The Analysis of Tsunami Risk Based on The Building Vulnerability and Community Preparedness in Kuta Alam Sub-District Banda Aceh

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Abstract. Kuta Alam Sub District was one of the worst impacted by Tsunami in 2004. More than 50% of the area was covered by the wave more than 1 meter. The research is using qualitative and quantitative approach through surveying and scoring. Qualitative methods are carried out to assess the level of disaster risk faced by the community. While quantitative methods are used to assess the level hazard, vulnerability and community preparedness. Data analyzing is conducted spatially through geographic information system. The result show that the level of vulnerable building classified can be into very high, high, fair, and low. From the total buildings in Kuta Alam Sub District, which have a very high vulnerability of 1.79%, high of 55.17%, fair of 35.21% and low of 7.83%. The preparedness of the community in average is low of 32.17%. However, high vulnerability and low preparedness will increase the potential risk of tsunami disaster.

Keywords: Tsunami, Geographic information system, Qualitative method

1. Introduction
A region is potentially disastrous impacted if the community and environment are quiet vulnerable toward various disaster whether it’s natural disaster or not [1]. As the region that is surrounded by the coastline, Banda Aceh city is vulnerable to be affected by disaster strike from the ocean such as wave of tidewater, tornado, and tsunami. Based on the history of paleo tsunami, in 1450 a tsunami disaster occurred in Aceh. Tsunami destroyed buildings during the sultanate of Aceh Darussalam [2]. The National Disaster Management Agency has designated Aceh province as one of the regions that has a high level of risk to the tsunami disaster [3].

Kuta Alam was one of sub district impacted by tsunami in December 2004. It is located directly with the coastline that has completely flat area with only more than less 0.5 meters from the sea level. Consequently, there were huge number of people killed in tsunami tragedy, beside devastatedly destroyed the infrastructure and the buildings. According to recorded data, losses of life in Kuta Alam due to the tsunami were 8,227 people or almost 15% from the total number of the people [4]. The buildings that were in about 2 kilo meters from the coastline generally devastated and collapsed.

After the 2004 Aceh tsunami disaster rehabilitation and reconstruction can be seen housing built with a simple residential building model. The house is very risky for the tsunami disaster. While the tsunami height is above 3 meters, then it is certain that the house will suffer major damage. Thus, community preparedness is vital for dealing with disasters that can occur at any time.
2. Building tsunami vulnerability analysis
This study aims to know the degree of tsunami risk in Kuta Alam area by conducting the study toward the vulnerability of building infrastructure and the community preparedness. The result would recognize the level risk of Tsunami in Kuta Alam sub-district. The level of risk would be low if the building vulnerability is low and community capacity awareness is high. However, The risk level would be high when vulnerability of the building is high and community capacity awareness is low. The studies were conducted in Kecamatan Kuta Alam, Banda Aceh. The area is located in the northern Banda Aceh that is bounded with Malacca Strait from north, Lhueng Bata Sub-district from south, Syiah Kuala and Titi Panjang river from east, and from west with Kuta raja sub-district and Krueng Aceh river.

The target of study is the preparedness of the people and infrastructures to deal with tsunami in Kuta Alam area. Data collection for susceptibility of the building conducted by direct survey toward all the constructions while that for the community preparedness through direct interview and questionnaire. The results are important for identifying the risk level of tsunami catastrophe. There are three parameters for analysing the grade of susceptibility toward the threat of tsunami as displayed in the following table 1.

| Parameter                      | Score |
|--------------------------------|-------|
| Building Condition             | $F_{wb} = 3$ |
| Inundation Zone                | $F_{w} = 2$ |
| Sea Defence                    | $F_{ws} = 1$ |

3. Community preparedness analysis
The preparedness is a series of organised activity conducted to cope with disaster properly [6]. According to Head of Disaster Relief Agency in 2012, communities are the main actor to relieve the disaster. In this case, people are expected independently able not only to adapt and overcome hazardness but also could relieve immediately from the disaster impact consequences. The calcification of the level of community preparedness against tsunami disasters is shown in the table 2.

| Community Preparedness | Level      | Score |
|------------------------|------------|-------|
| Low                    | Bad        | < 35  |
| Medium                 | intermediate | 35 – 50 |
| High                   | good       | > 50  |

Preparedness is a planning process for disaster management. Scenarios and objectives are set and agreed upon to prevent and reduce the impact of disasters [8]. The purpose of community preparedness is to reduce danger, reduce the vulnerability of the community, reduce the impact of disasters and can establish cooperation between communities [9].

4. Experimental procedure
There are three parameters for determining the level of building vulnerability those are (i) physics condition of the building, (ii) the height of inundation zone, (iii) Natural or artificial protection (sea defence) such as coastwise woods and sea wall [10-14]. Based on the parameter above, the approachment that can be conducted to calculate the level of building vulnerability toward the tsunami as followed below.

$$BTV\% = \frac{(F_{wb} \times F_{ch}) + (F_{wi} \times F_{ci}) + (F_{ws} \times F_{cs})}{\sum_{k=1}^{n}(F \times m \times k)} \times 100$$ (1)
In which $F_{wb}$ is the building weigh factor, $F_{cb}$ is the building condition factor, $F_{wi}$ is the inundation weigh factor, $F_{ci}$ is the inundation factor, $F_{ws}$ is the sea defence weigh factor, $F_{cs}$ is the sea defence factor, $k$ is the constanta and $F_{cmaks}$ is the indicator maximum.

In order to know the community level preparedness and readiness in each area, the questions of questionnaire are classified into five parameters group. They are (i) legislation and contiguity, (ii) organization, (iii) funding, (iv) capacity development, (v) disaster relief and recovery. Each question would be responded “Yes” or “No”. Respondent would be scored “1” for “yes” and scored “0” for responding “No”.

For community preparedness level, the process of interviewing data collected conducted with : (i) percentage of question indicator, which is every question has equal scoring system so that the scores between 0-100 %, (ii) scoring for each question from each indicator with score “1” for responding “yes” and score “0” for answering “No”. The levels of community preparedness and readiness to deal with tsunami are classified into three levels, low, medium, and high [15]. Defines risk marking as one of methodology to determine the scope of risk through analysing conduct toward potential disaster and evaluate existing vulnerable conditions that causes a threat or disadvantage for the population, properties, lives, and local environment [16]. Another approachment risk can be identified by observing threat, vulnerability and capacity.

\[ Risk = \frac{Hazard \times Vulnerability}{Capacity} \]  \hspace{1cm} (2)

5. Results and discussion

Kuta Alam subdistrict is one of the areas prone to tsunami disasters because the area is side by side with the sea. The level of vulnerability of the buildings varies from low to high. The level of community preparedness is relatively low. The level of disaster risk is potentially low for the Beurawe and Kota Baru areas. Potentially moderate to high level of disaster risk for the Lampulo, Lamdingin, Lambaro Skep, Peunayong, Keuramat, Mulia, Bandar Baru and Laksana areas. The experience of the tsunami disaster makes the level of community preparedness better.

Analysis result toward the physics of buildings, the height of tsunami swamp in 2004 that appeared in figure 1a [15], and condition of sea defence acquired level of building tsunami vulnerability ($BTV$) in Kuta Alam sub-district shown in table 3. Spreading each building tsunami vulnerability seen in building tsunami vulnerability map (figure 1b). Community preparedness and awareness in each area in Kuta Alam sub-district clearly shown by the map of community capacity in figure 1c.

| Building Tsunami Vulnerability Level | Amount (unit) | Ratio (%) |
|-------------------------------------|--------------|-----------|
| Very High                           | 197          | 1.79      |
| High                                | 6.088        | 55.17     |
| Medium                              | 3.885        | 35.21     |
| Low                                 | 864          | 7.83      |
| Summary                             | 11,034       | 100       |

Based on analysis result, building vulnerability and community tsunami awareness above, the level of disaster risk in Kuta Alam relatively high, whereas nine villages still potentially risk of disaster at medium to high except for Gampong Beurawe and Kota baru that were not impacted by the water of last tsunami on 26 December 2004. Tsunami risk map for Kuta Alam based on vulnerable building analysis and community tsunami awareness level presented in figure 1d.
Figure 1. Kuta Alam sub district map; (a) inundation zone, (b) building tsunami vulnerability, (c) community capacity, (d) tsunami risk.

6. Conclusion
It is concluded that the level of tsunami risk in Kuta Alam low to high. The level of building tsunami vulnerability (BTV) in Kuta Lama is various, the percentage for very high with 1.79%, high 55.17%, medium 35.21% and low 7.83%. The community preparedness and awareness of the tsunami relatively low, that is average 32.17%. The experience of survivors determines the tsunami disaster preparedness and awareness. The worse impact of the disaster experience in 2004 consequently to the community higher awareness level, and vice versa.

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