Analysis of the Potential Disaster Eruption of Mount Merapi in Klangon and Surroundings

Saskia Aulia Putri[1], Nur Wahyuni Zulianti[1], Alivia Nur Aini[1], Galuh Mayreva Capital[1], Malia Alfira Yani[1], Nugroho Hari Purnomo[1*]

[1]Geography Education, Faculty of Social and Political Sciences, State University of Surabaya, Indonesia
nugrohohari@unesa.ac.id.

Abstrak. This research aims to analyze the potential for eruption disasters. Mount Merapi in Klangon and its surroundings. The research method used namely an integrated rapid survey. Data collection techniques consist of field observations, interviews, and literature studies. The analysis is descriptive empirical by triangulating data from data collection techniques allows researchers to get a more comprehensive picture of the risk of geological disasters in Klangon Hill. The results of this research show that the location of Klangon Hill, which is right under the foot of Mount Merapi, makes this location vulnerable to lava flows and hot clouds. The potential for geological disasters that often occur are volcanic eruptions, earthquakes and landslides.

Keywords: Geological Disaster, Mount Merapi, Eruption.

1 Introduction

Mount Merapi is a volcano located in the Special Region of Yogyakarta. Administratively, it is located in four districts, namely Klaten, Boyolali and Mage-lang, Central Java Province and Sleman Regency, DIY [1]. The southern slopes are located in the administration of Sleman Regency and the rest are in the Central Java Province area, namely Magelang Regency on the west side, Boyolali Regency on the north and east sides, and Klaten Regency on the Southeast side. Merapi is a Strato-volcano type volcano whose magma is petrologically andesitic-basaltic [2]. The peak height of Mount Merapi is around 2,911 meters above sea level. Mount Merapi is one of the most active volcanoes in the world. Almost every period, Mount Merapi experiences an eruption. The return period for eruptive activity ranges from 2-7 years. Mount Merapi's eruptive activity is characterized by emitting incandescent lava and hot clouds, without forming a caldera (crater) [3].

A volcanic eruption is the process of releasing material from a volcano. The eruption occurred due to the movement of magma from the bowels of the earth [4]. The movement of magma is caused by strong gas pressure from the bowels of the earth which continuously pushes magma out. The material released can also be called

G. W. Pradana et al. (eds.), *Proceedings of the 4th International Conference on Social Sciences and Law (ICSSL 2024)*, Advances in Social Science, Education and Humanities Research 877,
https://doi.org/10.2991/978-2-38476-303-0_30

pyroclastic or pyroclastic rock. Pyroclastics are clastic materials consisting of materials volcanic. Pyroclastics consist of volcanic ash, lapilli, and rock ejected from volcanoes. This material will later be released into the atmosphere or onto the earth's surface in uncertain quantities.

At the foot of Mount Merapi, there is one tourist location that is often affected by eruptions, namely Klangon Hill. Klangon Hill is located at an altitude of around 1100 meters above sea level. This location is located in Kalitengah Lor, Glagaharjo, Cangkringan, Sleman Regency, Special Region of Yogyakarta. The risk of disasters in an area can result in property loss and even loss of life [4]. Disasters due to the eruption of Merapi in Klangon Hill occur very often, especially volcanic eruption types of disasters. This research aims to analyze the potential disaster impact of the eruption of Mount Merapi.

2 Methods

2.1 Research Observation Location

The location of this research observation is on Klangon Hill which is administratively located in Glagaharjo Village, Cangkringan District, Sleman, DI Yogyakarta.

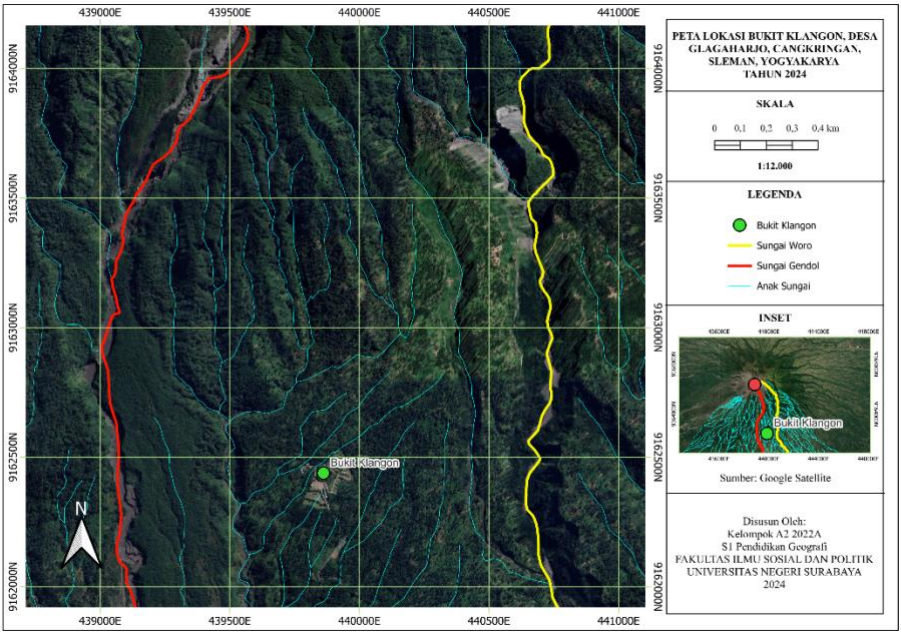

Fig. 1. Klangon Hill Location Map

2.2 Data Collection Techniques

The research method used is an integrated rapid survey applying the principle of triangulation consisting of direct observation, secondary data collection and interviews. Field observations were carried out by means of a direct survey at Klangon Hill, Yogyakarta. Field observation is a method that involves a series of data collection activities directly at the research location. This activity involves observing the geology, topography and infrastructure conditions affected by the eruption. In this field observation, researchers identified disaster-prone points, documented various damages that occurred, and recorded flow patterns of volcanic material distributed in the area.

Interview, interview is the process of obtaining information for research purposes by means of face-toface questions and answers between the interviewer and the respondent or person being interviewed. This interview was conducted in a semi-structured manner to obtain the respondents' perspectives, experiences and views regarding the geological disaster that occurred in Klangon Hill.

Researchers conducted literature studies and journals related to research. The literature study used in this research is in the form of scientific journals related to the topic of Volcanic Eruption Disasters [5].

2.3 Population and Sample

The population is all subjects who are interested in providing information related to the case that occurred. Populations can be people, objects or events. The population in this study were people in Klangon, namely Mount Merapi. The sample selection technique is accidental sampling.

2.4 Data Analysis

Experts define data analysis as a way to detail formal efforts to discover themes, formulate hypotheses, and provide support for themes and hypotheses based on data. In this research, the analytical technique used is empirical descriptive which is based on data triangulation.

3 Result and Discussion

Natural disasters are disasters caused by events or a series of events caused by nature, including earthquakes, tsunamis, volcanic eruptions, floods, droughts, hurricanes and landslides [6]. Potential is an ability that has the possibility of being developed [7]. Natural disasters themselves are broadly divided into 2 types, namely geological disasters and meteorological disasters. Geological disasters include volcanic eruptions, earthquakes, landslides and tsunamis. Among these disasters that often occur in Indonesia are volcanic eruptions, which are caused by the many active volcanoes in Indonesia. Volcanic eruption is the process of releasing magma to the earth's surface. One of the volcanoes that often experiences eruptions is Mount Merapi **(Fig.1.)**. Throughout the history of Merapi eruptions that have occurred are explosive eruptions

and effusive eruptions. Explosive eruptions produce eruptions of ash and hot clouds, while effusive eruptions produce lava flows [8].

Fig. 2. Mount Merapi photographed from Klangon Hill. Field Observation Source, 2024.

3.1 Volcanic Eruption

Volcanic eruptions or volcanic eruptions are the process of releasing magma to the earth's surface [9]. This process can occur in different forms depending on the characteristics of the volcano. Eruptions can be explosive (lava flows slowly to form a lava flow) or explosive (lava comes out followed by an explosion). The types of volcanic eruptions are broadly divided into 3, namely Hawaiian eruptions, Strombolian eruptions and Vulcanian eruptions.

However, from this eruption volcanic material can come out which is usually called pyroclastic. This pyroclastic material has several ways to spread, namely by flowing, blowing in the wind and falling.

3.2 Pyroclastic Flows

Volcanic eruptions or volcanic eruptions are the process of releasing magma to the earth's surface. Volcanic eruptions usually produce lava or pyroclastic flows. Pyroclastics are clastic materials consisting of volcanic materials. Pyroclastics consist of volcanic ash, lapilli, and rock ejected from volcanoes. Volcanic eruptions that produce pyroclastics can cause major damage to the surrounding environment and constitute a serious threat to human safety, especially in nearby areas. Pyroclastics themselves have several different types of impact, namely in the form of flowing material, blowing material and falling material. One of the mountains that emits this pyroclastic material is Mount Merapi. Mount Merapi itself is known as one of the most active volcanoes in Indonesia. The peak cone of Mount Merapi was formed by the youngest deposits in the form of washes and pyroclastics. The middle slope unit is built by washes, iroclastic and lava deposits. The foot slopes and Foot Plains are composed of pyroclastic, lava and alluvial deposits [10].

Pyroclastic flow or lava is a flow of volcanic material consisting of ash, rock, lava and hot gas that erupts from a volcano. Pyroclastic flows and eruptions originate from the same dome tops as lava flows (or from the collapse of lava domes and flows) [11]. Pyroclastic flow is a flow of a mixture of material from loose volcanic rock originating from volcanic eruptions that flows following a morphological shape, with the distribution pattern of the pyroclastic flow being almost completely controlled by topography, and the movement of the flow will stop in relatively flat to flat areas (mountain foot areas) [12]. The lava that comes out during a volcanic eruption then flows through cracks which then descends into the surrounding area and mixes with the surrounding material to become lava. Lava from Mount Merapi accompanied by gravel will come out and then spill down and damage trees and the surrounding environment. Not only are plants affected by this hot lava, residential areas can also be scorched and damaged if the lava reaches community settlements. It is very rare for lava from Mount Merapi itself to hit Klangon Hill and other settlements, but people are always alert and on guard if such an incident occurs.

Apart from flowing, pyroclastic material can also come out and then blow in the wind. When Mount Merapi erupted, pyroclastic material was released into the air. The material ejected included volcanic ash, lapilli (small rock particles), volcanic ash and smoke. This material can move at very high speeds and has hot temperatures. This of course also has an impact on the environment around Merapi, especially Klangon. The widespread air pollution by volcanic ash is very suffocating. The atmosphere is tense because even during the day the environment experiences darkness due to thick dust in the air and almost every day eruptions occur [13]. Hot smoke can make people feel hot and cause health problems, volcanic ash material can also pollute the environment because of the toxic materials it contains. This material can also interfere with breathing, resulting in shortness of breath.

After blowing in the wind, the pyroclastic material from the eruption of Mount Merapi will fall to the surface of the earth. Pyroclastic falls occur when volcanic eruptions cause part of the volcanic material to be thrown out of the mountain. When an eruption occurs, smoke containing volcanic ash, lapilli and rock fragments is formed above the mountain crater. When the energy runs out, the ash will spread in the direction of the wind or decay in rainwater and then fall back to the earth's surface. Although this ashfall is not an immediate danger to humans, the ash deposits can shed plant leaves and affect the surrounding environment. Of course, from this incident the environment most affected was the closest environment such as Bukit Pyroclastic flow or lava is a flow of volcanic material consisting of ash, rock, lava and hot gas that erupts from a volcano. Pyroclastic flows and eruptions originate from the same dome tops as lava flows (or from the collapse of lava domes and flows) [11]. Pyroclastic flow is a flow of a mixture of material from loose volcanic rock originating from volcanic eruptions that flows following a morphological shape, with the distribution pattern of the pyroclastic flow being almost completely controlled by topography, and the movement of the flow will stop in relatively flat to flat areas (mountain foot areas) [12]. The lava that comes out during a volcanic eruption then flows through cracks which then descends into the surrounding area and mixes with the surrounding material to become lava. Apart from flowing, pyroclastic material can also come out and then blow in the wind. When Mount

Merapi erupted, pyroclastic material was released into the air. washes and pyroclastics. The middle slope unit is built by washes, iroclastic and lava deposits. The foot slopes and Foot Plains are composed of pyroclastic, lava and alluvial deposits [10]. Mount Merapi itself is known as one of the most active volcanoes in Indonesia. The peak cone of Mount Merapi was formed by the youngest deposits in the form of Klangon.

Pyroclastic material can damage forests, buildings and infrastructure and threaten public safety. These flows often occur near volcanoes is active and represents one of the greatest threats to volcanic activity. However, apart from being dangerous, the volcanic material released by volcanoes usually contains a lot of primary minerals which have the potential to be a source of nutrients for plants and the weatherable primary mineral group is usually characterized by a high content of alkaline and alkaline earth metals such as Na, K, Ca and Mg. Therefore, it is necessary to know the primary mineral content of Mount Merapi after the 2010 eruption to see the potential nutrients available for plants.

1.1 Klangon is included in Disaster Prone Zone III

The Mount Merapi disaster-prone area is divided into 3 levels, namely: DisasterProne Area III, Disaster-Prone Area II, and Disaster-Prone Area I (detailed map in Figure 1). The division of disaster-prone areas through the preparation of maps of disaster-prone areas is based on geomorphology, geology, history of activity, distribution of previous eruption products, research and field studies [14].

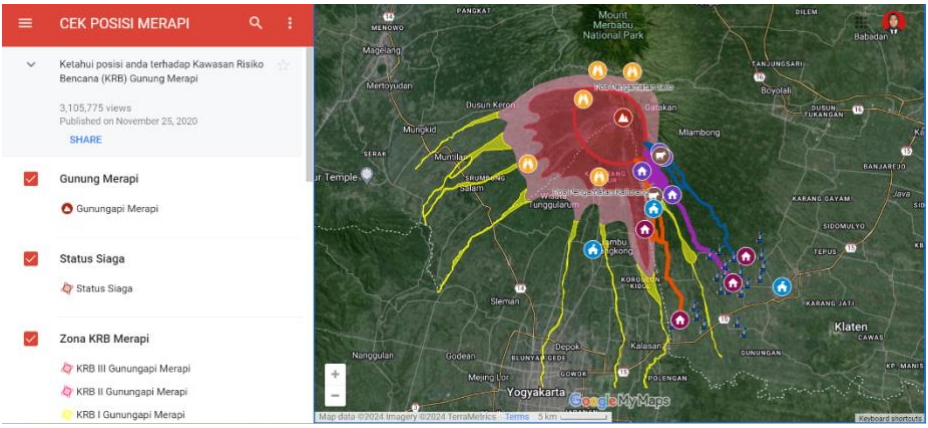

Fig. 3. Map Of The Disaster-Prone Area Of Mount Merapi [15]

Klangon Hill is located in the Disaster Prone Area (KRB) III zone of Mount Merapi, which is the area with the highest level of volcanic disaster risk. The KRB III zone includes areas that are most vulnerable to the impacts of volcanic eruptions, especially due to their proximity to the peak of Mount Merapi and the flow path of volcanic material. The main hazards in the KRB III zone include pyroclastic flows, which are a mixture of hot gas, volcanic ash, and rock fragments that slide at high speed from

mountain peaks during eruptions. This pyroclastic flow is very dangerous because of its very high temperature, which can reach hundreds of degrees Celsius, and its speed which can exceed 100 kilometers per hour. This flow can destroy everything in its path, from vegetation, buildings, to human life In addition, pyroclastic flows can cause the formation of hot clouds spreads in the surrounding area, increasing the risk of inhalation of harmful particles that can cause acute respiratory problems.

Merapi's main crater is currently a horseshoe-shaped opening pointing west-southwest. The morphology of this crater was formed after the eruption in 1961. The peak of Merapi is composed of wash domes that do not collapse. Several areas of Merapi's peak plains outside the main crater emit a lot of volcanic steam, namely in the Gendol and Woro areas [10]. Klangon Hill is located between the two rivers which often act as a medium for cold lava flows located in the southeastern part of the peak plain. The Woro River and Gendol River flow volcanic material which can cause lava floods in downstream areas, threatening human activities in Klangon Hill considering that this area is a tourist area that is often visited by the public.

3.3 Landslides

Landslides occur due to ground movement as a result of the movement of masses of soil or rock moving along the slope or outside the slope due to gravity factors [16]. In Klangon and the area around Merapi, landslides often occur caused by volcanic earthquakes resulting from the eruptive activity of Mount Merapi. This landslide was caused by the eruption of Mount Merapi which resulted in changes in the structure and composition of the soil and triggered the movement of land masses. The volcanic material that was avalanched was in the form of lava, lava, volcanic ash and gravel. According to residents, the steep and uneven topography of Mount Merapi's slopes also increases the risk of landslides on Klangon Hill, especially during the eruption of Merapi which causes landslides.

3.4 Earthquakes

An earthquake is a vibration that originates from within the earth and propagates to the surface due to cracks in the earth breaking and shifting violently. When the pressure in the earth exceeds the strength of the rock, a sudden shift occurs which produces earthquake waves. These waves travel through the earth and can be felt on the surface. Until now, earthquakes cannot be predicted when they will occur, where and how big they will be [17]. Apart from that, earthquakes can also harm people in the form of property or lives.

As a result of Mount Merapi's volcanic activity, earthquakes often occur in the surrounding area, especially in Klangon Hill. The impact is damage to building structures, especially inadequate planning and construction. Cracked walls, collapsed roofs and total building collapse can be a danger to the community around Klangon Hill. Falling lava and lahars resulting from the Merapi earthquake can also cause damage to residential areas and agricultural land. Apart from the physical and material impacts, the psychological condition of the people who experienced the earthquake disaster could lead to a traumatized attitude after the disaster occurred [18].

4 Conclusion

Potential disasters resulting from the eruption of Mount Merapi in Klangon Hill and its surroundings are the eruption of Merapi which causes the release of pyroclastic material, then there are landslides and earthquakes. This disaster certainly cannot be separated from the influence of Mount Merapi's activities. The pyroclastic material released always has an impact on the people of Klangon Hill, such as volcanic eruptions that burn down houses. Apart from having an impact on humans, Merapi's pyroclastic material in the form of volcanic ash caused many farmers' crops on the slopes of the mountain to die and be damaged, forests were also destroyed and air pollution was caused by smoke from the eruption. Therefore, this incident requires special attention from the government, especially the people around Bukit Klangon. Considering that Mount Merapi has a fairly high or frequent eruption rate.

5 Acknowledgement

This article is based on field research carried out in the framework of the Landscape Geography course. The authors express their gratitude to the Faculty of Social and Political Sciences, Surabaya State University for their very significant support.

References

1. Sugeng Widodo, Sriwidodo, Irham, and Jangkung Handoyomulyo, “DAMPAK ERUPSI GUNUNG MERAPI TERHADAP KAWASAN TAMAN NASIONAL GUNUNG MERAPI (TNGM) DI DIY DANJAWATENGAH,” *SEPA*, Sep. 2014.
2. Dhika Rosari Purbaa and Acep Purqonb, “Analisa Statistik Erupsi Gunung Merapi,” Dec. 2015.
3. A. N. Susilo and I. Rudiarto, “Analisis tingkat resiko erupsi gunung merapi terhadap permukiman di kecamatan kemalang, kabupaten klaten,” *Teknik PWK (Perencanaan Wilayah Kota)*, vol. 3, no. 1, pp. 34–49, 2014.
4. I. H. Pradana, L. Y. Irawan, D. Setiawan, F. S. Yuliano, and H. A. Mufid, “Analisis Daerah Tergenang Banjir Di Desa Sitiarjo, Kabupaten Malang Menggunakan Data SAR (Synthetic Aperture Radar) Sentinel-1,” *Jurnal Georafflesia: Artikel Ilmiah Pendidikan Geografi*, vol. 5, no. 1, pp. 58–67, 2020.
5. M. Yulfa Yulia S.St., S. M. K. Oktamianiza, S. K. M. K. Ns. Deni Maisa Putra, S. S. M. K. Rahmadhani, and Indah Oktavia, “Tinjauan Studi Literatur: Analisis Gambaran Pelaksanaan Sensus Harian Rawat Inap,” *Jurnal Rekam Medis dan Informasi Kesehatan*, Mar. 2021.
6. Qaiyim Asy’ari, “ANALISIS DAMPAK SOSIAL EKONOMI PASCA BENCANA DI KABUPATEN PAMEKASAN,” *Journal Of Management and Accounting*, Oct. 2018.

7. Asri Naleng, Hendrik Manossoh, and Steven J. Tangkuman, "ANALISIS POTENSI DAN EFEKTIVITAS PEMUNGUTAN RETRIBUSI PASAR DI KABUPATEN KEPULAUAN SIAU TAGULANDANG BIARO," *EMBA*, 2017.
8. Suwarsono, Totok Suprapto, Fajar Yulianto, Nurwita Mustika Sari, Parwati, and Wikanti Asriningrum, "DETEKSI GEJALA ERUPSI STROMBOLIAN GUNUNGAPI RAUNG JAWA TIMUR MENGGUNAKAN NORMALIZED THERMAL INDEX DARI DATA MODIS," *Penginderaan Jauh* , 2015.
9. Lis Noer Aini, Mulyono, and Eko Hanudin, "Mineral Mudah Lapuk Material Piroklastik Merapi dan Potensi Keharaannya Bagi Tanaman," *agro science*, Aug. 2016.
10. I. Hidayati, "BENTANG LAHAN JAWA BAGIAN TENGAH: Sebuah Catatan Lapangan di Provinsi Daerah Istimewa Yogyakarta," *JURNAL GEOGRAFI Geografi dan Pengajarannya*, vol. 18, no. 2, pp. 145–164, Dec. 2020, doi: 10.26740/jggp.v18n2.p145-164.
11. Pranowo Ibnu Khakim, "TINJAUAN TIPE ENDAPAN PIROKLASTIK PADA GUNUNG API MERAPI BERDASARKAN DATA PENGUKURAN STRATIGRAFI ," 2016.
12. Dinar Astari, Najib, Narulita Santi, and Wilfridus F.S. Banggur, "Pemetaan Zona Bahaya Aliran Piroklastik Gunung Merapi, Jawa Tengah dan Sekitarnya menggunakan Aplikasi Titan2D," *GEOSAINS DAN TEKNOLOGI*, Mar. 2022.
13. Sumbul Sembiring Depari and Ingan Ukur Br Sitepu, "ANALISIS KINERJA PEMERINTAH DALAM PENANGANAN PENGUNGSI ERUPSI GUNUNG SINABUNG SERTA DAMPAK TERHADAP SOSIAL EKONOMI MASYARAKAT KABUPATEN KARO.," Aug. 2019.
14. D. Astari, W. F. S. Banggur, N. Santi, and N. Najib, "Pemetaan Zona Bahaya Aliran Piroklastik Gunung Merapi, Jawa Tengah dan Sekitarnya menggunakan Aplikasi Titan2D," *Jurnal Geosains dan Teknologi*, vol. 5, no. 1, pp. 76–82, 2022.
15. Dr. Raditya Jati, "Identifikasi Posisi Terhadap KRB Gunung Merapi, Gunakan Cekposisi," https://bnpb.go.id/berita/identifikasi-posisi-terhadap-krb-gunung-merapi-gunakan-cekposisi.
16. K. Khosiah and A. Ariani, "Tingkat kerawanan tanah longsor di dusun Landungan desa Guntur Macan kecamatan Gunungsari kabupaten Lombok Barat," *Jurnal Ilmiah Mandala Education*, vol. 3, no. 1, pp. 195–200, 2017.
17. Iqbal luthfi nur rais and Lili Somantri, "ANALISIS BENCANA GEMPA BUMI DAN MITIGASI BENCANA DI DAERAH KERTASARI," *Kajian Ilmu dan Pendidikan Geografi*, 2021.
18. Haslita Rahmawati Hasan, Riska R, Muh. Mukhlis Sudrajad, Moh. Rezky Rajab Anugrah, and Nurin Rochayati, "ANALISIS SOSIAL EKONOMI MASYARAKAT HUNTAP (HUNIAN TETAP) TONDO PASCA RELOKASI BENCANAGEMPA BUMI DAN TSUNAMI PALU 2018," *Jurnal Kajian, Penelitian dan Pengembangan Pendidikan*, vol. Vol. 10, No. 2, Sep. 2022.