How ready we are? The temporary evacuation shelter (TES) and routes distance during the September 2018 earthquake based on survivor's preference

Rifai Mardin [a,1,*], Amar Akbar Ali [a], Alifi Yunar [b], Y.A.Rahman [c]

[a] Architecture Department, Engineering Faculty, Tadulako University
[b] Civil Engineering Department, Engineering Faculty, Tadulako University
[c] Electrical Engineering Department, Engineering Faculty, Tadulako University
[1] rifaimardin@yahoo.com
* corresponding author

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ABSTRACT

During Palu earthquake on September 28 2018, people in the coastline area immediately evacuates to decent heights locations. Their action preference is purely based on the aim of surviving the tsunami events. This research is aim on identify, in that conditions, how the survival chooses the TES and their route to it. This research also seeking their preference of TES and Evacuation route during the normal conditions, and compare the survival preference and what is happened during the tsunami events in September 2018. The result shows that during the tsunami disaster events, only 5 out of 74 survivals preferred evacuate to the higher buildings around the coastline within te tsunami prone area, while the others preferred to move further to the higher ground on the city centre. Majority of the survivals failed to understand the important of shortened their route as what is standard demanded.

1. Introduction

Several studies about the evacuation process during the tsunami hazard had been carried out, especially after the Aceh tsunami in 2014 and the Japan tsunami of 2011. The awareness of this kind of study rising since massive numbers of victims occur in the areas that affected directly by the 2004 tsunami.

Aceh earthquake occurred at 7:58:53 pm. The epicenter is located at the longitude of 3,316 ° N 95 854 ° E, approximately 160 km west of Aceh as deep as 10 kilometers. The earthquake measuring 9.3 according to the Richter scale, this is the most in the last big earthquake in the last 40 years total victims killed 126.732 people, 93.662 people missing, and estimated about the US $ 4.45 billion damages.

In the Aceh tsunami, community and government readiness and preparedness are very low. The tsunami disaster mitigation is not available, especially in the city master plan. The worst scenario of tsunami disaster is not well considered in the region, impacting people's ignorance.

Japan tsunami earthquake started with relatively similar to the events in Aceh 2014, started with nine on the Richter scale earthquake in the Tohoku region. The impact, according to Japan's National Police Agency, around 15.891 people reported dead, and around 2,500 people are still missing, while the estimated material loss of about US $ 300 billion (Becky Oskin 2015). During this event, preventing disaster risk is already good considering japan community and their government are ready. being ready is one key issue on disaster risk reduction

Palu Bay Area, located in the most active earthquakes source, comes from a shift in the Palu-Koro Fault, which is located just above the Palu-Koro Fault [1]. Palu City, which is the Provincial Capital (Central Sulawesi Province) and as one of the National Activity Center (PKN) become the most populous area in the region; it has a population of 379,782 [2]. This situation makes the Disaster Risk in this administrative area are very high. Due to the frequent earthquakes, this coastal city also becomes vulnerable to tsunami threats.

The earthquake that followed the tsunami has repeatedly occurred in Palu Bay Area. Historically, earthquakes followed by tsunamis were recorded from 1927 until the recent one on September 28, 2018, at 18:02:44 Central Indonesia Time (UTC + 8).

Based on The Donggala Regency Report [3], the earthquakes and tsunamis recorded in this area are:

- Watusampu earthquake; December 1, 1927, with a magnitude of 6.5 Richter Scale (RS), resulting in a 15-meter high tsunami wave that hit the coastal bay area and killed 14 people, and 40 people are wounded. The worst areas are in the southern and northern parts of the bay.
- Donggala earthquake on May 20, 1938. With a magnitude of 7.6 on RS (on another information 7.9 RS), it Introduces a 4-meter tsunami on the west coast of Palu Bay.
- Tambu Earthquake/Mapaga Earthquake on August 15, 1968, with a magnitude of 6.5 SR. Sent tsunami waves as high as 10 in Tambu village.
- Tonggolobibi earthquake on January 1, 1996, with magnitude 6.8 RS, send a tsunami of 4 meters heights.
- Palu earthquake of September 28, 2018, the strength recorded at RS 7.4 in magnitude and triggered an underground landslide that caused a tsunami along Palu Bay's coast.

This last tsunami disaster destroyed almost all buildings along the coast of Palu Bay up to 2000 meters inland. As a result of this disaster, the estimated death toll is 2,045 people. In considering these histories of earthquakes and tsunamis, this disaster can reoccur in the future.

People are aware of this situation, learning from the previous tsunami in Palu, and learning Aceh and Japan tsunami from the news, communities and local governments already grasp some idea of self-rescue measures,

The problem comes up with different characteristics of the tsunami disaster in Palu. General understanding believes that the tsunami will hit the shore after more or less than 20 minutes, while the Indonesian Tsunami Early Warning System (InaTEWS) could inform the communities to evacuate to the higher ground/building. What happened in Palu is different from what usually happens, the tsunami hit only 3-4 minutes after the earthquake [4], [5] and the early warning system failed to inform the coastal settlers to evacuate immediately. This situation is exceptionally challenging. Unpreparedness [6] causes people confusion to save themselves, sporadically, people who are afraid of running to places they consider safe. Many were unable to find a temporary evacuation site due to confusion until tsunami waves dragged it.

On the other hand, after learning from massive destruction in Aceh 2004, the Indonesian government enhances the need for disaster preparedness and adequate mitigation through spatial planning. Indonesia has produced several tsunami risk instructions, including the importance of early warning systems, temporary evacuation shelter (TES), and evacuation routes.

However, as in most coastal cities in Indonesia, Palu city still does not have an ideal temporary evacuation shelter and TES route. This situation becomes one major weakness and increasing the risk of safety threats to people living in coastal areas. The TES, which was drafted in Indonesian spatial planning guidelines, is unclear since it mixed all disaster thread types to a uniform TES. The guidelines also mix the concept of TES and TEA.

One form of natural disaster preparedness, including tsunami, is Temporary Evacuation Shelter (TES), also called Vertical Shelter [7][8][9] and Evacuation Shelter Building [10], in disaster-prone locations. Studies on TES have been conducted by some researchers such as [10][11][12].

The TES for tsunamis are essentially buildings with strong structures that can withstand earthquakes and have higher floors that can withstand flood levels above tsunami level and must be placed in disaster-prone areas so that they can be easily accessed [9][13]. Unlike evacuation centers or final evacuation centers, where people can stay longer and use them until relief and recovery efforts are complete, TES is a temporary space for people to save themselves just before disaster strikes immediately. Similar to flash floods, evacuation time windows are very limited for tsunami disasters. Evacuation centers or long-term evacuation shelters cannot be easily accessed within 5 minutes after the initial evacuation is announced. Another thing to note is that refugees are usually on foot. Therefore TES is very important to spread along vulnerable areas for refugees to access in a short period. TES is an essential planed to deal with catastrophic events [9] [13]. The ability to access TES can minimize the number of people in disaster areas, including tsunami disasters in the Aceh, Tohoku region, and Palu City.

Several methods and models have already been developed to simulate the evacuation of people living in affected areas, with the primary goal of identifying problems that can occur at the time of evacuation. These problems can be vehicle congestion and accidents that contribute to increased evacuation times and injuries. However, conventional and heuristic methods for determining evacuation routes are generally based primarily on geographical proximity and search for the shortest travel time [14][15][16]. Such techniques do not guarantee that route capacity will satisfy the strong demand for transportation during evacuations. None of the resulting routes will present coinciding crossing points, which could ultimately be congestion prone to potential accidents and considering other elements that should be validated is the result of evacuation behavior.

During the tsunami disaster 2018, it had been identified people who saved themselves to TES. Based on their local knowledge, the TES location they were aiming for is also varied. Their preferences will be an interesting study, especially to see their preference for choosing the TES. It is also essential to consider whether the selected TES has qualified or not.

This study is to identify the community's readiness, especially survivors in the tsunami evacuation process, in the Palu 2018 tsunami case. This research also identifies their understanding of the location of the TES after the disaster.

2. Method

2.1. Study Area

The study area is in the most populous coastal area in SILABETA, an abbreviation from 4 sub-district name in Palu, which are Silae, Lere Besusu Barat and Talise (Figure 1). The area is considerably at severe risk because it is right at the end of the bay, has the highest population as the initial location of the urban area, this area especially Lere sub-district and the Besusu Barat is a large plain formed by alluvial estuary from Palu River. According to the major of Palu, the highest tsunami occurs on this area which take 1.365 live

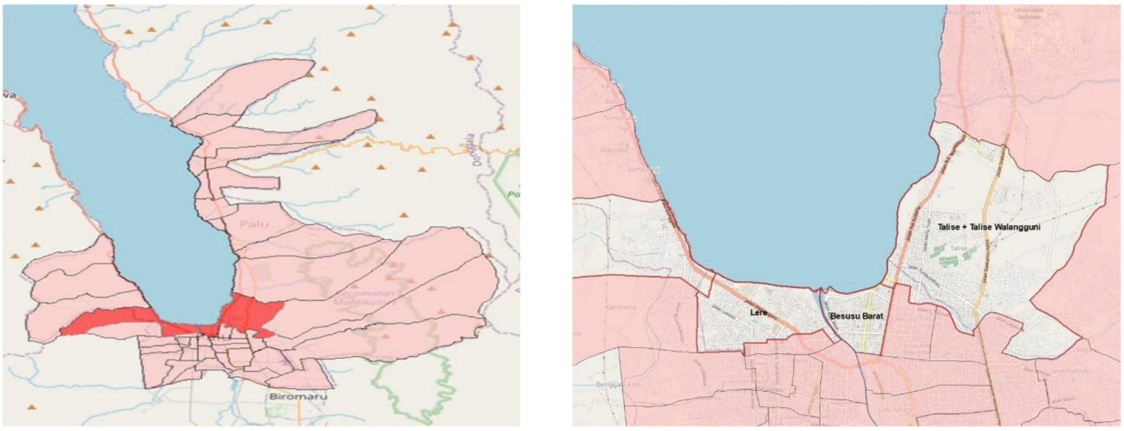

Fig. 1. The Study area

2.2. Interview and mapping

This study uses interview and mapping methods. In the interview followed by location mapings, there are two main questions delivered: to measure their understanding of evacuation and TES during the tsunami disaster of 2018. Secondly, their understanding of tsunami evacuation to TES after the disaster The question as follows:

2.2.1. Understanding of tsunami evacuation to TES during the disaster

1) Do they understand their location related to the tsunami-prone area to carry out the Tsunami evacuation process?

Their location during the earthquake will be given by pointing their location a map. This location later will be overlayed with the official tsunami-prone area to check whether the survival respondent in the tsunami-prone area or not

2) Are they evacuate to a suitable place as TES?

a) Where is TES location they choose?

The TES Location that the respondent answer and show on the map will be checked whether it is suitable as a TES or not,

b) The route distance from their origin location to the TES?

Is the route distance chosen by the respondent suitable in terms of traveling time and the security or not suitable?

3) Who takes the initiative using evacuation routes and Temporary Evacuation Shelters during the evacuation process?

Since there are choosing process on what TES and how to reach TES, the respondent will be divided into two groups, respondent who choose the route and TES by themselves (leader) or group which only follow what other do (follower)

2.2.2. Understanding of tsunami evacuation to TES after the disaster

1) if allowed to re-select the TES location, what would the respondent do? The research will divide the answer option into four groups, which are:

- maintain the option on the previous selected TES, and the TES itself is suitable
- maintain the option on the previous selected TES, but the TES itself is not suitable
- evacuate to a new location that suitable for TES conditions
- evacuate to a new location that does not match TES conditions

Based on the four-answer group, this research will conclude the level of understanding of survivors about TES, whether they can identify a suitable TES or not. If they choose. "a" or "c", it is mean that they understood to save their selves to the *TES*. The interviews were conducted on 74 survivors, where majority are the survivors of 2018 tsunamis. The average respondent (survival) was an adult group between 20-45 years old mixed by both male and female.

3. Results and Discussion

Answering the questions A. Understanding of tsunami evacuation to TES during the disaster

3.1. Do the evacuee understand their location related to the tsunami-prone area to carry out the Tsunami evacuation process?

All respondents (100% of 76 survivor respondents) understand the dangers that threaten their location. They all have understood that their location was in a tsunami-prone area during the 2018 earthquake. As seen in the map below, the survival was in the area which is hit by 7-11 meters tsunami (Figure 2)

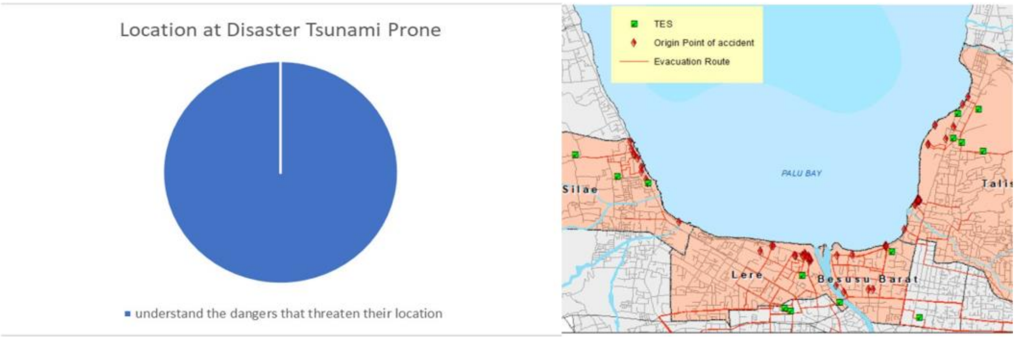

Fig. 2. Location at disaster tsunami-prone

Understanding the dangers of tsunamis within their location becomes a basic knowledge of Palu's people because of repeatedly historical factors of tsunami disasters. This is an advantage because this knowledge is the basis for taking necessary actions at critical times.

3.2. Are they evacuate to a suitable place as TES?

1) The TES location they meet standard?

Out of 76 Respondent, 73 manage to evacuate. Due to confusion, three survivors did not have time to evacuate and stayed at home. This result confirmed that although three survivors failed to evacuate, most respondents performed the self-rescue process to the suitable TES.

2) The route distance from their original location to the TES?

The majority of the Survivor respondent (48%) choose to move very far away from the coastline 6% (3 people stayed at home), and only 11 % (6 people) manage to move to the nearest shelter (no more than 500 meters from their origin location (Figure 4). The other 20% move more than 500 meters to 1 Km. The other 15 % move further to 3 Km.

The 48% (26 people) travel more than 3 Km, the majority using the vehicle. Furthermore, the others who reach 1 km are majority running on foot. While the distance of 1 Km to 3 Km mixed between the survivors with vehicle or on-foot at the time of the disaster, vehicle lane density threat hampered the evacuation process for those driving. The majority who drive by car get obstacles to moving quickly. Another thing that is hindering is the damage to roads and roads due to the earthquake, on the other hand, survivors who evacuate by running have distance and speed barriers to the nearest TES.

Fig. 3. Self-rescue process to the suitable TES

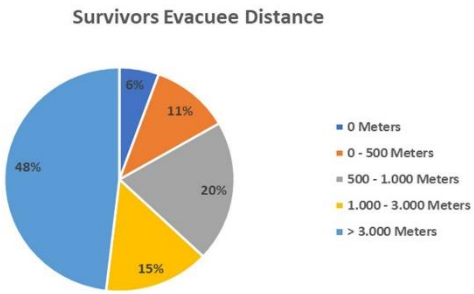

Fig. 4. The route distance from their original location to the TES

3.3. Who takes the initiative using evacuation routes and Temporary Evacuation Shelters during the evacuation process?

Taking the right initiative in a disaster emergency becomes one of the crucial keys in the evacuation process. The study found that most (84% / 64 people) of survivors could take their initiative or initiation in groups appropriately. This result is encouraging because this process can speed up the time of self-rescue (Figure 5). On the other hand, 12 percent of survivors are followers of fast-moving groups. the lack of followers is a good sign for the understanding of the evacuation process

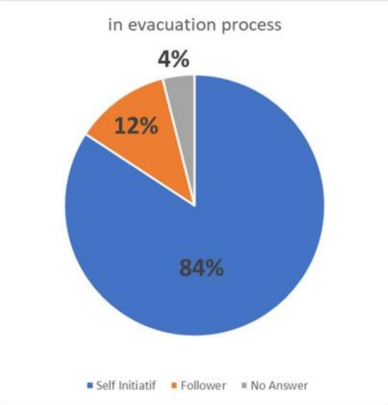

Fig. 5. An initiative using evacuation routes and Temporary Evacuation Shelters during the evacuation process

Answering the questions B. Understanding of tsunami evacuation to TES after the disaster

1) *If allowed to re-select the TES location, what would the respondent do?*

After the 2018 disaster, respondents increasingly understood the process of self-rescue. Onethird of respondents (25 people) said they would move to a different and safer TES if allowed to choose again during the 2018 disaster (Figure 6). Another 33 percent (24 people) continued to use the TEST they chose earlier because it was safe enough.

For different reasons (as emotional reasons for the same disaster repeated), 27 respondents did not want to answer this question. from existing answers, most survivors have had a good understanding of the evacuation to TES

2) *Review if the re-select the TES location for the TES if suitable*

After reviewing the test location of the respondent's choice on the map, all respondents, beyond the 27 respondents who refused to answer (Figure 7), were able to choose a test that was safe from the tsunami in the form of tall buildings with suitable structures, as well as in open space which is high enough from sea level.

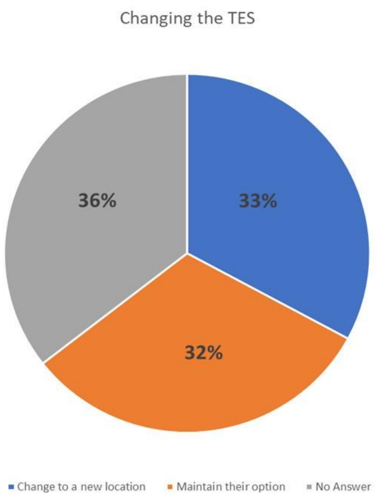

Fig. 6. Re-select the TES location

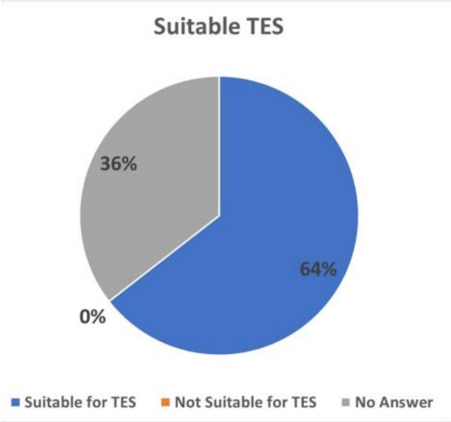

Fig. 7. Re-select the TES location for the TES if suitable

4. Conclusion

This research successfully understands the understanding and behavior of survivors in self-rescue during the 2018 tsunami disaster.Some important points that are key to the rescue process, such as:

- An understanding of the location of tsunami disasters is very high in the community due to the recurring history of the region, as well as the news of tsunami disasters that hit other areas such as Aceh, Tohoku, and Padang
- The community represented by the respondent can also understand the self-rescue process at the location of the Temporary evacuation shelter (TES).
- Most respondents, especially after the 2018 disaster, have also understood the need for adequate shelter as a temporary evacuation shelter.

The problem that arises as an additional note is the lack of temporary evacuation shelter locations in this tsunami-prone area. Moreover, with a brief period (recorded less than 4 minutes after the earthquake, the tsunami, the coastal area), the reachable TES is urgently needed. The TES locations in this tsunami-prone area should consider security factors, especially the building structure and building height. This temporary evacuation shelter should be directed to considering walking/running time during a tsunami.

Another critical note of this research is that the government's understanding of TES has not considered tsunami disasters' characteristics. TES's understanding is also mixed with the Final Evacuation Shelter, different from the final evacuation center, which should accommodate refugees for a more extended period. The use of Tsunami TES only takes a smaller space to stand crammed for a few minutes until the seawater recedes. However, the number of tsunami TES must distribute evenly across the area to be reachable as soon as possible. This research is the preliminary study of the evacuation system in TES. The further research is to identify the ideal TES location for tsunamis on the coast of Palu city

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