GeoJournal of Tourism and Geosites
ISSN 2065-1198, E-ISSN 2065-0817

Year XIV, vol. 39, no. 4spl, 2021, p.1430-1438
DOI 10.30892/gtg.394spl14-787

MAPPING A ERUPTION DISASTER-PRONE AREA IN THE BROMO-TENGGER-SEMERU NATIONAL TOURISM STRATEGIC AREA (CASE STUDY OF MOUNT SEMERU, INDONESIA)

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Citation: Wahyuningtyas, N., Yaniafari, R.P., Rosyida, F., Megasari, R., Dewi, K., & Khotimah, K. (2021). MAPPING A ERUPTION DISASTER-PRONE AREA IN THE BROMO-TENGGER-SEMERU NATIONAL TOURISM STRATEGIC AREA (CASE STUDY OF MOUNT SEMERU, INDONESIA). *GeoJournal of Tourism and Geosites*, 39(4spl), 1430–1438. https://doi.org/10.30892/gtg.394spl14-787

Abstract: Tourism is a sector of the world's economy, a macro-industry, and dynamic that has the fastest growth rate in the world. Tourism is often associated with beauty and pleasure. But behind that tourism is an economic activity that is very vulnerable to natural disasters, including volcanic eruptions. Management of tourism mapping in the Semeru Volcano disaster-prone area (Bromo Tengger Semeru National Park Tourism Strategic Area) can be used as a reference in development guidelines, disaster mitigation, and recovery in tourist areas. Thus, the purpose of this study is to produce a mapping of disaster-prone areas and the distribution of tourist attractions around Semeru Volcano. The research method used is the use of ArcGIS and Microsoft Excel applications. The data used is from the Population, Tourism, and Disaster Data of Semeru Volcano. The analysis technique uses map buffering and overlaying. Based on the results of the mapping, 57 villages are predicted to be affected and experience heavy losses. The number of villages is divided into 17 villages in Malang Regency and 40 villages in Lumajang Regency. These villages belong to several sub-districts, namely Ampelgading, Poncokusumo, Tirto Yudo, Wajak, Pasrujambe, Candipuro, Pronojiwo, Pasirian, Candipuro, Tempursari, Tempeh, Sumbersuko, and Tempursari. In addition, these disaster-prone areas are areas that have a lot of tourism potential. Most of the tourist attractions are affected by the eruption zone and affected by the lava flow. The tourism objects studied in this study amounted to 23. While the tourist objects that are classified as safe amounted to 11 objects. All tourist attractions around Semeru Volcano require the provision of pre-disaster knowledge, disaster mitigation, and restoration of tourist areas. With this knowledge, tourism will become the main economic sector of the community and can recover quickly after volcanic activity.

Key words: Tourism Objects, Disaster-Prone Areas, Mapping

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INTRODUCTION

Tourism is a sector of the world economy that contributes as one of the largest contributors to the country's growth. This strategic sector is developing significantly and cannot be stopped by the progress of the times. Tourism is a macro and dynamic industry (Wahyuningtyas et al., 2019) that has the fastest growth rate in the world (Goliath-Ludic and Yekela, 2021). This sector is a field that can change the environment and socio-culture (Dayananda and Leelavathi, 2016) as well as become the wheel of economic growth (Garcia et al., 2015; Idris et al., 2021). Tourism contributes 9.9% of total employment and 10.4% of GDP worldwide (WTTC, 2017). While Asia-Pacific is the largest region for tourism and travel sector jobs in 2020. This sector accounts for 55% (151 million) of all global Travel and Tourism jobs (WTTC, 2021). Meanwhile, the number of foreign tourist arrivals in Indonesia continues to increase (BPS, 2018, 2019) which is 12.58% from 2017 (14.04 million) to 2018 (15.81 million). This potential sector can be a source of creating a healthy investment climate (Thompson, 2011), a source of job creation (Kim et al., 2016; Martin et al., 2008), a source of income (Nurhajati, 2018), a source of income generation (Du et al., 2016), and sources of state economic contributors (Idris et al., 2021).

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Tourism is often associated with beauty and pleasure. But behind that tourism is an economic activity that is very vulnerable to natural disasters. This disaster is from a hydrometerological, geological, and biological perspective. Natural disasters can include hurricanes, earthquakes, volcanic eruptions, floods, and droughts (Delita, 2017; Oloruntoba et al., 2018; Orhan, 2016). As happened in 2007 the growth of world tourism activities decreased by 3.9% after the occurrence of natural disasters and terrorism (Rindrasih et al., 2015). The contribution of the tourism sector to GDP in Asia-Pacific decreased by 53.7%, compared to the global decline of 49.1% due to the Covid-19 pandemic disaster (WTTC, 2021). Meanwhile, in Indonesia, the Lombok tourism area suffered a loss of IDR 12.15 trillion due to the earthquake (Gumelar, 2018), the number of tourists who became victims was 4,636, tourists decreased by 100,000, and the tourism sector suffered a loss of IDR 1.4 trillion (Wahyuningtyas et al., 2019). Losses in tourist areas due to the disaster also threaten the people living around Semeru Volcano.

Mount Semeru (8°06′05″LS, 112°55′E) is the highest volcano in Java (3,676 m). Semeru Volcano is one of the composite volcanoes that remains active on Earth. This mountain belongs to the massive Semeru-Tengger volcano (Solikhin et al., 2012). The area of 900 km2 around Semeru Volcano includes Jonggring-Seloko, Jambangan and Ajek-Ajek, Bromo-Tengger caldera, Mahameru-Semeru Conical Complex, and Mount Kepolo (Thouret et al., 2007). This volcano is one of the most effective lava generators on Earth. The main economic activities around Semeru Volcano which include Lumajang Regency and Malang Regency are agriculture, forestry production, and plantations.

The activities of the Semeru Volcano threaten various economic, educational, political, social and other sectors. The threat of this volcanic disaster is no exception in the tourism sector. Tourism around Semeru Volcano is one of the main economic sectors of the surrounding community. Semeru Volcano is included in the strategic tourism area of TNBTS (Bromo National Park, Tengger, Semeru). TNBTS targets in 2019 are areas with achievements of the International Geo-Ecoculture Park (Purnomo et al., 2018). The ecosystem types of this area are sub-montane, montana, and sub-alphin with large trees that are hundreds of years old (Geological Agency, 2014). Tourist attractions include meadows, lakes, pine forests, bamboo forests, campgrounds, temples, waterfalls, beaches, and baths. The majority of attractions in this area are waterfall tours including Kapas Biru Waterfall, Coban Sewu, Coban Srengenge, Coban Pelangi, Goa Tetes, Coban Trisula, Mist Rainbow, Kedung Jumali, Coban Sriti, and others. In addition, there is a Tourism Village Institute (LADESTA) in Gubugklakah Village which manages the tourism potential in the vicinity and is the main entrance to TNBTS. LADESTA there are 49,251 visitors from local tourists and 3,848 visitors from foreign tourists (Purnomo et al., 2018).

There are many related studies, but limited to the integration of tourism management between village government and local community participation (Purnomo et al., 2020; Wahyuningtyas et al., 2019, 2020), gaps and low volcano mitigation policies (Pen, 2017), planning and tourism development strategies (Jannah and Idajati, 2018), as well as identification of the potential, benefits, and carrying capacity of coastal areas (Rini et al., 2015). Meanwhile, research related to mapping has been carried out by several researchers such as mapping of volcanic erosion and gradation (Thouret et al., 2014), zoning of disaster risk areas and land use (Endarwati et al., 2017), development of applications based on Google Map or GIS which is for tourists (Anamis et al., 2017; Arifin, 2017), vulnerability mapping (Hizbaron et al., 2018), and mapping of lava flows and volcanic hazard analysis (Thouret et al., 2007). The limited integration of disaster mapping and tourist sites is a gap in increasing the role of tourism in disaster-prone areas. Based on this explanation, it is necessary to organize, manage, and regulate tourism destination managers to increase the role of tourism (Mamycheva et al., 2017; Van and Vanneste, 2015). Tourism management in the Semeru Volcano disaster-prone area can be used as a reference in development guidelines, disaster mitigation, and recovery in tourist areas. Thus, losses in tourist areas caused by the Semeru Volcano disaster can be minimized. In addition, tourism can still be projected to be the main economic sector of the community. Thus, the purpose of this study is to produce a mapping of disaster-prone areas and the distribution of tourist attractions around Semeru Volcano.

MATERIALS AND METHODS

The research method used is the GIS (Geographic Information System) technique to create a Map of Eruption-Prone Areas of Eruption and Tourism Zoning Map of the Semeru Volcano Region. This mapping uses Microsoft Excel 2010 and ArcGIS 10.4 applications. The research data uses the Indonesian Earth Map, population data from Lumajang and Malang Regencies, TNBTS tourist attraction data, DEMNAS images, Administrative Maps of Lumajang and Malang Districts, as well as other supporting data. The analysis technique uses buffering and data overlay. The buffering technique in disaster-prone areas uses a distance of 5 km and 8 km from the point of eruption.

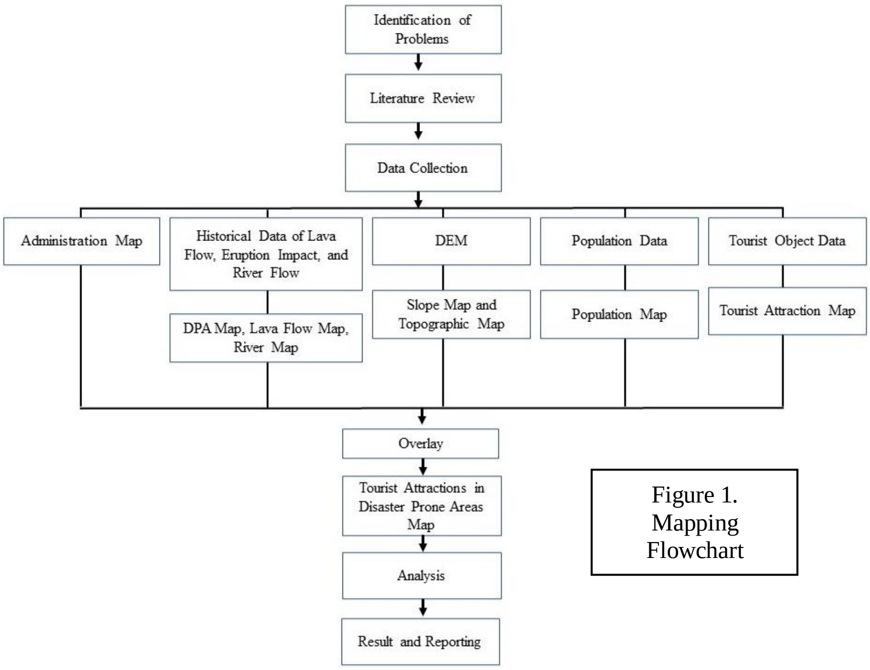

Figure 1. Mapping Flowchart

Furthermore, the buffering technique for zoning tourist objects uses a distance of 1 km from the location of the tourist attraction. The determination and classification of disaster-prone areas is divided into three, namely disaster-prone areas I, disaster-prone areas II, and disaster-prone areas III. The stages of mapping and analysis are problem identification, literature study, data collection, digitizing and inputting data, overlaying, map analysis, and results. The mapping flow chart is below.

RESULT AND DISCUSSION

The results and discussion section consists of four discussions, namely 1) the condition of the Semeru Volcano, 2) the types of Hazard of the Semeru Volcano, 3) the mapping of the Semeru Volcano disaster-prone area, and 4) the mapping of tourism objects in the disaster-prone area. The in-depth description is below.

a. Semeru Volcano Condition

Mahameru Peak is the highest peak on the island of Java (3,676 m). The lava dome of the Semeru volcano is named Jonggring Seloko (3,744 m). The slopes of the Semeru Volcano stretch to the east to the plains of Lumajang and Pasuruan. While to the west, the slopes of this mountain stretch up to the plains of Malang and Turen. Furthermore, to the north the slope is limited by the Jambangan Mountains which consists of Ranu Kumbolo, Mount Kepolo, and Mount Ayek-ayek. To the south, the development of the foothills of the Semeru Volcano is blocked by the Southern Mountains (Tertiary-aged mountains). The irregular condition of the peak of the Semeru Volcano is caused by the frequent displacement of the center of activity from northwest to southeast. The current center of activity is the Jonggring Seloko Crater emerging in the south southeast of Mahameru, which is separated by a narrow saddle. The cauliflower-shaped eruption column is constantly erupted through its crater. Generally the eruption smoke pillar reaches a height of between 300 m - 500 m above the crater. These eruption clouds are usually blown away by the wind. Sometimes the color of the eruption cloud ranges from white or gray, it can also be blackish, this depends on the ash content in it. At night, fragments of smoldering rock are often seen at the bottom of the eruption column. When the activity increases, it appears that the type of volcanic eruption is interspersed by the Stromboli type, so it can be classified that the eruption of Mount Semeru is of mixed type (Hasib et al., 2013). Semeru volcano is a strato type with a volcanic-strombolian type of eruption (Ayu et al., 2013). Ash clouds can reach a height of 4000 m above the summit, while smoldering volcanic material is thrown up to 1000 m above the crater and then falls back around the crater, and slides along the slope as far as 1500 m from the crater rim. Large eruptions of Mount Semeru are often followed by hot clouds of eruptions. During periods of activity or when activity declines, lava flows flow out of the crater to form lava tongues. The steep slopes of Mount Semeru caused some of the tip of the lava to slide and avalanches of incandescent lava to occur. Where this is sometimes accompanied by hot clouds avalanche. The increase in the activity of the Semeru Volcano is usually short-lived, while the eruption phase lasts from a few days to several months. Periods of activity are interspersed with periods of rest.

b. The Danger of the Semeru Volcano Disaster

Volcanic disasters erupt when an area whose land use, settlements, infrastructure, and others are affected by volcanic eruption materials. These materials include ash rain, toxic gases, hot clouds, lava flows, thrown stones (incandescent), and lava (floods). Based on the type of hazard, there are two kinds of hazards resulting from volcanic activity or eruptions that threaten the slopes and foothills of Mount Semeru. This type is a primary hazard and a secondary hazard (Bronto et al., 1996). Primary hazards (the result of volcanic eruptions) mostly threaten the peak and surrounding areas, while secondary hazards or rain lahars threaten the lower slopes to the foot area. Rainy lahars can occur months or years after the last eruption. Where in the last eruption, the origin of the loose material is not yet solid. Generally, lahars cause damage far down in residential areas, therefore many villages and crops were destroyed. Primary hazards (hazards that have an immediate impact) are hazards as a direct result of volcanic eruptions such as: lava fragments, lapilli, hot clouds, lava flows, ejected materials in the form of volcanic bombs, sand, and volcanic ash. During the period of activity, lava flows out of the crater through the low rim and forms lava tongues on the slopes. Its length is up to hundreds of meters with a volume of up to millions of m3. The tip of this lava tongue is easily broken into pieces, resulting in hot clouds of avalanches.

This type of hot cloud can reach a distance of 10 km from the summit at a speed of about 40-70 km/hour. However, if the volume of the lava that slides is large, the speed can reach lk 100 km/hour. Hot clouds eruption generally follow the river valley that comes from around the peak. The temperature of this hot cloud is estimated to be around 1000^0C at the eruption hole and about 400oC at the end of the stream. Ejected materials such as incandescent rock (volcanic bombs), lapilli, sand, ash, and lava fragments are generally thrown perpendicular to the top in the form of cauliflower or mushrooms. At the time of the peak of the eruption, incandescent rock (volcanic bombs) can be ejected up to approximately 8 km from the eruption hole. Bombs still burning can cause injuries and fires in homes with thatched roofs. Heavy rain of ash and sand can cause roofs to collapse, especially during the forest season and crop damage. Ash rain is also dangerous for humans because it can cause respiratory problems. Secondary hazard is a hazard in the form of rain lava (secondary lahar). The danger of rain lava (secondary lava) is an indirect hazard from volcanic eruptions. This rain lava occurs at the time of the eruption or after, which at that time there was heavy rain around the peak and its surroundings for quite a long time. In the area of Mount Semeru, lava flows are also called besuk. If it rains around the slopes of a volcano that is full of loose material, the river will carry the material from the eruption into lava. Volcanic ash causes the specific gravity of the flow to be about 2 or more. Because of this high density, lava can carry large chunks of several meters3 as if floating in it. This kind of lahar destroys anything in its path of flow. When the lava flows, it is easy to change the direction of the flow, resulting in deviation or overflow. If not long after the eruption it rained, the lava was hot because the rainwater mixed with hot cloud deposits.

c. Mapping of Semeru Volcano Disaster-Prone Areas

The mapping of the Semeru Volcano disaster is a complex mapping. This mapping requires some data analysis. The data needed in this mapping are hydrological flow, lava flow, population, slope, and the distance to the center of the eruption. Each data is analyzed one by one to be used as reference material in the formulation of policies of the Central Government, Regional Government, the community, and other related parties. This mapping analysis was also carried out to measure vulnerability in the areas of Mount Merapi (Donovan et al., 2012) and Mount Kelud (Hizbaron et al., 2018). Through this mapping, it can be seen the areas affected by lava flows and lahars.

Hydrological flow is a river path that leads to the lowest place as its estuary. The direction of river flow (hydrology) from Puncak Mahameru (peak of Mount Semeru) is dominant towards the east, southeast, south, and west (Figure 3). This condition causes the flow of lava and lava from Mount Semeru to flow following the condition of its hydrological path when it erupted (Arianto, 2015). Moreover, the hydrological flow will control the erosion and gradation of Semeru Volcano (Thouret et al., 2014). This hydrological path is estimated as modeled on the mapping of the National Disaster Management Agency (BNPB) in Indonesia. This volcanic eruption-prone area has a mountainous topography in the north. This area includes Mount Kepolo, Mount Ayek-ayek, and Ranu Kumbolo. Furthermore, the slopes of the Semeru Volcano stretch to the south and east. The southern and eastern regions are areas that belong to Lumajang Regency. While the western part, the slopes of the Semeru Volcano stretches to Malang Regency. Thus the flow of lava and lahar adjusts the hydrological path, namely to the east, south, southeast, and west.

The slope of a slope is one of the indicators in measuring the level of volcanic disaster threat. The slope value is a parameter in determining the flow of lava and lahars. The higher the slope (steep) it can reduce the height of the lava flow. On the other hand, the lower the slope of the land will expand the affected area and increase the intensity of the high lava flow. Determination of the slope of this slope using the USLE criteria (Ramdan, 2020) namely 1-2% (flat), 2-7% (slightly sloping), 7-12% (sloping), 12-18% (slightly steep), 18-24 % (steep), and >24% (very steep). The flow of lava and lava from the eruption of Semeru Volcano also follows the direction of the slope. The slope is more dominant south and southeast than north. The slope of the Semeru Volcano area can be seen on the Slope Map (Figure 1). The northern part is more dominated by mountains and hills. Where the flow of lava and lava originates in the crater of the summit of Mount Semeru. Furthermore, it flows to the dominant rivers to the south, namely Lumajang Regency and Malang Regency. The mouth of this river is the Indian Ocean. The morphology and altitude of the Semeru Volcano area can be seen on the topographic map (Figure 4). The USLE classification table in determining the slope of the Semeru Volcano area is as follows.

Table 1. Slope by USLE in the Semeru Volcano Area (Source: Research results)

No	Class (%)	Classification	Location of the slope of the Semeru Volcano
1	1 - 2	Flat	Mostly in the eastern and southeastern areas
2	2 - 7	Slightly sloping	Mostly in the east, west, south, and southeast
3	7 - 12	Sloping	Mostly in the east, west, south, and southeast
4	12 - 18	Slightly steep	Mostly in the northern and southern regions
5	18 - 24	Steep	Mostly in the northern area
6	> 24	Very Steep	Mostly in the northern area

Table 2. Population Data in Largest Affected Areas (Source: Processed from BPS Subdistrict Ampelgading, Poncokusumo, Tirto Yudo, Wajak, Pasrujambe, Candipuro, Pronojiwo, Pasirian, Candipuro, Tempeh, Sumbersuko, and Tempursari, 2020)

Classification	Total Villages	Total population (people)	Total Areas (km^2)	Population density ($people/km^2$)
Disaster-Prone Area III	3 villages in Malang Regency and 8 villages in Lumajang Regency	67,083	98.38	920.8
Disaster-Prone Area II	6 villages in Malang Regency and 7 villages in Lumajang Regency	91,726	205.9 km^2	826.48
Disaster-Prone Area I	8 villages in Malang Regency and 25 villages in Lumajang Regency	211,954	287.87 km^2	2,938.08

The Semeru Volcano disaster-prone area against mass flows (lava and lahar) may experience expansion. This also has the potential to cause cold lava flooding. It can even potentially experience hot cloud drift. It is predicted that it will hit most of the areas adjacent to rivers that originate at Mahameru Peak. This disaster-prone area covers various sides, namely 1) in the west including Kali Manjing and Kali Kembar (river route enters Ampel Gading District, Malang), 2) in the southeast includes Kali Besuk Boan and Besuk Semut (this river route enters Pronojiwo District, Lumajang), Kali Liprak (this river route enters Candipuro District to Pasiran District, Lumajang), 3) the east includes Besuk Tengah and Besuk Tompe (this river route enters Pasrujambe District, Lumajang), and then 4) the south includes Besuk Kembar, Besuk Bang, and Kali Lengkong (this river line is in Pronojiwo District, Lumajang), Kali Glidik (this river line is in Pronojiwo District to Tempursari District, Lumajang). From the expansion and deviation of hot clouds from Semeru Volcano, it is possible that it can hit villages and sub-districts around the river. The prediction of the expansion of disaster-prone areas depends on the size of the volcanic eruption. Identifying the distance of the area from the source of a volcanic eruption is a very important activity. This identification is to be able to assess areas that have the potential to be affected by material throwing from volcanic activity. Identify this distance using a buffering technique. This buffering technique uses 5 km and 8 km distances from BNPB data (Arianto, 2015; Bronto et al., 1996).

There are 8 villages included in the 5 km buffering area, namely Ngadas, Pasrujambe, Supiturang, Oro-Oro Ombo, Tamansari, Pronojiwo, Sumber Urip, and Sidomulyo. While in the 8 km buffering area, there are 5 namely Sumberputih, Tamansatriyan, Mulyosari, Argoyuwono, and Sumbermujur. However, the extent of the affected area and the magnitude of the loss to this area can be seen from the magnitude of the eruption of Mount Semeru. Lava flow is one of the disasters caused by volcanic activity. This phenomenon can threaten and disrupt the activities of people living in volcanic areas. The impacts caused by this disaster range from loss of property, human casualties, environmental damage, and psychological impacts (Endarwati et al., 2017). The flow of lava and lava which is a hydrological route has an impact on the villages around the mountain. Likewise with the area around the Semeru Volcano. The digitization of areas affected by the eruption of Mount Semeru is based on administrative boundaries (Arianto, 2015).

These administrative boundaries are in the form of Regency/City boundaries, District boundaries, and Village boundaries. Digitizing the villages affected by the eruption will provide a reference for the community and government in making policies. In addition, it can be used by various agencies to review and overcome the impact of the eruption of Mount Semeru. The historical traces of the Semeru Volcano's lava flow impacted several villages in Malang Regency and Lumajang Regency. The list of villages is grouped by zone of disaster vulnerability level (Arianto, 2015). There are a number of affected areas, namely 106 villages. This village is located in the zoning of the Semeru Volcano disaster-prone area. However, with the number of villages, there are 57 villages that are predicted to be affected and suffer heavy losses. The number of villages is divided into 17 villages in Malang Regency and 40 villages in Lumajang Regency. These villages belong to several sub-districts, namely Ampelgading, Poncokusumo, Tirto Yudo, Wajak, Pasrujambe, Candipuro, Pronojiwo, Pasirian, Candipuro, Tempeh, Sumbersuko, and Tempursari.

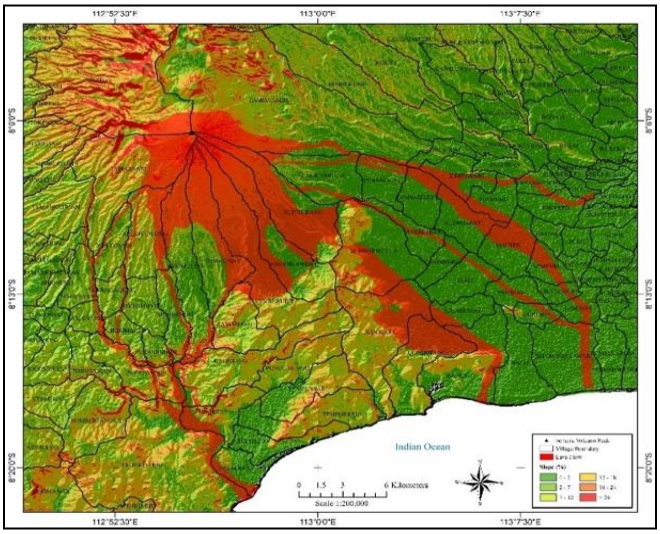

Figure 2. Slope Map in Lava Flow Area (Source: Research results)

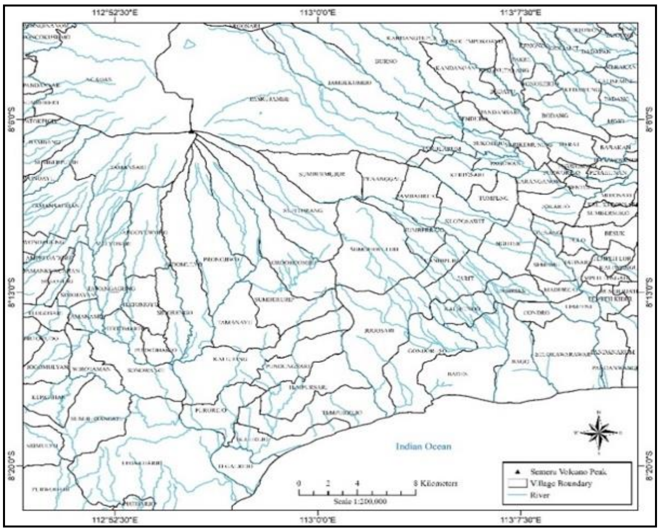

Figure 3. River Map in Lava Flow Area (Source: Research results)

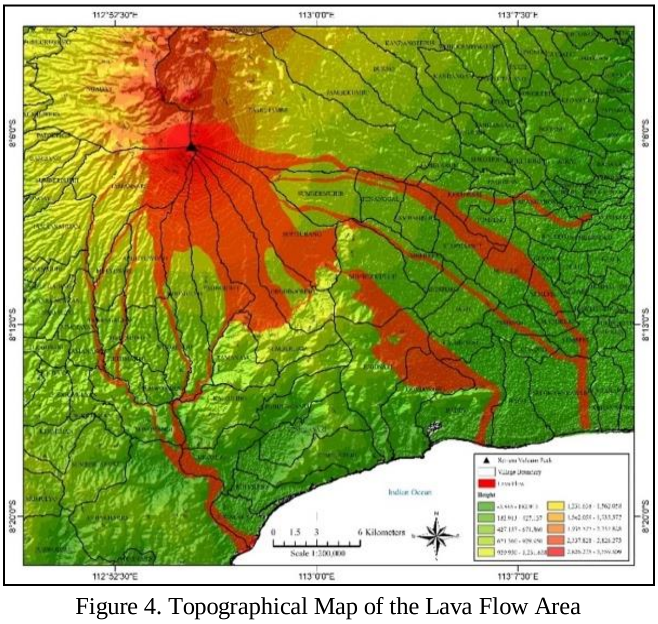

Figure 4. Topographical Map of the Lava Flow Area

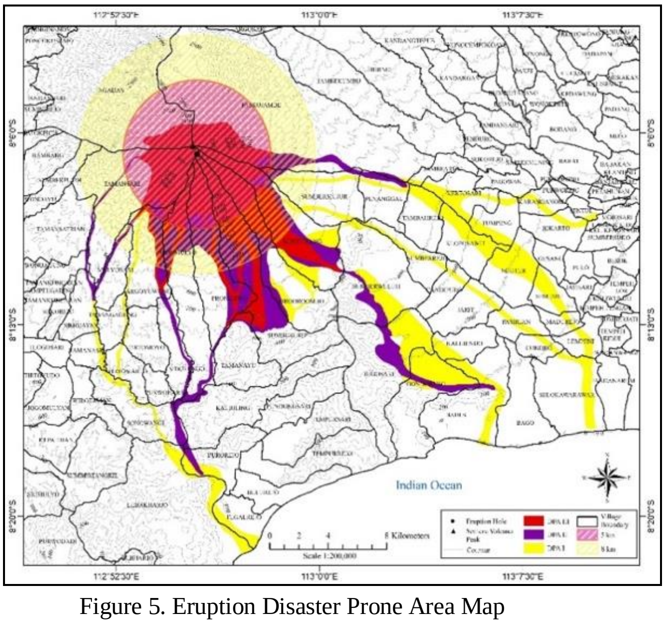

Figure 5. Eruption Disaster Prone Area Map

(Source: Research results)

A map of disaster-prone areas (Figure 5) is made to be used as a reference in making government, community, or other related parties' policies. In addition, it can be used as an action plan in reducing the risk of volcanic disasters. This area is divided into three areas. Disaster-Prone Area III (high status area), Disaster-Prone Area II (medium status area), and Disaster-Prone Area I (low status area). Disaster-Prone Area III covers the threat area of 3 villages in Malang Regency and 8 villages in Lumajang Regency with a total area of 98.38 km^2. Disaster Prone Area II covers the threat area of 6 villages in Malang Regency and 7 villages in Lumajang Regency with a total area of 205.9 km^2. The division of this area can be seen on the Disaster Area Map (Figure 5). Mapping with this zoning method was also carried out in the area of Mount Merapi (Asriningrum, 2004). The villages affected by major losses based on their vulnerability zones (Figure 5) are as follows: Disaster-Prone Area III consists of 11 villages covering Malang Regency (Argoyuwono Village, Tamansari, Ngadas) and Lumajang Regency (Pasrujambe Village, Sumbermujur, Oro Oro Ombo, Pronojiwo, Sidomulyo, Sumberurip, Supiturang, Tamanayu). Furthermore, Disaster-Prone Area II consists of 13 villages covering Malang Regency (Mulyoasri Village, Purwoharjo, Sidorenggo, Simojayan, Ampelgading, Tamansatriyan) and Lumajang Regency (Bades Village, Gondoruso, Jugosari, Penanggal, Sumberwuluh, Purorejo, Kaliuling). Disaster-Prone Area I consists of 33 villages covering Malang Regency (Bambang Village, Sumberputih, Lebakharjo, Sonowangi, Tamanasri, Tawangagung, Tirtomatro, Tirtomoyo) and Lumajang Regency (Bago, Condro, Kalibendo, Madurejo, Nguter, Pasirian, Selok Anyar, Selok Awar Awar, Sememu, Candipuro, Jarit, Kloposawit, Sumberrejo, Addrejo, Tumpeng, Penanggal, Jambearum, Karanganom, Kertosari, Pagowan, Jokarto, Lempeni, Mojosari, Sentul, Tegalrejo).

The study of population size in formulating disaster policies is an important topic. Through this study will be able to identify areas that have a high population density. The higher the number of people living in volcanic areas and the closer they are to the center of the eruption, the higher the risk of being affected by a volcanic disaster. This population study is processed based on population data at the Central Statistics Agency (BPS) in Indonesia in 2020 and the processing of residential areas in ArcGIS. The total population in the Disaster-Prone Area III is 67,083 people with a population density of 920.8 people/km^2. The total population in the Disaster-Prone Area II is 91,726 people with a population density of 826.48 people/km^2. Meanwhile, the total population in Disaster Prone Area I is 211,954 people with a population density of 2,938.08 people/km^2. The map of the population can be seen in Figure 6.

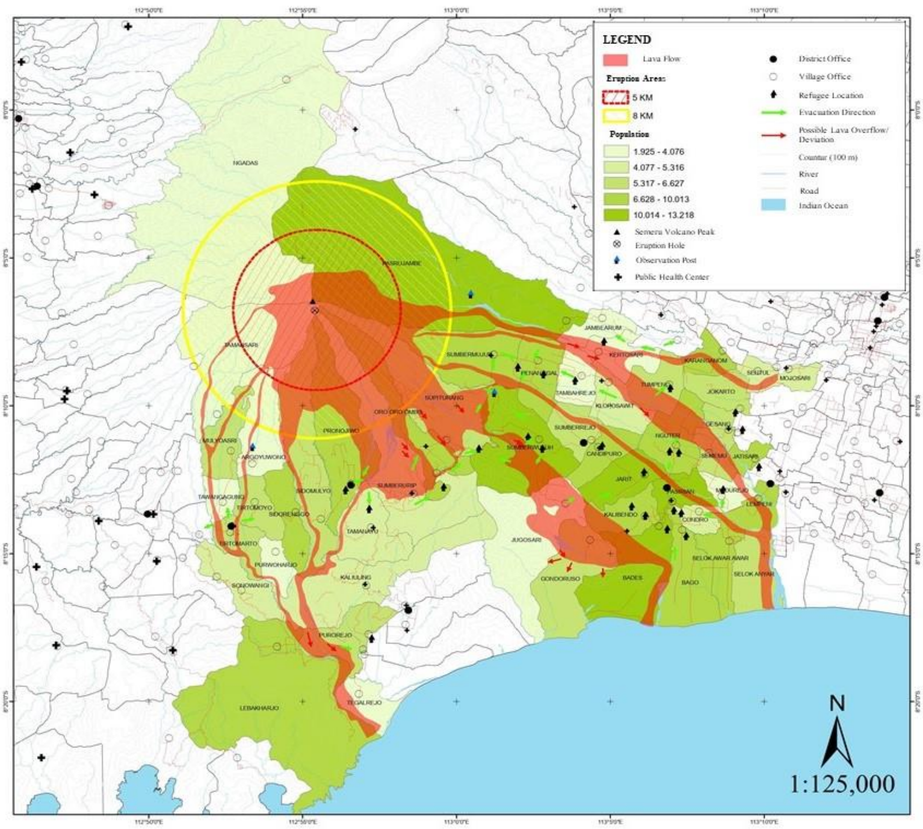

Figure 6. Population Map in the Lava Flow Area (Source: Research results)

c. Mapping of Semeru Volcano Tourism Objects

The activities of the Semeru Volcano threaten various economic, educational, political, social and other sectors. The threat of this volcanic disaster is no exception in the tourism sector. Semeru Volcano is included in the strategic tourism area of TNBTS (Bromo Tengger Semeru National Park). TNBTS targets in 2019 are areas with achievements of the International Geo-Ecoculture Park (Purnomo et al., 2018). The ecosystem types of this area are sub-montane, montana, and sub-alphin with large trees that are hundreds of years old (Geological Agency, 2014). Volcanic activity cannot be prevented in any way. However, the threat from volcanic activity needs to be followed up to minimize its impact. As a series of efforts made by village governments and local communities in Lombok (Wahyuningtyas, 2019, 2020), companies in Chile (Tironi and Manríquez, 2019), and companies in Turkey in responding to disasters that occurred there (Orhan, 2016). Attractions around Semeru Volcano are divided into several classifications. Tourist attractions include meadows, lakes, pine forests, bamboo forests, campgrounds, temples, waterfalls, beaches, and baths. Grassland tourism consists of 3 objects which include Panggonan Cilik, Oro-Oro Ombo, and Cemoro Kandang Meadow. There are 3 lake tours which include Ranu Kumbolo, Ranu Pani, and Ranu Regulo. Pine forest tourism consists of 2 which include the Semeru Pine Forest and Siti Sundari. Bamboo forest tourism consists of 1 object which includes the Lumajang Bamboo Forest. The camp tour consists of 2 which includes the Kalimati and the Songo Tawon. Temple tourism consists of 2 objects which include Jawar and Samudro. Waterfall tourism consists of 16 objects which include Kapas Biru Waterfall, Coban Sewu, Coban Srengenge, Coban Pelangi, Goa Tetes, Coban Trisula, Kabut Pelangi, Kedung Jumali, Coban Sriti, Coban Telaga Warna, Coban Gintong, Tiga Bidadari, Coban Sonowangi, Kembar, Manggisan, and Randuagung. Beach tourism consists of 4 objects which include Dampar, Watu Gedhek, Tpi, and Licin. The bathing tour consists of 1 object which includes the Sememu Natural Bath.

Mapping of tourist attractions in disaster-prone areas of Mount Semeru can be used as a reference for the Central Government, Regional Governments, practitioners, the community, and various other parties. This mapping can also help in efforts to increase community preparedness in tourist areas. Community preparedness is expected to avoid property losses, loss of life, and changes in people's lives in the future (Sutton and Tierney, 2006). This mapping uses buffering of 1 km from the location of the tourist attraction. The use of buffering is to determine the distance of tourist objects from areas prone to volcanic eruptions and affected by lava flows. On the overlay of the eruption point zone using buffering distances of 5 km and 8 km. Next, overlay the lava flow using the guidelines from the Disaster Hazard Map from BNPB. The results of the mapping of disaster-prone areas and the identification of the location of these attractions can be seen on the Map of Tourist Attractions in the Semeru Volcano Eruption Disaster-Prone Area (Figure 7). Based on the mapping of this tourist attraction, there are 23 objects that are in dire need of repair and disaster education. This education is to provide knowledge about pre-disaster, mitigation, and recovery activities. So that the impact of disasters can be minimized and the tourism sector can be restored quickly after volcanic activity occurs. Meanwhile, 11 tourist objects that are classified as safe areas must still be equipped with disaster knowledge from both the government and local knowledge. This is very important because it is a prevention effort when a volcanic eruption enlarges and lava flows expand.

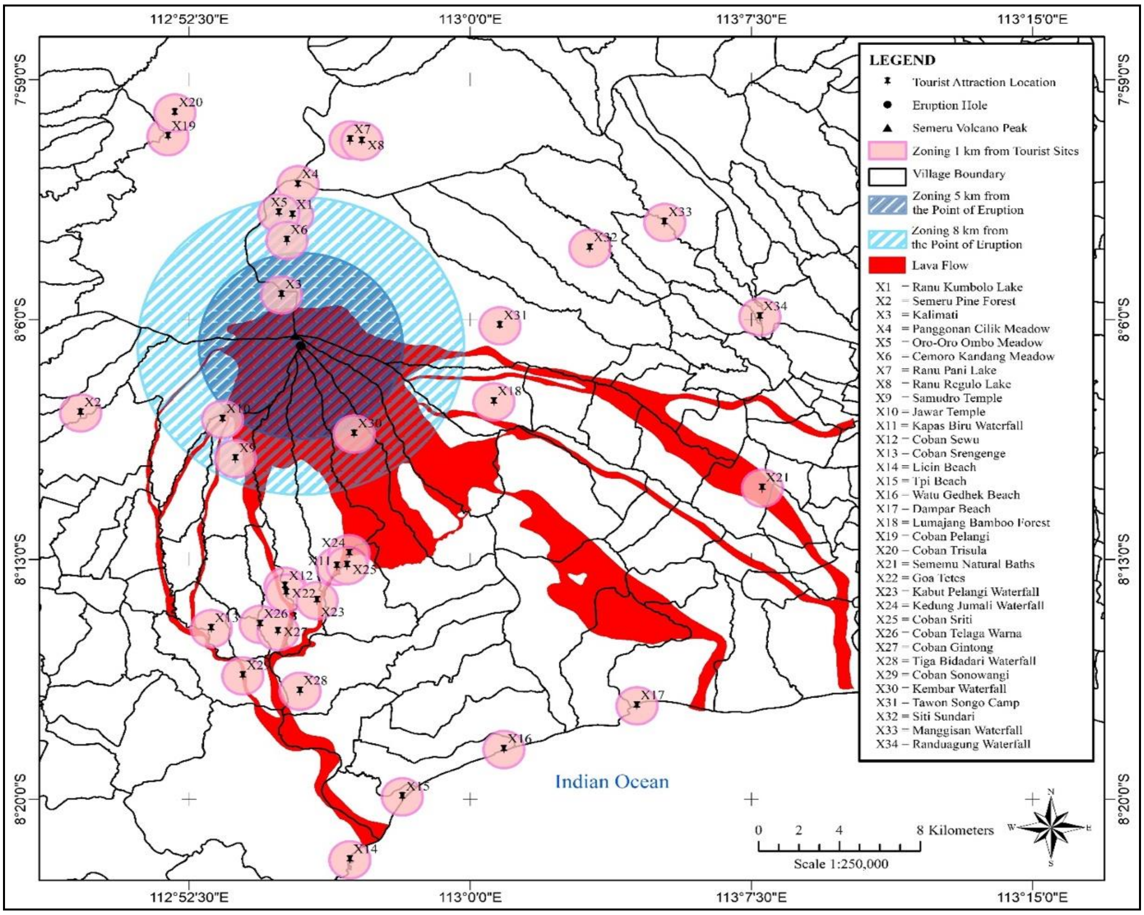

Figure 7. Map of Tourism Objects in the Semeru Volcano Disaster-Prone Area (Source: Research results)

There are 4 tourist objects affected by the 5 km zoning. These tourist objects are threatened by volcanic material and lava at a distance of 5 km from the center of the eruption. These attractions include the Kalimati Campground, Cemoro Kandang, Jawar Temple and Kembar Waterfalls. While in the 8 km zoning there are 4 attractions. This tourist attraction means that it will be affected by volcanic material and lava at a distance of 8 km from the center of the eruption. These attractions include Samudro Temple, Ranu Kumbolo Lake, Panggonan Cilik Meadow, and Oro-oro Ombo Grassland. In addition to zoning using distance buffering from the eruption, there are other tourist objects identified as disaster-prone using lava flow digitization. Attractions affected by the lava flow consist of 15 objects. These attractions include Tawon Songo Campground, Sememu Natural Baths, Lumajang Bamboo Forest, Tiga Bidadari Waterfall, Coban Sonowangi, Coban Srengenge, Coban Telaga Warna, Coban Gintong, Kabut Pelangi Waterfall, Goa Tetes, Coban Sewu, Coban Sriti, Kedung Jumali Waterfall, Licin Beach, and Kapas Biru Waterfall. Meanwhile, tourist objects that are still classified as safe based on buffering techniques for volcanic eruptions and lava flows consist of 11 objects. These objects include Watu Gedhek Beach, Tpi Beach, Dampar Beach, Semeru Pine Forest, Siti Sundari Pine Forest, Randuagung Waterfall, Manggisan Waterfall, Coban Trisula, Coban Pelangi, Ranu Pani Lake, and Ranu Regulo Lake. The majority of tourist attractions in the Semeru Volcano area are threatened by volcanic activity. Communities living around tourism require in-depth disaster mitigation supplies to be aware of disaster risks. This is considering that tourism potential is very important for improving their economy. There are previous research studies that assess that there are gaps and low mitigation policies for Semeru Volcano. Communities tend to use local wisdom in disaster mitigation because the anticipation, policies, and funding from the local government are not good (Pen, 2017). Local governments need to adopt preparedness carried out by various outside regions. A strengthening study by the leadership was also carried out on companies in Turkey. Leaders should increase employee knowledge about pre-disaster actions, disaster mitigation, and how to overcome them to reduce greater risks in Adapazari, Turkey (Orhan, 2016). Moreover, disaster leadership in Chile integrates local community knowledge with political knowledge as an important element for efficient disaster management (Tironi and Manríquez, 2019).

CONCLUSION

The mapping of the Semeru Volcano disaster-prone area (Bromo Tengger Semeru National Park) is important. This can be used as a reference in the management of tourism around the Semeru area. Based on the results of the study, it is known that the direction of river flow (hydrology) from the Mahameru Peak (the peak of Mount Semeru) is dominant to the east, southeast, south, and west. The flow of lava and lava from the eruption of Semeru Volcano also follows the direction of the slope. The slope is more dominant south and southeast than the north. The northern part is more dominated by mountains and hills. Where the flow of lava and lava originates in the crater of the summit of Mount Semeru.

Disaster-Prone Areas are divided into three areas. Disaster-Prone Area III covers the threat area of 3 villages in Malang Regency and 8 Lumajang Regency with a total area of 98.38km2, a population of 67,083 people, and a population density of 920.8 people/km2. Disaster-Prone Area II covers the threat area of 6 villages in Malang Regency and 7 Lumajang Regency with a total area of 205.9 km2, a population of 91,726 people, and a population density of 826.48 people/km2. Disaster-Prone Area I covers the threat area of 8 villages in Malang Regency and 25 Lumajang Regency with a total area of 287.87km2, a population of 211,954 people, and a population density of 2,938.08 people/km2. The results of the mapping show that there are 57 villages that are predicted to be affected and suffer heavy losses. The number of villages is divided into 17 villages in Malang Regency and 40 villages in Lumajang Regency. These villages belong to several sub-districts, namely Ampelgading, Poncokusumo, Tirto Yudo, Wajak, Pasrujambe, Candipuro, Pronojiwo, Pasirian, Candipuro, Tempursari, Tempeh, Sumbersuko, and Tempursari. In addition, these disaster-prone areas are areas that have a lot of tourism potential.

The majority of tourist attractions are affected by eruption zones and are affected by lava flows. The number of these tours is 23 objects. While the tourist objects that are classified as safe amounted to 11 objects. All tourist attractions around Semeru Volcano require provision of pre-disaster knowledge, disaster mitigation, and restoration of tourist areas. With this knowledge, tourism will become the main economic sector of the community and can recover quickly after volcanic activity. There are 4 tourist objects affected by the 5 km zoning. While in the 8 km zoning there are 4 attractions. In addition to zoning using distance buffering from the eruption, there are other tourist objects identified as disaster-prone using lava flow digitization. Attractions affected by the lava flow consist of 15 objects. Meanwhile, tourist objects that are still classified as safe based on buffering techniques for volcanic eruptions and lava flows consist of 11 objects. The majority of this tourist area is a type of waterfall tourism. The waterfall tourist area has a high risk because of its location in the lava flow and is included in the volcanic eruption zone.

Acknowledgments

This work was supported by PNBP research grant of Universitas Negeri Malang Under Contract No: 4.3.13/UN32/KP/2021.

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Article history: Received: 16.07.2021 Revised: 14.11.2021 Accepted: 16.12.2021 Available online: 31.12.2021