

Volcanic disaster mitigation based on local wisdom: A case study from a local community in the Mount Galunggung, Indonesia

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Abstract. The eruption of Mount Galunggung in 1822 resulted in the deaths of 4,011 people and the destruction of 114 villages. A subsequent eruption in 1894 caused further devastation, destroying 50 villages. In 1982, Mount Galunggung erupted for a period of nine months. Currently, the area surrounding Mount Galunggung is a center for coffee and palm plantations with a dense population. This study aims to identify the disaster mitigation implemented by local communities in response volcanic disaster. The research was conducted between August and November 2023 and employed an ethnographic approach to assess community preparedness and disaster mitigation strategies. The respondents' knowledge level regarding the Mount Galunggung eruption disaster falls within the moderate category, with an average score of 2.86. In contrast, the respondents' preparedness for volcanic disasters is classified as low, with an average score of 1.96. Disaster mitigation efforts based on local wisdom in Mount Galunggung include: 1) the use of the kentongan (a traditional wooden alarm instrument), 2) local knowledge of natural disaster signs, and 3) mystical beliefs associated with Mount Galunggung. The implication of this study is the necessity for multi-stakeholder collaboration in building community knowledge and preparedness in facing volcanic disasters around Mount Galunggung.

1 Introduction

Indonesia is a country with a high potential for natural disasters due to its geographical location at the convergence of three major tectonic plates—Eurasian, Indo-Australian, and Pacific—and its position within the Pacific Ring of Fire. This makes it prone to earthquakes, volcanic eruptions, and tsunamis [1,2]. Its varied topography and tropical climate with high

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rainfall also contribute to vulnerabilities to floods and landslides [3]. Over the past five years, data from the National Disaster Management Agency (BNPB) recorded more than 15,000 natural disaster events, with floods being the most frequent occurrence [4]. For instance, the major floods in early 2020 in Jakarta claimed more than 60 lives and displaced thousands [5], while flash floods in Luwu Utara, South Sulawesi, in July 2020 resulted in fatalities and destroyed infrastructure [6]. Earthquakes, such as the 7.0 magnitude earthquake in Lombok in 2018 and the 7.4 magnitude earthquake in Palu-Donggala the same year, both followed by tsunamis, caused thousands of deaths and widespread destruction [7]. With over 4,500 disaster events recorded in 2020, Indonesia faces significant challenges in disaster mitigation, requiring strengthened policies, increased public awareness, resilient infrastructure development, and effective early warning and evacuation systems [8,9].

Volcanic areas offer significant agricultural potential due to their fertile soils, rich in minerals like phosphorus, potassium, and calcium derived from volcanic ash deposits [10]. This fertility supports various agricultural activities, including horticulture, plantations, and food crops. For horticulture, these areas are suitable for cultivating vegetables like cabbage and carrots, as well as fruits such as strawberries and apples [11,12]. Plantation crops such as coffee, tea, and cocoa thrive on volcanic slopes, with regions like Mount Ijen and Mount Kerinci being notable production centers. Additionally, volcanic soils support food crops like rice, corn, and cassava on the slopes of Mount Semeru and Mount Merapi. Despite these advantages, the risks of volcanic disasters must be addressed through effective mitigation to ensure sustainable agricultural benefits [13,14].

Communities living in volcanic regions face significant hazards from volcanic activity. Eruptions can cause immediate threats such as lava flows, pyroclastic flows, ashfall, and lahars, which can destroy settlements and agricultural lands [15]. Pyroclastic flows, with temperatures reaching hundreds of degrees Celsius, pose a deadly threat to residents living on or near the slopes. Thick volcanic ash can damage crops, contaminate water sources, and cause respiratory issues for humans and animals [16]. Additionally, lahars, formed from volcanic materials mixed with water, can rapidly sweep away anything in their path [17]. For farmers in these areas, the hazards not only threaten lives but also disrupt their economic livelihoods by damaging farmland [18]. Long-term exposure to volcanic ash can also degrade public health [19]. Despite these risks, many people continue to live in these areas due to the fertile soil that supports agricultural productivity. It is crucial to enhance their awareness and preparedness through disaster mitigation education.

Knowledge, training, and disaster mitigation are essential for communities living and farming in volcanic regions. Adequate knowledge enables people to recognize early signs of volcanic activity, understand the risks, and take appropriate actions during emergencies [20]. Additionally, understanding disaster mitigation measures, such as managing farmland to reduce risks from lahars or ashfall, helps sustain their livelihoods [21]. Effective early warning systems, government support, and coordination among stakeholders are also critical to enabling communities to respond promptly during crises. With a combination of strong knowledge, training, and mitigation strategies, communities in volcanic regions can not only live more safely but also maintain their economic activities and environmental sustainability [22].

Mount Galunggung, located in Tasikmalaya Regency, West Java, is an active volcano known for its major eruption in 1982–1983, which dispersed volcanic ash widely and disrupted international air traffic. Despite its history of hazardous volcanic activity, the region offers significant agricultural potential due to its fertile volcanic soils, supporting crops such as rice, coffee, tea, and horticultural products [23]. However, the risks remain, including lahars, ashfall, and volcanic earthquakes, which can damage farmland and threaten residents' safety [24]. Therefore, implementing disaster mitigation measures, early warning systems, and community education is essential to manage risks while sustainably utilizing the region's

agricultural potential. This study aims to analyze the community's knowledge and preparedness regarding disaster mitigation practices and to identify volcanic disaster mitigation strategies based on local wisdom in Mount Galunggung.

2 Research Methods

The research was conducted from August to November 2023 in Sinagar Village and Linggajati Village, Sukaratu Subdistrict, Tasikmalaya Regency. The locations were purposefully selected based on the consideration that the majority of residents in these villages work as farmers in the Mount Galunggung area, and geographically, both villages are situated within the Mount Galunggung region. The main commodities cultivated by the community are vegetables and Arabica coffee [25].

The study employed a mixed-method approach, combining quantitative and qualitative methods [26]. The total number of respondents was 40 farmers with the Central Limit Theorem approach which requires a minimum of 30 samples for a study [27]. Data collection using research questionnaires aimed to identify the community's knowledge level and disaster mitigation efforts regarding the potential eruption of Mount Galunggung. The questionnaires were distributed using the accidental sampling method [28]. This method was intentionally chosen due to the difficulty of meeting farmers, as they spend most of their time in the fields.

Additionally, the study gathered information on volcanic disaster mitigation based on local wisdom through five key informants selected using the snowball sampling method. These informants included village heads and community leaders with experience and knowledge of the Mount Galunggung eruption in 1982.

The measurement of the community's knowledge level and disaster mitigation efforts regarding the potential eruption of Mount Galunggung utilized a Likert scale with four categories: 1) Very Low, 2) Low, 3) Moderate, and 4) High. The Likert scale is a psychometric scale commonly used in questionnaires to gauge responses to given statements [29]. While Likert scales typically use an odd number of categories, this study adopted four categories to avoid bias [30].

Data from questionnaire responses were tabulated, categorized, and interpreted. Meanwhile, data from in-depth interviews were analyzed using an interactive data analysis approach, which includes three stages: data reduction, data display, and conclusion/verification [31].

3 Results and Discussion

3.1 Respondents' knowledge of the Eruption Disaster

The level of community knowledge about a disaster is crucial to analyze, as it forms the foundation for developing short-term, medium-term, and long-term programs. This study identifies respondents' knowledge of the potential eruption of Mount Galunggung to provide baseline information on whether the community is aware of the hazards around their living environment. The results of the respondents' knowledge identification regarding the potential eruption of Mount Galunggung are presented in Figure 1.

In general, the level of respondents' knowledge regarding the Mount Galunggung eruption disaster falls within the moderate category, with an average score of 2.86. Of the six statements measuring respondents' knowledge of volcanic disasters, three aspects scored below three, while the other half scored above three. The statements with the lowest scores were *Cause of the eruption of Mount Galunggung* (score: 2.28) and *Signs of the eruption of Mount Galunggung* (score: 2.58). In contrast, the statements with the highest scores were

Disaster potential of Mount Galunggung (score: 3.03) and the negative impact of the eruption of Mount Galunggung (score: 3.33).

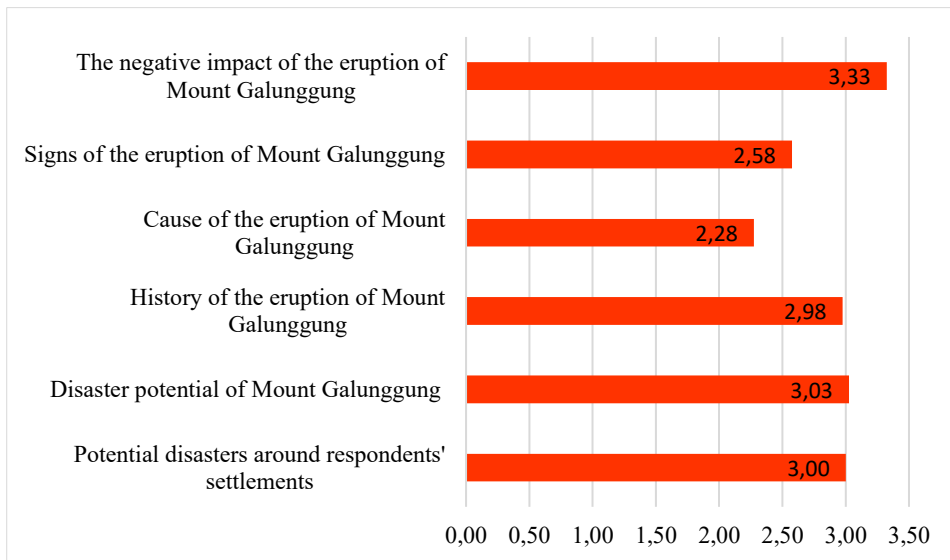


Fig. 1. Respondents' Knowledge of the Mount Galunggung Eruption Disaster
 Source : Primary data (2023)

The relatively high knowledge among respondents regarding the potential and negative impacts of the Mount Galunggung eruption can be attributed to the fact that most respondents were witnesses and victims of the 1982–1983 eruption. As a result, the events remain vividly etched in the memories of those living near Mount Galunggung. Nevertheless, efforts to enhance community understanding and preparedness remain in the low category, despite the community and stakeholders being aware of the potential risks posed by the volcano [32]. There is a lack of integrated and sustainable initiatives to improve community knowledge and preparedness for future eruptions of Mount Galunggung. Many studies explain that one of the reasons for program failure is the lack of multi-stakeholder collaboration and the unsustainable nature of the program [33],[34]. Therefore, programs aimed at enhancing community knowledge and preparedness for volcanic disasters at Mount Galunggung must be integrated and sustainable.

3.2 Respondents' Preparedness Level for Volcanic Disasters

Identifying community preparedness for volcanic disasters is crucial as a baseline for developing future programs. Community preparedness is the most important aspect of disaster mitigation. Communities with a high level of disaster preparedness are expected to take swift and appropriate mitigation actions when disasters occur. The respondents' preparedness level for volcanic disasters in the Mount Galunggung area is presented in the Tabel 1.

Table 1. Respondents' Preparedness Level for Volcanic Disasters in the Mount Galunggung

No	Indicator	Score	Category
1	Evacuation plan in case of Mount Galunggung eruption	2.42	Moderate
2	Galunggung disaster evacuation route	2.00	Low

3	Volcanic eruption disaster shelter/gathering point	1.92	Low
4	Emergency transportation	2.65	Moderate
5	Relatives who provide temporary shelter	2.77	Moderate
6	Volcanic disaster evacuation equipment	1.73	Low
7	Local agreement-based warning system	1.73	Low
8	Volcanic eruption disaster warning tools/technology	1.65	Low
9	Warning system from official information from the Government	2.65	Moderate
10	Disaster evacuation simulation or drill	1.58	Low
11	Family members who have participated in disaster preparedness training	1.31	Low
12	Ownership of Volcanic Eruption disaster guidance module	1.42	Low
13	Access to information from other sources regarding volcanic eruptions	2.35	Moderate
14	Family members who have disaster preparedness skills	1.50	Low
15	Funding to deal with disasters	1.46	Low
16	Social networks during disasters	2.73	Moderate
	Average	1.96	Low

Source : Primary data (2023)

The level of respondents’ preparedness for volcanic disasters at Mount Galunggung is classified as low, with an average score of 1.96 (see Table 1). Of the 16 statements related to respondents’ preparedness for volcanic eruptions, 10 were classified as low, six were classified as moderate, and none were classified as high. These findings illustrate that the preparedness level of the community surrounding Mount Galunggung is generally low.

The low level of community preparedness for volcanic disasters warrants deeper examination, especially given the significant disaster potential of the region and the lack of optimal mitigation efforts. Collaboration among government agencies, private sectors, communities, and other stakeholders is essential to improve preparedness especially in volcano disaster [35],[36].

Mount Galunggung is an active volcano with ongoing volcanic activity, underscoring the urgent need to enhance the preparedness of communities living in its vicinity. Comprehensive, integrated, and sustainable programs are necessary to develop effective disaster mitigation strategies for the Mount Galunggung area. Furthermore, multi-stakeholder collaboration is a key factor in successfully enhancing community preparedness to face disasters optimally[37],[38].

3.3 Volcanic Disaster Mitigation Based on Local Wisdom

Disaster mitigation efforts based on local wisdom in the Mount Galunggung area include: 1) the *Naskah Amanat Galunggung* (Galunggung Mandate Manuscript), 2) the use of the kentongan (a traditional wooden alarm instrument), 3) local knowledge of natural disaster signs, and 4) mystical beliefs associated with Mount Galunggung. In detail, the explanation related to local wisdom practices for disaster mitigation in the Mount Galunggung area is explained in Table 2.

Table 2. Volcanic Disaster Mitigation Based on Local Wisdom in Mount Galunggung

No	Local Wisdom	Description
1	Naskah Amanat Galunggung	The <i>Ancient Galunggung Manuscript</i> was written by King Rakyan Darmasiksa in the 15th century. This manuscript provides guidance on virtuous conduct, including instructions on protecting the environment.
2	<i>Kentongan</i>	The <i>kentongan</i> is a traditional communication tool from Indonesia, typically made of wood or bamboo. It functions as an early warning system for disasters.
3	Local knowledge of natural signs of disaster	Natural signs indicating an impending eruption of Mount Galunggung include lightning and thunder at the mountain's summit, as well as animals descending from the mountain into community settlements.
4	Mystical beliefs of Mount Galunggung	In addition, the cries of sorrow emanating from Mount Galunggung are believed to signify an imminent eruption, as was the case during the 1982 eruption

Source : Primary data (2023)

Table 2 provides information indicating that the communities living around Mount Galunggung possess local wisdom in volcanic disaster mitigation. This local wisdom emerges from the longstanding relationship between the community and nature [39], passed down through generations, forming a body of local knowledge related to volcanic disasters. The presence of local wisdom in volcanic disaster management serves as vital social capital for efforts to enhance preparedness and implement disaster prevention programs [40],[41]. Therefore, integrating this social capital with current technological advancements is essential to developing robust volcanic disaster mitigation strategies in the Mount Galunggung area.

4 Conclusion

The respondents' level of knowledge regarding the Mount Galunggung eruption disaster falls within the moderate category, with an average score of 2.86. Although respondents are aware of the potential for disasters from Mount Galunggung, they lack understanding of the underlying causes. The community often associates such disasters with mystical factors. Among the indicators, the negative impact of volcanic eruptions received the highest score (3.33), as the community has directly experienced the adverse effects of such events in the past.

The level of respondents' preparedness for volcanic disasters at Mount Galunggung is classified as low, with an average score of 1.96. The preparedness indicators with the lowest scores include: 1) family members participating in disaster preparedness training (1.31), 2) ownership of a volcanic eruption disaster guidance module (1.42), and 3) funding allocated for disaster response (1.46). Programs aimed at enhancing preparedness for volcanic disasters remain limited, often implemented partially, and lack an integrated and sustainable approach.

Disaster mitigation efforts based on local wisdom in the Mount Galunggung area include: 1) the *Naskah Amanat Galunggung* (Galunggung Mandate Manuscript), 2) the use of the *kentongan* (a traditional wooden alarm instrument), 3) local knowledge of natural disaster signs, and 4) mystical beliefs associated with Mount Galunggung.

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