The next question arises as the effect of the tsunami is how about the way to anticipate the tsunami. Because it is hard to a prediction when it will happen. One of the solutions between the construct of the buildings is the application of a Geographic system like the research presented by Zaitunah et al. (2011). The system includes the information of the run up of the tsunami, how much the area will be flooded, and where the evacuation place if the tsunami happened. Besides that, The Tsunami Early Warning System or TEWS should be work effective. It needs routine treatment both of the system and the tools like the buoy. Remember the Banten tsunami in 2018 caused by the Anak Krakatau eruption? The tsunami is late to be anticipated because the buoy did not work well.

The other potential of the tsunami in Lombok coming from earthquake occurred in the subduction zone, in the south of Lombok island. The subduction is still included in the megathrust zone elongated from the west part of Java. The subduction zone is deeper than the Flores Fault; of course, the potential earthquake that can be happened in the subduction zone is bigger than Flores. Based on BMKG information, the earthquake with magnitude 8.5 potentially occurred. With the velocity reach hundreds, it just takes a few minutes for the tsunami wave to reach the mainland.

IV. CONCLUSION

A tsunami can be triggered by an earthquake. The deformation of the earthquake moves some water in a certain volume value from the hypocenter to the shoreline. In a tsunami, the law of conservation energy is applied. The kinetics energy value depends on the bathymetry, the deeper of bathymetry resulting in bigger velocity and kinetics energy. Near to the shoreline, the bathymetry is shallower, and the velocity will decrease, then the kinetics energy changed to potential energy formed in the height of the tsunami. Based on the modeling, the earthquake with magnitude 7.8 located 30 km from Lombok that is located in Flores Fault potentially caused the tsunami with velocity reach to 100 km/s and 5 m height of the tsunami wave. The second tsunami potential is coming from the subduction zone. BMKG predicts that if there is an earthquake coming from the subduction zone, its potential has a magnitude around 8.5 because the subduction in the south of Lombok still includes the megathrust as the extension of the subduction zone in Java. The potential effect will cause a bigger and higher tsunami. As the main tourism in Indonesia, Lombok has a lot of facilities to support tourism; it will be a warning to protect the buildings from the tsunami. Identification of the area that potentially destruction by the tsunami waves includes the run-up, the flooded, and the shape of the buildings is very important. Then all of them can be incorporated into one system of geographic information around Lombok. Besides that, the Tsunami Early Warning System treatment both of the system and the tools like buoy is also important. Remember the Banten Tsunami in 2018; the tsunami is late to be anticipated because the buoy did not work well.

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