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SPATIAL EVACUATION ANALYSIS BASED ON MOUNT KABA VOLCANO, BENGKULU INDONESIA DISASTER MITIGATION ERUPTION

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ABSTRACT

This study aims to analyze the zoning of the eruption hazard, the area of land affected, and the determination of the evacuation route based on the eruption mitigation of the Mount Kaba Volcano. This study uses the interpolation method and maximum likelihood for determining the type of land use and the network analyst approach for determining the distance of the effective evacuation route. The zoning for the Mount Kaba Volcano eruption in Selupu Rejang and Sindang Kelingi Districts can be divided into 4 zonings. The first is the forbidden zone (0-3km) with an affected area of 1,431.37 ha. The second hazard zone I (3-5 km) with an affected area of 1,300.28 ha. The three danger zones II (5-7 km) with an affected area of 1,464.78 ha, and the four moderate danger zones (7-10 km) with a land area of 1,045.2 ha which has the potential to be affected by the eruption of Mount Kaba Volcano. The land uses consist of 1803 ha of forest, 2895.3 ha of gardens, 186.3 ha of fields, 213.95 ha of shrubs, and 143 ha of settlements. The evacuation route for the Mount Kaba Volcano eruption disaster can be divided into 3 routes. First evacuation route I with a length of 7.98 km, evacuation route II with a length of 11.89 km, and evacuation route III with a length of 5.8 km which can be utilized by the community in mitigating volcanic eruptions.
Keywords: Mitigation, Evacuation Route, Mount Kaba

INTRODUCTION

Indonesia is geographically located at the confluence of 3 world tectonic plates, i.e the Indo-Australian plate, the Passive plate, the Eurasian plate (BNPB, 2017). The influence of Indonesia's location makes Indonesia vulnerable to natural disasters (Sri Winarni, 2016; Pradiptasari, 2015; Setyadi, 2016). Indonesia is not only vulnerable to floods, landslides, earthquakes, tsunamis and tornadoes but also vulnerable to catastrophic eruptions. The territory of Indonesia is traversed by two active mountain ranges in the world, the Pacific Circum and the Mediterranean Circum, which results in Indonesia having many volcanoes (Suryaningsih, 2017). Indonesia consists of a row of 129 active volcanoes that make Indonesia vulnerable to catastrophic eruption eruptions (BNPB, 2017).

Volcanoes are a form of piles (cones and others) on the surface of the earth that are built by piles of eruptive spices or places where molten rock (magma)/lose spices/gas comes from the inside of the earth (BAKORNAS PB, 2007). Besides its existence has great benefits for the life and dynamics of the natural surroundings, volcanoes also save the potential for natural disasters that are quite powerful. Volcanic eruptions are part of volcanic activity known as "eruption" (BNPB, 2017). Volcanic eruptions are very dangerous because they produce hot lava flows, hot clouds, toxic (deadly) gas, and eruption lava.

Disaster is a condition that causes casualties, damage and losses (Isnainiati, 2014). Disaster is a series of events that threaten and disrupt people's lives and livelihoods caused by both naturals, non-natural and human factors, resulting in human casualties, environmental damage to property losses, and psychological impact (Law No 24, 2007). Disaster (disaster) is a phenomenon that occurs because the components of the trigger (trigger), threats (hazards), and vulnerability (vulnerability) work systematically together, causing a risk to the community (BNPB, 2011; Hayati, 2019).

Indonesia is a country that has a very complex type of disaster, so the implementation of disaster management should use the paradigm of disaster risk reduction through mitigation programs (Isnainiati, 2014). To reduce the risk of disaster, it is necessary to have a community order that is in harmony with the potential hazards in the region. Efforts that can be made are building disaster management systems. Disaster management is a series of activities consisting of disaster events, emergency response, rehabilitation, reconstruction, mitigation, and preparedness to face the next disaster (Law No 24, 2007). One part of disaster management is disaster mitigation, which is a series of efforts to reduce disaster risk through physical development as well as awareness-raising and capacity building to deal with disaster threats (BAKORNAS PB, 2007; Setyowati, 2013). Mitigation is a stage that aims to reduce the likelihood of the negative impact of a disaster event on life or can be interpreted as mitigation as taking actions to reduce the effects of a hazard before the hazard occurs (Nirmalawati. 2011). The purpose of mitigation is to reduce the likelihood of risk, reduce the consequences of risk, avoid risk, accept risk, and transfer, share, or disseminate risk (Agung, 2018; Kusumasari, 2014).

Evacuation is a radical solution to protect human life that may not always be carried out under favourable conditions and can have negative consequences if not properly prepared. However, evacuation is the most effective way to reduce the number of victims. evacuation system can be five components, i.e early warning system, gathering point, the evacuation route, evacuation route, communication and transportation, and evacuation shelter/barracks (Blong, 1984; Ema, 2005). Kaba Volcano is one of the active volcanoes in Indonesia, precisely in Rejang Lebong Regency, Bengkulu Province. This mountain has an altitude of 1,952 meters above sea level consisting of 2 craters. The last eruption of Mount Kaba occurred on March 26, 1952, which was marked by eruption ash and volcanic rumble, then in 2000, there was an increase in the earthquake activity of Mount Kaba triggered by the Bengkulu tectonic earthquake measuring 7.8 on the Richter scale. The character of the Kaba Volcano eruption is explosive. This eruption caused a rain of ash along with hot clouds and lava. The duration of this explosive type of

volcanic eruption is quite long, the centre of eruption often moves, phreatic and magmatic phreatic eruptions occur frequently. Based on observations made by researchers, it is known that there are 2 craters of Mount Kaba, one of which is still active today. To reduce the negative impact of the Mount Kaba volcano eruption disaster, it is necessary to do disaster mitigation.

In carrying out disaster mitigation actions, the initial step we must take is to conduct a disaster risk assessment of the area. In calculating the disaster risk of an area we must know the hazards, vulnerability and capacity of an area based on the characteristics of physical conditions and the region. One of the disaster mitigation efforts in the active volcano area is by making evacuation routes. As one part of the disaster response system, the evacuation route has an important role. This is related to its existence as a supporter of population mobility during disasters. In this study, researchers used geographic information system technology which is one of the tools that can be used as an initial step in implementing disaster mitigation programs with interpolation methods and maximum likelihood with a network analyze approach. Interpolation is a method for obtaining data based on some data that is known. In mapping, interpolation is the process of estimating values in areas that are not sampled or measured, so a map or distribution of values is made for the entire area. Spatial interpolation assumes that data attributes are continuous in space and that these attributes are spatially dependent (Kristant, 2005).

Network Analyst is a type of network analysis to determine the area covered by all roads that are accessible (roads that are not blocked). Network Analyst uses impedance in determining the best path. Network analyst has various functions including 1) Direct path analysis. This analysis is used to find the closest path from one point to another: 2) In network analysis there is also an optimum routing function that is used to find routes to get to many locations in one go: 3) In addition to the route or path, network analysis can also be used to analyze the closest facility to get service; 4) Drive time analysis is an analysis used to analyze travel time to the centre of the facility; 5) Being a driver's direction is like replacing a paper map or functioning as a mapquest. To analyze the eruption zoning, the area of land affected and the determination of the Gunung Api Kaba eruption evacuation route, it is necessary to conduct a study.

METHODS

This study uses the method of interpolation and maximum likelihood with a network analyst approach. This research was conducted in Selupu Rejang District and Sindang Kelingi District. Tools and materials used include laptops, cellphone stationery, Google Earth software, GIS, Microsoft Excel and GPS essential.

RESULT

Based on observations, field surveys and data processing carried out through GIS, it can be described zonation of the Mount Kaba volcano eruption, the area of land affected and the eruption disaster evacuation route as follows:

3.1 Mount Kaba Volcano Eruption Zoning

Selupu Rejang Sub-district and Sindang Kelingi Sub-district Rejang Lebong Regency are areas that are potentially affected by the eruption of the Mount Kaba Volcano, this area is located at an altitude of 900 masl to 1952 masl (Peak of Mount Kaba). For more details, please look at the following picture:

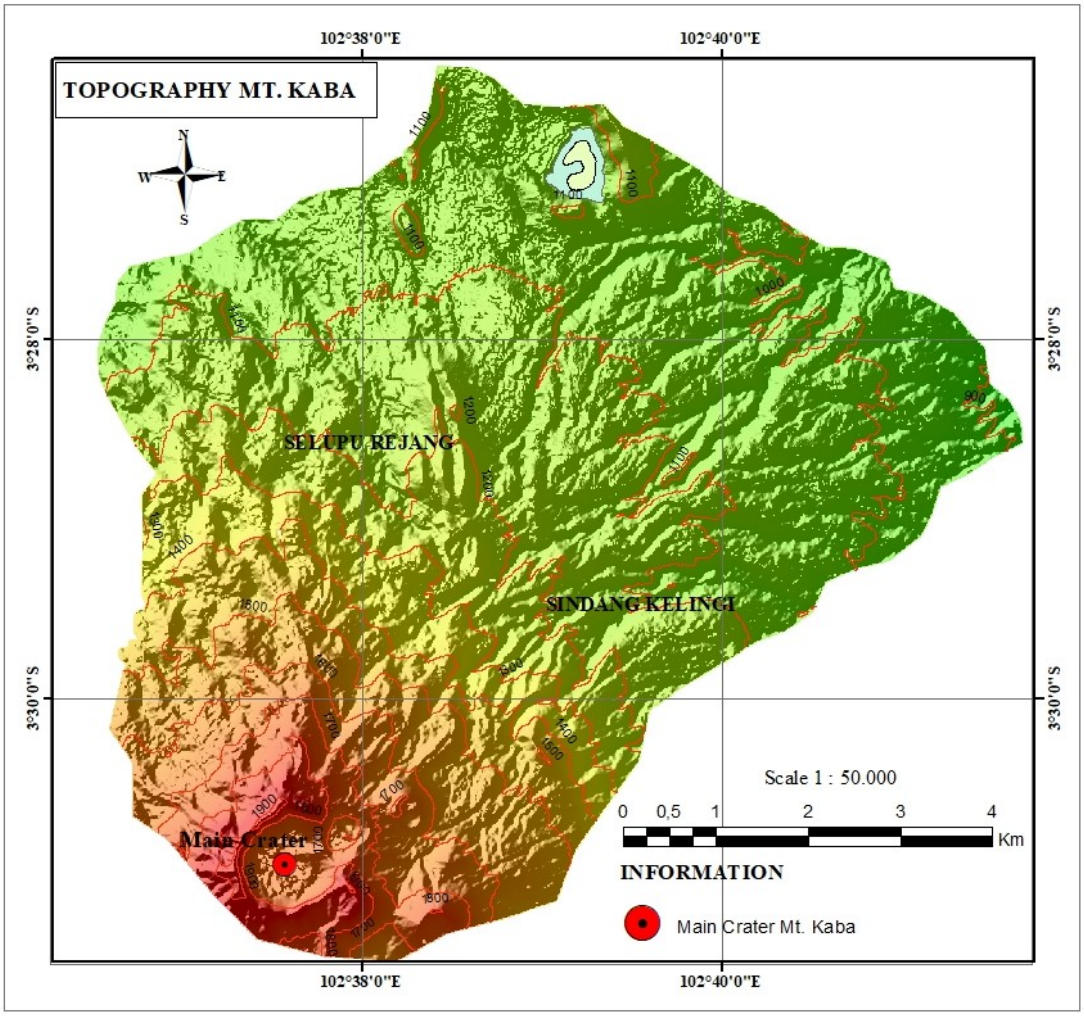

Figure 1. Map of The topography of Mount Kaba Volcano

Volcano eruption disaster zones can be divided into 5 zones, namely:

a. Restricted zone (0-3 km)
b. Danger zone I (3-5 km)
c. Hazard zone II (5-7 km)
d. Medium danger zone (7-10 km)
e. Safe zone (> 10 km)

Based on the processed data, Selupu Rejang District and Sindang Kelingi District Rejang Lebong Regency are divided into 4 zones. for more details can be seen in the following Table 1 below.

Table 1. Zonation of Mount Kaba Volcano Eruption 1952 masl

No	Eruption Zone	Affected Land	Ha area	Area Km2
1	Forbidden Zone (0-3 km)	Forest	1.410,98	14,11
		Garden	19,49	0,19
		Bush	0,90	0,01
	Total Area		1.431,37	14,31
2	Danger Zone I (3-5 km)	Forest	383,25	3,83
		Garden	773,85	7,74
		Bush	64,10	0,64
		Field	73,98	0,74
		Settlement	5,10	0,05
	Total Area		1.300,28	13,00
3	Danger Zone II (5-7 km)	Forest	8,78	0,09
		Garden	1.235,53	12,36
		Field	104,31	1,04
		Bush	36,76	0,37
		Settlement	79,40	0,79
	Total Area		1.464,78	14,65
4	Medium Danger Zone (7-10 km)	Garden	866,49	8,66
		Field	8,02	0,08
		Bush	112,19	1,12
		Settlement	58,50	0,59
	Total Area		1.045,20	10,45

Source: Processed Primary Data 2019

The data table above shows that the Mount Kaba volcano eruption disaster in Selupu Rejang District and Sindang Kelingi District is divided into 4 zones. First, the forbidden zone with a radius of 0-3 km with an area of land affected that is an area of 1,431.37 Ha. Second, the danger zone I with a radius of 3-5 km with an area of land that is 1,300.28 Ha. The third danger zone II with a radius of 5-7 km with an area of affected land which is an area of 1,464.78 Ha, and fourth, a medium hazard zone with a radius of 7-10 km with an area of affected land 1,045.2 ha. To see the eruption of the Mount Kaba volcano eruption in Selupu Rejang and Sindang Kelingi Districts, Rejang Lebong Regency can be seen in the following figure:

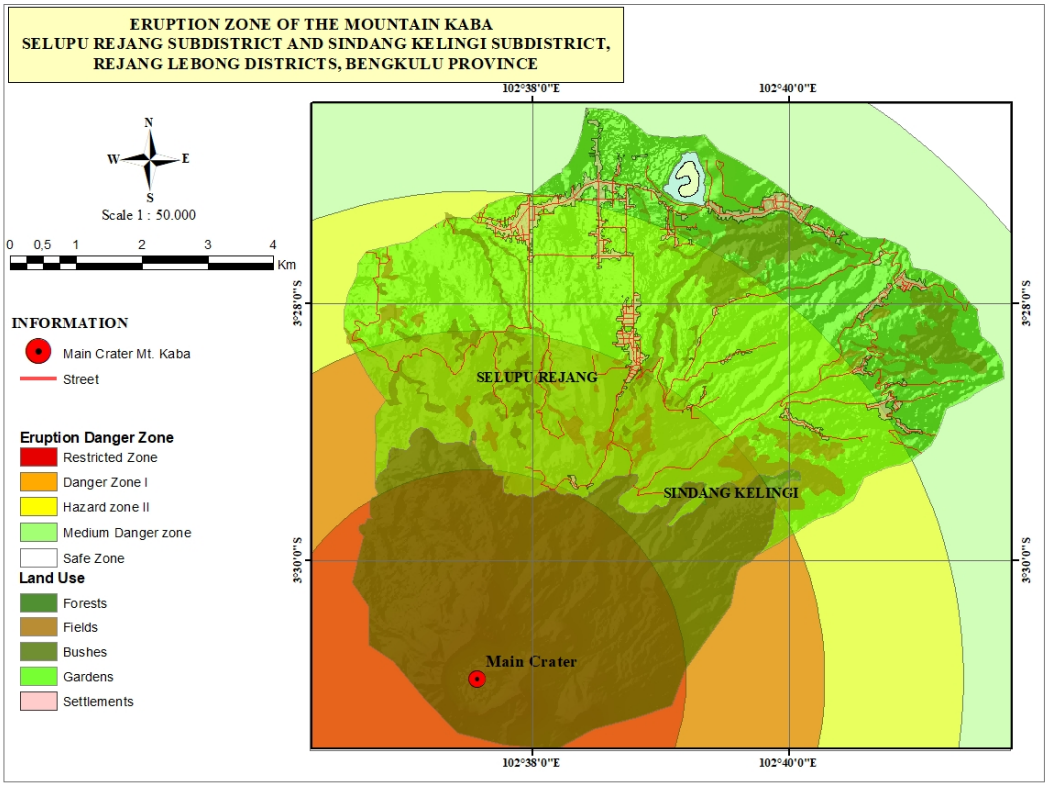

Figure 2. Zonation of Mount Kaba Volcano Eruption 1952 masl

3.2 Land Use

In general, land use in Selupu Rejang and Sindang Kelingi DistrictsRejang Lebong Regency can be described in the following table:

Table 2. Land Use District Selupu Rejang and Sindang Kelingi District Rejang Lebong Regency

No	Land Use	Ha area	Area Km2
1	Forest	1803,0	18,03
2	Field	186,3	1,86
3	Garden	2895,3	28,95
4	Bush	213,95	2,14
5	Settlement	143	1,43
	Total Area	5241,6	52,42

Source: Processed Primary Data 2019

For more details about land use in Selupu Rejang and Sindang Districts Kelingi Regency of Rejang Lebong can be noticed can be seen in the following picture:

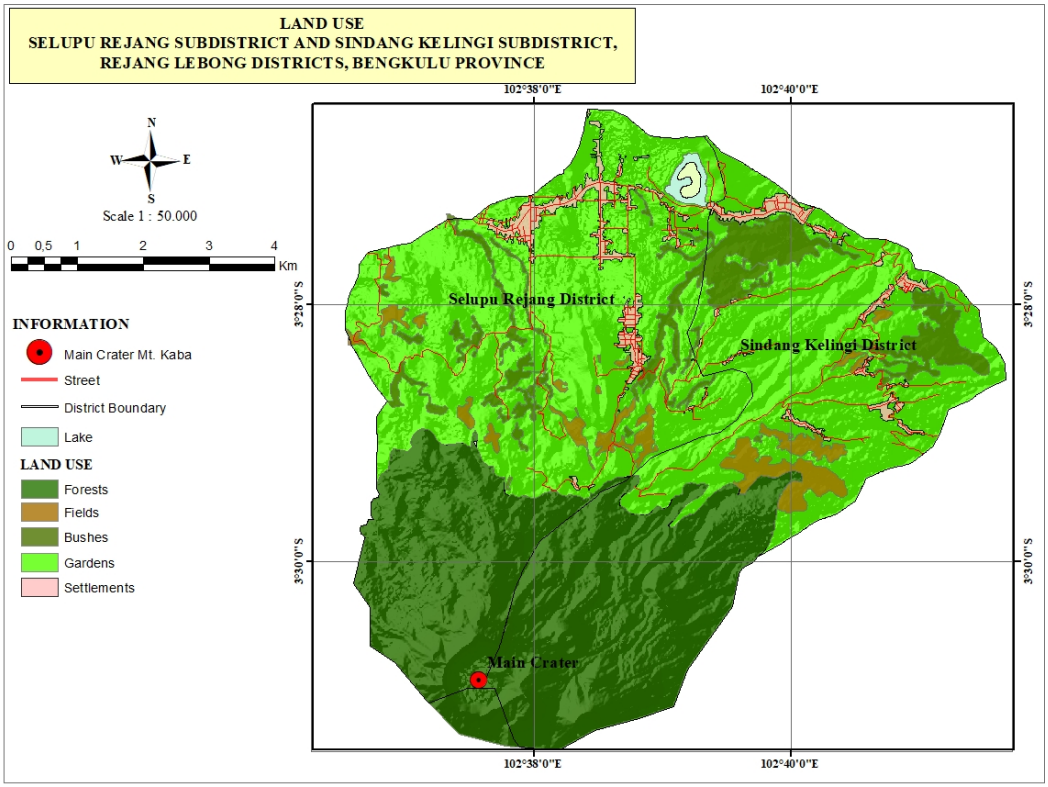

Figure 3. Land Use of Selupu Rejang District and Sindang Kelingi District Rejang Lebong Regency

3.3 Evacuation Route

Evacuation route is a path that is specifically intended to connect all areas to a safe area as a gathering point. Determination of evacuation routes following community needs is possible to minimize losses and the number of victims caused by volcanic disasters. That is because there is an infrastructure that can strengthen preparedness and reduce the vulnerability of the community in dealing with disasters. The preparedness in question is a quick action of the community to save themselves and securing possessions when there is an early warning or a phenomenon that marks a volcanic disaster (precursor) (Kristant, A. 2005). Based on the data processed, the evacuation route for the Gunung Kaba volcano eruption in Selupu Rejang and Sindang Kelingi sub-districts consists of 3 evacuation routes. The first evacuation route is 7.98km long, evacuation II is 11.89 km and evacuation III is 5.8 km. For more information, see the map below:

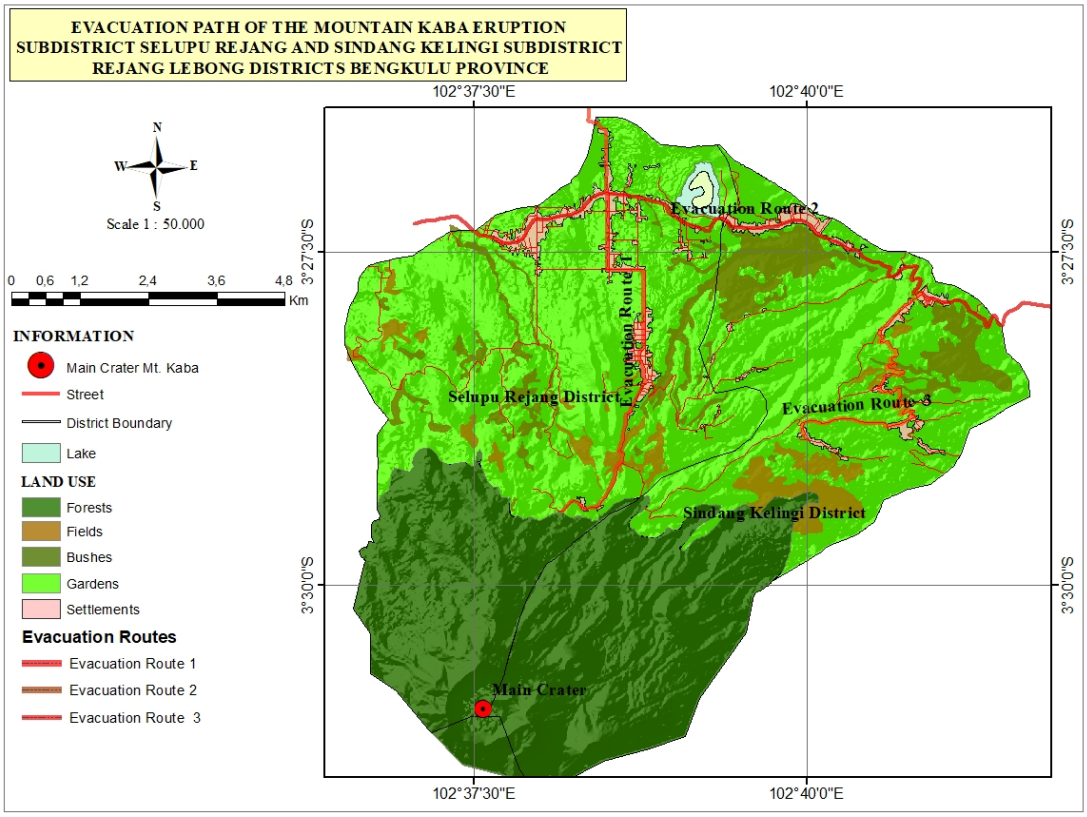

Figure 4. Evacuation Route for Mount Kaba Volcano Eruption 1952 masl

CONCLUSION

First, the eruption of the Mount Kaba volcano eruption in Selupu Rejangand Sindang Kelingi Districts, Rejang Lebong Regency can be divided into 4 zones, namely the forbidden zone, the danger zone I, the danger zone II, and the moderate danger zone. *Second*, land use in Selupu Rejang District and Sindang Kelingi District, Rejang Lebong consists of a forest with an area of 1803ha, a garden of 2895.3 ha, a bush of 213.95 ha, a field of 186.3 ha and a settlement of 143 ha. *Third*, the evacuation route for the Gunung Kaba volcano eruption in Selupu Rejang District and Sindang Kelingi District in Rejang Lebong Regency there are 3 evacuation routes. The evacuation route is effective can be used by the community in avoiding the Mount Kaba volcano eruption disaster.

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