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EARTHQUAKE VULNERABILITY ASSESSMENT (EVAS): ANALYSIS OF ENVIRONMENTAL VULNERABILITY AND SOCIAL VULNERABILITY IN RANAU AREA, SABAH, MALAYSIA

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ABSTRACT

Earthquakes are one of the most common and widely distributed natural risks to life and property. There is a need to identify the possible risk by assessing the vulnerability of the research area. The topic on Earthquake Vulnerability Assessment (EVAs) in Malaysia is very new and received little attention from geoscientists and engineers. Taking the 5.0 Ranau Earthquake 2015 as research study, the research's main objective was to identify the social vulnerability and environment vulnerability on that area. The framework was formulated semi quantitively through the development of database for risk elements (properties) based on the information from secondary data, literature review and fieldwork. The vulnerability parameter includes social status (injury, fatalities, safety, loss of accommodation and public awareness) and interference of environment (affected period, daily operation and diversity). Each considered parameter in the vulnerability parameter is allocated with certain index value ranges from 0 (0% damage/victims/period),0.25 (1-25% damage/victim/period), 0.50 (26-50% damage/victims/periods), 0.75 (damage/victims/period), and 1.0 (75-100% damage/victim/periods). The value obtained from field work are calculated by using formula and are classified into five classes of vulnerability namely class 1 (<0.20): Very Low Vulnerability: Class 2 (0.21-0.40): Low Vulnerability; Class 3 (0.41-0.60); Medium Vulnerability; Class 4 (0.61-0.80): High Vulnerability; and Class 5 (>0.81): Very High Vulnerability only. Results from this study indicate that a further study is needed to the area of high to very high vulnerability only. This approach is suitable as a guideline for preliminary development in the research area and potentially to be extended with different background and environments.

KEYWORDS

Earthquake Vulnerability Assessment, secondary data, parameter, geoscientists.

1. INTRODUCTION

The aim of this paper is to investigate the social vulnerability and environment vulnerability of the research area which is Ranau, Sabah. Ranau is a rural district located in North Borneo, Sabah, Malaysia. The seismic activities in this area is considered as one of the most active in this country due the movement of a few major plates around Sabah area which are Eurasian plates, Indian-Australians plates and Philippine-Caroline-Pacific plate [1]. The movement of these plates resulted a few active faults around Sabah area. The recent Ranau Earthquake 2015 is due to movement of the active fault which is the Lobou-Lobou Fault on the area. The earthquake has caused a lot of negative implications such as it triggered another natural hazard (rockfall, mudflow and landslides) to occur, as well as building destructions, loss of life, water shortage and disturbance in daily life. It took months and some needs years to recover, however there are a few aftershocks recorded even after a few years of the Ranau Earthquake 2015. This means that this area is exposed to so many dangers in the future. It is likely to be under serious threat of the implication of the seismic activities. Hence, the earthquake vulnerability assessment is needed so that the hazard can be managed properly in the future to minimize the negative impacts.

The term 'vulnerare' comes from the Latin word which means 'to wound' or 'to be susceptible'. It is also defined as 'exposed to damage and danger; not protected from danger. A researcher defined vulnerability as the degree of loss (damage) of an element or a few elements which is unprotected/exposed to natural hazard [2]. In certain magnitudes. Vulnerability can also be defined as the degree of loss to a given element at risk, or set of such elements, resulting from an earthquake of a given magnitudes or intensity, which is usually expressed on a scale from 0 (no damage) to 10 (total loss).

2. RESEARCH AREA

The research area which is the Ranau area is located in the state of Sabah, Malaysia (Figure 1). Ranau is one of the famous tourist attraction in Sabah because of the magnificent views of Mount Kinabalu and the cool weather [3-5]. This town is growing larger which is the local communities are increasing in number, more economic activities and town development are being held here every day.

Figure 1: The location of the research area in Sabah shown in the white box. (Source: Google Map)

As mentioned before, the location of the research area is determined by a few important aspects which are the information are gathered through finding literature reviews, secondary data and field observation [6]. There are four main locations have been determined (Figures 2-5). Among the four-main location chosen sixty readings have been recorded during field observation.

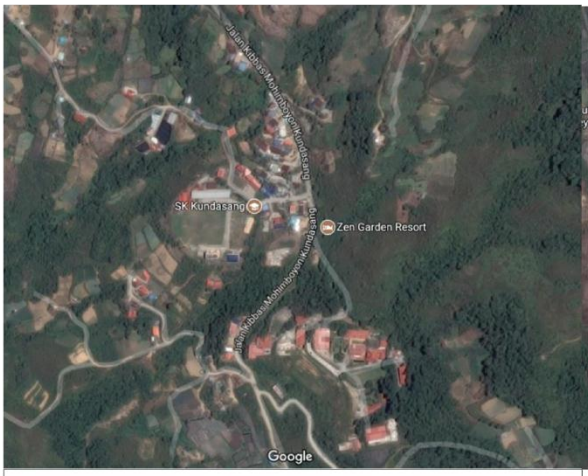

Figure 2: Location 1 is in Kg. Dumpiring, Kundasang.

Figure 3: Location 2 is in Kg. Kibbas-Mihomboyon, Kundasang.

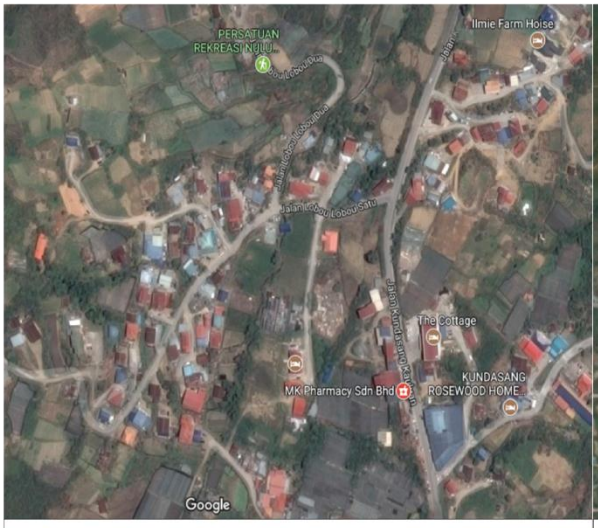

Figure 4: Kg. Location 3 in Lobou-Lobou, Kundasang.

Figure 5: Location 4 in Kg. Mesilau, Kundasang.

3. MATERIALS AND METHODS

This research focuses on the social vulnerability and environment vulnerability analysis in Ranau area, Sabah, Malaysia. Figure 6 shows the flowchart on how this research is carried out.

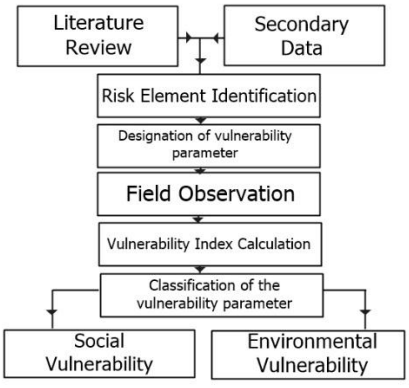

Figure 6: The flowchart shows how the social and environmental vulnerability analysis is carried out.

Literature reviews and finding secondary data are conducted at the beginning of the research to gather information about the research background. The seismic activities, natural hazards history and earthquake history are recorded if any of these will affect the vulnerability of the research area. It is important to identify the risk elements before the determination of vulnerability parameter [7]. There are two vulnerability parameters for this study, they are social vulnerability and environmental vulnerability. These parameters including injury, fatalities, safety, loss of accommodation, public awareness, affected period, daily operation and diversity. These to parameter are chosen based on the availability of secondary data on the research area. Data is taken during field observation so that the index value of the data can be calculated [8]. To generate value for each parameter, this vulnerability assessment is allocated with certain index value ranges from 0 (0% damage/victim/period), 0.25(1-25% damage/victim/period), 0.50(26-50% damage/victim/period), 0.75(51-75% damage/victim/period) &1.00(75-100% damage/victim/period).

The data fields are then re-analyzed based on Standardization Method introduced by a researcher which aim to rescale the data field by Linear Transformation Numerical (LTN) approach which starting from 0.00 to 1.00 by applying the following equation [3]:

Standardization Method = Raw data/ Raw data Maximum

The social vulnerability index will be calculated according to this formula;

Social Vulnerability (Vs) = $\frac{(5\ x\ as)+(4\ x\ bs)+(3\ x\ cs)+(2\ x\ ds)+(1x\ es)}{15}$

Where,

as: injury; *bs*: fatalities
cs: safety; *ds*: loss of accommodation; and *es:* public awareness.
The environmental vulnerability index will be calculated according to this formula;

Environmental Vulnerability (Ve) = $\frac{(3\ x\ ae)+(3\ x\ be)+(1\ x\ ce)}{6}$

Where,
ae: affected period; *be*: daily operation
ce: diversity;

Then the value of will be classified into five classes of vulnerabilities, namely:

a) Class 1 (<0.20) (very low vulnerability);
b) Class 2 (0.21-0.40) (low vulnerability);
c) Class 3 (0.41-0.60) (moderate vulnerability);
d) Class 4 (0.61-0.80) (high vulnerability)
e) Class 5 (>0.81) (very high vulnerability)

4. RESULTS AND DISCUSSION

Table 1 and Table 2 show the index value of social vulnerability and index value of environmental vulnerability that are obtained from field observation. Based on Table 1, the index value of injury, fatalities, safety, loss of accommodation and public awareness are 0.56, 0.19, 0.63, 0.63 and 0.56 respectively [9]. The index value of injury, safety, loss of accommodation and public awareness the average value are more than 0.50 except the index value of fatalities which is only 0.19. This is because there are very few incidents of loss of lives due to the seismic activities in the research area. Table 2 shows the index value for environmental vulnerability which are 0.69 for affected period, 0.63 for daily operation and 0.44 for diversity. The social vulnerability (Vs) and the environmental vulnerability (Ve) of the research area are calculated by using formula below;

Social Vulnerability (Vs),

$= \frac{(5\ x\ as)+(4\ x\ bs)+(3\ x\ cs)+(2\ x\ ds)+(1x\ es)}{15}$

$= \frac{(5\ x\ 0.56)+(4\ x\ 0.19)+(3\ x\ 0.63)+(2\ x\ 0.63)+(1x\ 0.56)}{15}$

=0.48 (moderate vulnerability)

Environmental Vulnerability (Ve),

$= \frac{(3\ x\ ae)+(2\ x\ be)+(1\ x\ ce))}{6}$

$= \frac{(3\ x\ 0.69)+(2\ x\ 0.63)+(1\ x\ 0.44)}{6}$

=0.63 (high vulnerability)

Table 1: Index Value of Social Vulnerability (Vs)

No.	Explaination	Damage Percentage (%)	Value Index	Explaination	Kg. Dumpiring	Jln Kibbas Mihomboyon	Kg. Lobou-Lobou, Kundasang	Kg. Mesilau	Index Value (average)
1	Injury	0	0	Very low					0.56
		1-25	0.25	low					
		26-50	0.5	moderate		√	√	√	
		51-75	0.75	high	√				
		76-100	1.0	Very high					
2	Fatalities	0	0	Very low		√			0.19
		1-25	0.25	low	√		√	√	
		26-50	0.5	moderate					
		51-75	0.75	high					
		76-100	1.0	Very high					
3	Safety	0	0	Very low					0.63
		1-25	0.25	low					
		26-50	0.5	moderate		√		√	
		51-75	0.75	high	√		√		
		76-100	1.0	Very high					
4	Loss of accommodation	0	0	Very low					0.63
		1-25	0.25	low					
		26-50	0.5	moderate	√	√			
		51-75	0.75	high			√	√	
		76-100	1.0	Very high					
5	Public Awareness	0	0	Very low					0.56
		1-25	0.25	low					
		26-50	0.5	moderate	√	√		√	

		51-75	0.75	high			√		
		76-100	1.0	Very high					

Table 2: Index Value of Environmental Vulnerability (Ve)

No.	Explaination	Damage Percen-tage (%)	Value Index	Explaination	Kg. Dumpiring	Jln Kibbas Mihomboyon	Kg. Lobou-Lobou, Kundasang	Kg. Mesilau	Index Value (average)
1	Affected Period	0	0	Very low					0.69
		1-25	0.25	low					
		26-50	0.5	moderate				√	
		51-75	0.75	high	√	√	√		
		76-100	1.0	Very high					
2	Daily Operation	0	0	Very low					0.63
		1-25	0.25	low					
		26-50	0.5	moderate		√		√	
		51-75	0.75	high	√		√		
		76-100	1.0	Very high					
3	Diversity	0	0	Very low					0.44
		1-25	0.25	low				√	
		26-50	0.5	moderate	√	√	√		
		51-75	0.75	high					
		76-100	1.0	Very high					

The index value for each of the social vulnerability and environmental vulnerability are based on the four-chosen location around the research area through fieldwork observation (Figures 2-5). The index value for social vulnerability is 0.48 which is classified as moderate vulnerability. These results show that the social status for this area is in moderate level. The environmental vulnerability from the calculation shows that this area has quite high vulnerability. This means that the interference of environment of this area is high. The seismic activity on this area has caused high interference of environment (Figures 7-10).

Social Vulnerability analysis in this study involves a few parameters such as injury, fatalities, safety, loss of accommodation and public awareness. The social vulnerability index is 0.48 which is the vulnerability is in moderate level. This means that the area is still safe for the residents to live in and able to do their daily activities although there are a few physical injury incident or loss of accommodations due to the seismic activities. The public awareness is considered as in moderate level. Base on my field work survey, the residents of this area are still realized about the danger of the hazard, but some of them prefer to ignore because they have nowhere to go and lack of resources to rebuild the damages caused by the earthquakes (Figures 7-10).

Environmental Vulnerability analysis in this study involves a few parameters such as affected period, daily operation and diversity. The Environment Vulnerability index value which is obtained from fieldwork and calculations is 0.63 which is categorized in high vulnerability class. This value indicates that the environment vulnerability of the research area is very high. The research area affected over a long period of time not rebuild or not getting fix as soon as possible, where through my field observation, the damage houses, public facilities, or building structures are not fixed yet after the strong earthquake that happens two years ago (Figures 7-10). Most damage on the buildings are still can be observed clearly until today worse than it, people are still living inside the buildings. The daily operation of the residents in the research area is slightly affected due to this because some facilities unable to use. The diversity of the research are also affected adversely due to this constraints. As mentioned before, lack of budgets to rebuild the area is the main reason why the environmental vulnerability is high.

Figure 7: Damaged house in Kg. Mesilau due the seismic activities in the area

Figure 8: Extremely damaged on column structures caused by the seismic activities in the area.

Figure 9: A house located in Kg. Lobou-Lobou Kundasang destroyed by the 2015 Ranau earthquake. The damage is very visible and dangerous, but the resident of the house is still living inside the house.

Figure 10: The landscape of the research area is highly affected due to the seismic activity.

5. CONCLUSION

In the light of available information, the following conclusion may be drawn from this study;

1. The ideal index value suggestion for social vulnerability are as follows;
   - injury: 0.56
   -
   - fatalities: 0.19
   - safety: 0.63
   - loss of accommodation: 0.63
   - public awareness: 0.56
2. The Social Vulnerability of the research area is 0.48 which indicates the area has moderate level of vulnerability.
3. The ideal index value suggestion for environment vulnerability are as follows;
   - Affected period: 0.69
   - Daily operation: 0.63
   - diversity: 0.44
4. The Environment Vulnerability of the research area is 0.63 which indicates the area has high level of vulnerability.
5. Further study is needed especially from moderate to high vulnerability area.
6. This assessment approach is suitable as a guideline for preliminary development planning, control and manage the risk in the study area and potentially to be extended with different background environments.

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REFERENCES

[1] Tongkul, F. 2015. Status of Mount Kinabalu Water Catchments after June 2015 Ranau Earthquake – Lesson Learned. International Conference on the Heart of Borneo, Kota Kinabalu. 11 – 12 November.

[2] Varnes, D.J., IAEG Commissions on Landslide. 1984. Landslide hazard zonation – a review of principles and practices. Paris: UNESCO. DOI: 10.1007/BF02594758.

[3] Voogd, H. 1983. Multi-criteria evaluation for urban and regional planning. Pion. London, 367.

[4] Adger, W.N. 2006. Vulnerability. Glob Environ Change, 16, 268-281.

[5] Roslee, R., Jamaludin, T.A., Simon, N. 2017. Landslide Vulnerability Assessment (LVAs): A Case Study from Kota Kinabalu, Sabah, Malaysia. Indonesian Journal on Geoscience, 4 (1), 45-59.

[6] Roslee, R., Jamaludin, T.A., Talip, M.A. 2011. Aplikasi GIS dalam Pentaksiran Risiko Gelinciran Tanah (LRA): Kajian Kes bagi kawasan sekitar Bandaraya Kota Kinabalu, Sabah Malaysia. Bulletin of the Geological Society of Malaysia, 57, 69-83. DOI:10.55393/jgg. v4n1p18.

[7] Roslee, R., Jamaluddin, T.A. 2012. Kemudah terancaman Bencana Gelinciran Tanah (LHV): Sorotan Literature dan Cadangan Pendekatan Baru untuk Pengurusan Risiko Gelinciran Tanah di Malaysia. Bulletin of the Geological Society of Malaysia, 58, 75-88.

[8] Roslee, R., Jamaluddin, T.A., Talip, M.A. 2012. Integration of GIS using GEOSTAtistical INTerpolation Techniques (Kriging) (GEOSTAINT-K) in determine model for landslide susceptibility analysis (LSA) at Kota Kinabalu, Sabah, Malaysia. Journal of Geography and Geology, 4 (1), 18-32.

[9] Tongkul, F. 2015. The 2015 Ranau Earthquake: Cause & Impact. Sabah Society Journal 32, 1-28.