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# Planning area of resist natural disaster in Bentenan Village South Eastern Minahasa

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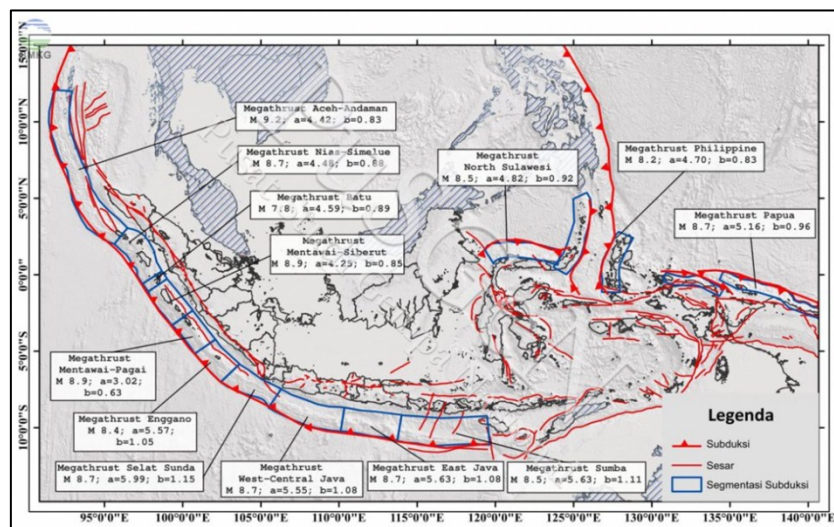
**Abstract.** Disaster management is crucial to protect the area in order to overcome the impact from such disaster. This paper aims to plan safety zone area and evacuation route for village settlement to be natural disaster resistance. Moreover, an evacuation building is planned with a safe structure as a temporary place for the community. The study area is Bentenan village in North Sulawesi. This area has a high risk of natural disaster including earthquake and tsunami. The methodology is field study with data collected using a drone to get data contour area and analyse using computer program AutoCAD for measurement. The standard for safe area and previous research is used as a comparison for the zoning area. The result shows that for maximum 30 meter high of a tsunami wave, all area has a great impact on damage due to the area of settlement is under 30-meter-high above the sea level. For evacuation route, more alternative safe evacuation area should be provided with a location on the highest area. Available main streets are easily accessed while route on the green area should be made. Building for evacuation should have a good quality of material and structure and easy access for the community.

## 1. Introduction

A natural disaster is hard to predict and therefore has a great impact on damage and fatality. Disaster management can help the community in an impact area to understand on how to avoid more damage and save more people. Indonesia as an island country is vulnerable to natural disaster due to its location on the ring of fire. Moreover, the city area is a lack of planning for earthquake resist building structure and area [1]. During the period of 1629 to 2002, the tsunami in Indonesia has occurred 108 times including 9 times due to the volcanic mountain and 98 times caused by the tectonic earthquake [2]. Map of tectonic in Indonesia and ring of fire can be seen in the Figure 1.

A natural disaster such as earthquake and tsunami are the most disaster with large damage and area covered. Tsunami characteristic is a movement from an area with a number of waves resulted as a focus of spread wave [5]. This wave is varied within 0.5 meters to 30 meter high. The cause of the tsunami is an earthquake under the sea, the power of the earthquake on the Richter scale and the depth of water as the centre of the earthquake. As the wave of the tsunami reaches the land, the level of the wave is higher than the level of the land. Most settlement in Indonesia is located in the beach area with a large number of people including community and visitor. For area on the beach with function as a tourism destination, people from many places are added to the area which created a busy place. A safety approach with facility for evacuation during a natural disaster is a must.





**Figure 1.** Tectonic map of Indonesia [3, 4].

Natural disaster in North Sulawesi province during the period of 1815 to 2014 are 169 events. The most disaster is flooding, drying, strong wave and landslide [6]. Other disasters are forest fire, earthquake and tsunami. Tsunami reaches the highest number of victims and properties destruction. The risk class of natural disaster in North Sulawesi province can be seen in Table 1. Based on Indonesia disaster risk index [4], it can be seen that South east Minahasa has a high risk of 195.2 compare with other areas in North Sulawesi. The most area in North Sulawesi is high risk in natural disaster including Southeast Minahasa area. Bentenan as a village in this area is a settlement near the beach and part of the beach is a tourist destination with a large number of people. Recently, the area has a large number of the visitor but lack of facility for evacuation during a natural disaster. Therefore, planning for safe area and evacuation route for people is analyse and modelled in this paper.

**Table 1.** Area and risk class in North Sulawesi.

No	City/Kabupaten	Score	Risk Class
1	Minahasa	212.4	High
2	South East Minahasa	195.2	High
3	South Minahasa	173.6	High
4	City Of Bitung	162.3	High
5	North Minahasa	158.4	High
6	Sangihe Island	154.4	High
7	Bolaang Mongondow	149.6	High
8	South Bolaang Mongondow	149.6	High
9	North Bolaang Mongondow	144	Medium
10	City Of Manado	130.4	Medium
11	City Of Tomohon	119.2	Medium
12	Talaud Island	102.8	Medium
13	City Of Kotamobagu	76	Medium

## 2. Literature review

Literature on tsunamis in North Sulawesi is limited, therefore the reference is based on natural disaster in other area, standard available and history. These references affect the year of publication to be evaluated more than 5 years of required amount of year. The level of the tsunami wave is varied based on the location and source of the tsunami. A tsunami wave can reach many different levels when

reaching the land is maximum 30 meters [7], 10 m to 20 m [8], 10 m [9], 10 m to 18 m for Northern Sulawesi and 2–7 m for Minahasa Peninsula [8]. The wave speed can reach a maximum of 90 km/hour [10] and 20 – 30 miles per hour or 50 km/hour [11].

The source of the tsunami is an earthquake, landslides, volcanic activity, certain types of weather and near earth object with the location of energy on the entire water column [11]. Wavelength is varied between 60 to 300 miles in a period of 5 minutes to 2 hours. By comparison, the wavelength of wind wave is 300 to 600 feet in 5 to 20 second with speed 5 to 60 miles per hour. The tsunami wave is around ten times than the normal wave. Walking speed is 1,5 m/s. For walking speed, area of the street has the highest speed values followed by a dense population and mangrove area [12]. Speed of tsunami evacuation time is formulated as  $S = v.t$  where  $s$  is speed,  $v$  is distance and  $t$  is time. With the speed of 45km/h and evacuation time 30 minutes, speed is 23km/h based on the distance of the street and therefore, the evacuation is mapping [13].

Guideline for the safe area of natural disaster is based on management disaster board. Management disaster is divided into three steps including pre-disaster, emergency and after the disaster [14]. The area in Indonesia shore area is vulnerable to earthquake, tsunami and flooding which can be seen in a number of research [15-18]. Level of land, previous tsunami and level of water is needed in creating such a map [14]. Planning for evacuation route need to considered pedestrian behaviour and movement [19].

Data needs for planning disaster resist area are the condition of the study area, distance measurement, population and elevation of land [14]. Guideline for evacuation building design area such as the requirement for building concrete structure, SNI 2847:2013, minimum load for structural building SNI 1727:2013, a guideline for earthquake building design SNI 1726-2012. Mitigation disaster by identifying vulnerable coastline is important in planning a safe strategic area including facility provided, environment change and local wisdom [20].

Model for unpredictable damage by tsunami and risk map consist of earthquake characteristic, distribution, circulation and loss of properties [21]. Moreover, the method for modeling tsunami wave based on roughness detail map of density with 10 meter wave is used for three areas such as Kuta Bali, Padang West Sumatra and Cilacap southern coast Java [9]. Risk map with evacuation route is prepared for the community to cope with the natural disaster [22]. Mapping area of evacuation and evacuation shelter is needed a basic map, street map, demography and contour map [23].

### 3. Methodology

Methodology for this research is a survey in which data gain from the drone for the map of area and contour as a basic map for analyse affected and not affected area by the tsunami. The site visit is important to get facility and access available for the people during evacuation. Data is analysed using computer program AutoCAD for measurement the area. The standard for disaster management and previous research is used as a comparison in the analysing area, access to the street and other places and for building design. Location of research is Bentenan Village, South East Minahasa, North Sulawesi (see Fig. 2).



**Figure 2.** Picture map of Bentenan Village, South East Minahasa, North Sulawesi, Indonesia.

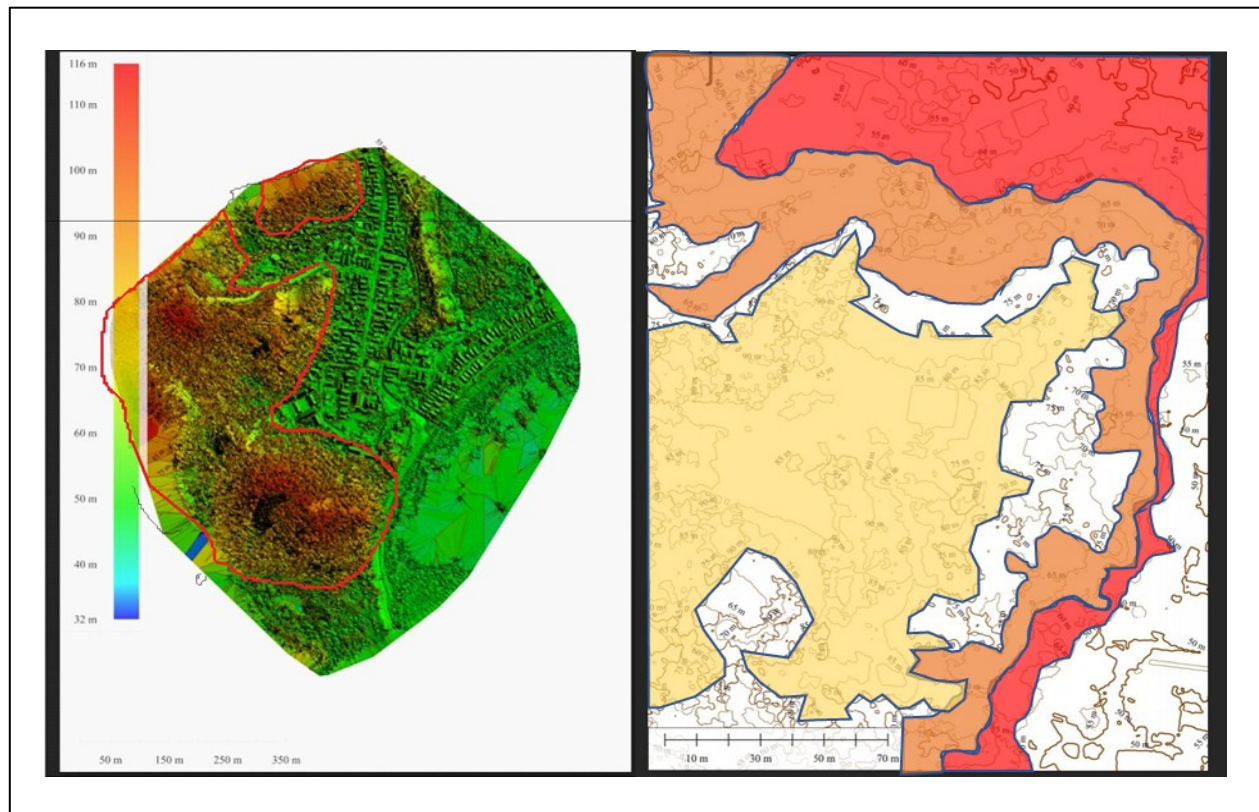
Bentenan village is in Posumaen area located along the beach of Bentenan, Molucas sea in the east, farming in the west and south. The distance of this village is 20 kilometre south area of Pusomean city centre. Most of the people in Bentenan village is a fisherman with majority come from Bolaang Mongondow tribe, an area in North Sulawesi, followed by different tribes such as Bugis, Buton, Sangir, Bajo, Java, Tidore and Ternate.

## 4. Results and discussion

### 4.1. Mapping areas affected by the tsunami wave

Based on different literature, the area is planned with different level variables of a tsunami wave and different speed of the wave. Variable 1 is 30 meters [7], variable 2 are 10 meters and 20 meters [8] also 10 meters [9] and variable 3 is 10-18 meter [8]. From demography data of Bentenan Village [24], the number of people in Bentenan Village is 812 for Bentenan village, 534 for Bentenan One and 454 for Bentenan Indah [24]. These villages are part of Pusomaen area. The density of people is 182.71 for the area of Pusomaen [24]. The area of Pusomaen consists of 10 vilage in the beach area with a total area of 5172 ha or 5.97% of South east Minahasa area. The distance of the village to the centre of Pusomaen is 4 km for Bentenan and Bentenan Satu and 7 km for bentenan Indah. The area of Bentenan is 540 ha, Bentenan Satu 41 ha and Bentenan Indah 300 ha. The total area of bentenan is 881 ha. The number of household in Bentenan is 226 households, Bentenan Satu 159 household and Bentenan Indah 119 household. The total number of household in Bentenan Village is 504 household. Figure 3 shows the contour of Bentenan village and the areas that can be effected by a tsunami including the evacuation area. Based on the analysis, the result for each variable is summarized in Table 2.





**Figure 3.** Picture Contour of Bentenan Village and safe area (left) and affected area of tsunami wave (right) scenario 10 meters (red), 20 meters (orange), 30 meters (white) and evacuation area (yellow).

**Table 2.** Areas affected by the tsunami wave.

No	Variable	Result	Total Number
1	10 meter	Only houses and building near the beach affected by the tsunami wave	
2	20 meter	Houses and building at the village settlement affected by tsunami wave accept in the forest area	
3	30 meter	All houses and building at the village settlement affected by the tsunami.	Land = 881 ha Building = 504 household

Speed of wave on land with variable 1. Speed 20 – 30 miles per hour or 50 km/hour [11] and variable 2. Maximum speed 90 km/hour [10]. Based on data literature that tsunami wave hit the land from 1 kilometre and above from the beach. Therefore, based on scenario the wave speed 50 km/hour and 90 km/hour, all area is affected by tsunami wave and destruction.

#### 4.2. Evacuation rout

For walking time to evacuation building with walking speed 1.5 m/s, using the formula:  $S = v \cdot t$ , where  $S$  is speed,  $v$  is distance and  $t$  is time. Evacuation walking time for 6 alternatives route can be seen in

Table 3. Using data of time arrival before the first wave hit the land for 20 minutes including warning and dissemination for 15 minutes [12], walking time to the evacuation area based on roughness calculation for 5 minutes, there should be enough time for the community to reach the area of evacuation.

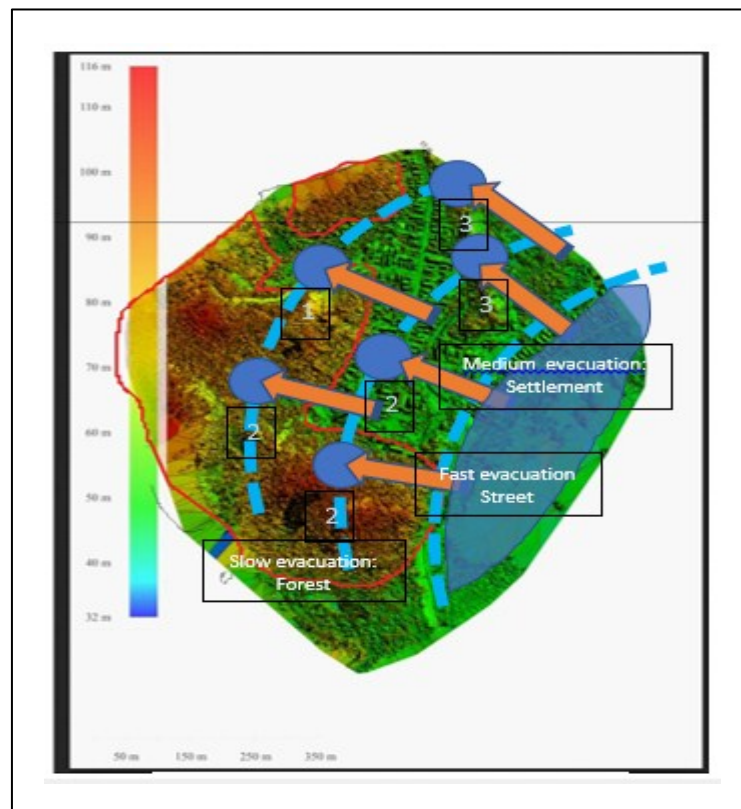
**Table 3.** Walking time to evacuation building.

No	Distance (m)	Walking time to evacuation building (min) walking speed 1.5m/s	Area
1	355.5	4.0	Village Street, Forest (Alternative Evacuation Area 2)
2	361.2	4.0	Village Street, Settlement (Alternative Evacuation Area 1)
3	355,8	4.0	Village Street, Settlement (Alternative Evacuation Area 1)
4	413.2	4.6	Village Street, Settlement (Alternative Evacuation Area 1)
5	197.5	2.2	Village Street, Forest (Alternative Evacuation Area 3)
6	216.7	2.4	Village Street, Forest (Alternative Evacuation Area 3)

Considering wave speed maximum 90km/hour and for the area in Indonesia 50km/hour, time available for the pedestrian is slower. This means time for people to reach the evacuation building is not enough as the tsunami wave is faster. Therefore, the model of evacuation route and location of evacuation building should be placed between different levels of land. The scenario of the high tsunami wave in three variable 10 m, 20 m and 30 meters should be taken into account. Evacuation route and area based on scenario wave high and model evacuation route in Bentenan Village can be seen in Table 4 and Figure 4.

**Table 4.** Evacuation route and area based on scenario wave high.

No	Wave high (m)	Evacuation building	Area
1	10	Settlement area of 20 m	Settlement area (Alternative Evacuation Area 2 and 3)
2	20	Settlement area of 20 m	Settlement area (Alternative Evacuation Area 2 and 3)
3	30	Settlement area of 30 m and above	Forest area (Alternative Evacuation Area 1)



**Figure 4.** Model evacuation route in Bentenan Village (the arrow is the direction to the evacuation area, the circle is the destination area).

Based on the model of evacuation route, the map of evacuation route and the access to evacuation area are drawn in Figures 5 and 6 while the illustration on how people reach the highest level in Bentenan village for evacuation can be seen in Figure 7. In this level, the evacuation building is planned with some parameters listed in Table 5.

**Table 5.** Design parameters for evacuation building design.

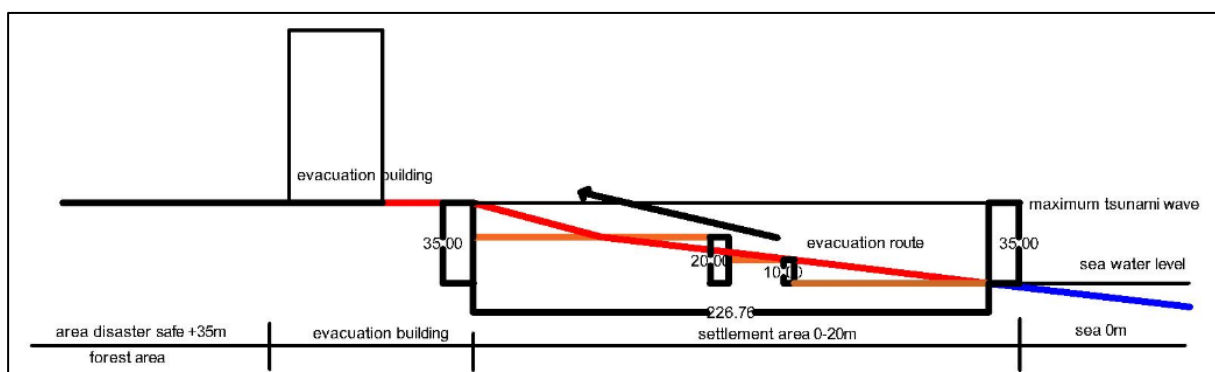
No	Parameters
1	Three storey building
2	The height of each story ranges from 3.5 – 4.5 meter
3	Evacuation building can be used as function building for community activities





**Figure 5.** Evacuation route in Bentenan Village with 6 alternatives access.

Temporary Evacuation Building is the first safety place for the community due to the tsunami. The place proposes for Bentenan Village is located in the highest area in the village with 350 meters distance from the beach. The building is 9 meters tall consist of 3 stories in which the first floor is 4.5 meters tall, the second floor is 3.5 meters and third floor plat deck at 8 meters elevation. This building can be used as a multi-function building in everyday life. The location can be seen in the picture below.



**Figure 6.** Access to the evacuation route.



**Figure 7.** Access to the highest level in Bentenan village.

## 5. Conclusions

Mapping disaster area is important in preparing the community and visitor on the area to have direction and guideline during a natural disaster in the area. Planning area in the coastline is a must due to the vulnerable area for great impact on tsunami wave. Bentenan village in South East Minahasa, North Sulawesi, Indonesia as one of the most high risk areas for a natural disaster is lack of guideline for evacuation. The level of land for maximum impact of the tsunami wave has resulted in the area has maximum land and building destruction as well as a large number of people as the victim. Planning disaster area for Bentenan village shows that two levels of evacuation area are needed considering the high level of the wave for local area 10 meter and high level of area 30 meter. Evacuation route using street available should be supported by facility access to the highest level of the area 30 meter and above sea level. Further research needs to expand the surrounding area of coastline in South East Minahasa and other areas in North Sulawesi to have a more comprehensive model map planning natural disaster resist area.

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