

Strengthening Community Resilience: Mapping Local Capacity to Mitigate Mount Merapi Eruption Risk in Dukun Sub-district, Indonesia

Ulya Zulfa Hanifah*, Juhadi

Department of Geography, Faculty of Social and Political Sciences,
Universitas Negeri Semarang, Indonesia

*sayazulfa26@students.unnes.ac.id

Abstract

This study aims to map community capacity in efforts to reduce the risk of Mount Merapi eruption disasters in Dukun Sub-district, Magelang Regency. The objectives include: (1) analyzing the threat levels and community capacity index; (2) examining efforts to enhance community capacity; and (3) mapping the levels of community capacity based on the Disaster-Prone Area (Kawasan Rawan Bencana/KRB) zones. A quantitative descriptive approach was employed with a *cluster random sampling* technique, based on KRB zoning (KRB I, II, and III). Data were collected through observation, questionnaires, and documentation, and analyzed using scoring and descriptive interpretation. The results show that the threat level is categorized as moderate in KRB I and high in KRB II and III. The community capacity index is generally at a moderate level across all zones; however, capacity in KRB I is categorized as moderate, while in KRB II and III it is low. These findings highlight the urgent need for more intensive strategies to strengthen community capacity, especially in high-risk areas.

Keywords: Eruption, Community Capacity, Disaster-Prone Area, Disaster Risk

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*Corresponding Author

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1. Introduction

Indonesia has a complex and strategic geographical characteristic, which directly contributes to the high potential for natural disasters in the region (Nurhadi et al., 2018). Tectonically, Indonesia is located at the convergence of three major active plates: the Indo-Australian Plate, the Eurasian Plate, and the Pacific Plate. The interaction among these plates forms a morphostructural configuration in the form of island arcs surrounded by deep sea basins and oceanic trenches. This condition makes Indonesia one of the most active tectonic-volcanic zones in the world, known as the Ring of Fire, which is a zone

of active volcano distribution stretching along the Pacific region (Sriyono et al., 2022).

Mount Merapi is one of the most active volcanoes in Indonesia and is located in an area with a high population density. Mount Merapi is a stratovolcano with a lava dome, standing at approximately 2,911 meters above sea level and spanning about 30 kilometers in width. Unlike most volcanoes that tend to erupt over long intervals, Mount Merapi is known for its relatively short eruption cycles. These eruptions typically occur every 2 to 5 years, which is considered a short interval, while medium intervals last 5–7 years and long ones up to 30 years. Due to its frequent eruptions and the presence of densely populated communities around its slopes, Mount Merapi has received particular attention from the government (Yudistira et al., 2020).

Communities around the Mount Merapi area extensively utilize volcanic natural resources to support economic activities, particularly in the sectors of agriculture, plantations, industry, and the exploitation of volcanic materials such as sand and stone (Ardi et al., 2017). The presence of Mount Merapi has positively impacted the surrounding community, primarily through the provision of fertile soil due to volcanic ash deposits. Volcanic activity naturally enriches the soil structure, thus supporting agricultural productivity. Furthermore, eruptive materials, such as rocks, are also used as construction materials. Furthermore, the mountainous region boasts high aesthetic and recreational value, making it an attractive natural tourism destination. The availability of these natural resources is a major motivating factor for communities to remain on the slopes of Mount Merapi, despite the high potential risk of disasters (Ardi et al., 2017).

Although Mount Merapi provides various ecological and economic benefits, as one of the most active volcanoes in Indonesia, it also poses significant negative impacts on the surrounding areas. Eruptive activity can cause damage to infrastructure, including public facilities and residents' buildings. Volcanic ash from eruptions disrupts daily community activities, paralyzes the economic sector, and degrades environmental quality. In addition, the potential for lahars, which can occur at any time, especially during the rainy season poses a serious threat to communities living and working along riverbanks, due to the powerful flow of volcanic materials that carry a high risk to human safety and material losses (Bappenas & BNPB, 2011).

Volcanic eruptions are highly complex natural phenomena that significantly affect both human populations and the surrounding environment. Their negative impacts include loss of life, destruction of infrastructure, and environmental contamination due to phenomena such as pyroclastic flows, lava, volcanic ash, toxic gases, and hot clouds. Moreover, secondary hazards, such as cold lava flows triggered by rainfall have been documented following events like the Mount Merapi eruption on March 4, 2024. However, volcanic eruptions may also bring positive outcomes, including geothermal energy potential, improved soil fertility, and the emergence of mineral-rich springs (Istijono et al., 2025).

Volcanic hazards are dangers caused by volcanic eruptions or activities, in the form of solid, liquid, gas materials, or a combination of them, which pose a threat or tend to cause damage, loss of life, and material losses within the human living environment (Haeriah et al., 2018). One of the largest eruptions of Mount Merapi occurred in October 2010. This eruption resulted in 367 fatalities, more than 2,300 damaged houses, the evacuation of 400,000 people, and thousands of hectares of agricultural land destroyed,

causing losses of up to 3.5 trillion rupiah (BNPB, 2011). In general, the damage affected the residential, infrastructure, economic, and public service sectors. Eruptions of Mount Merapi continue to occur to this day, although not as severe as in 2010. Eruptions can be highly detrimental to communities if disaster mitigation efforts are not implemented. The risk of disaster will continue to increase in the absence of proper disaster management (Bappenas & BNPB, 2011).

The high volcanic activity of Mount Merapi has led to several surrounding areas being classified as Disaster-Prone Areas (KRB). Interestingly, these areas are still densely populated, as they are considered to have a comfortable and fertile environment for settlement (Rachmawati, 2018). One of the areas included in Mount Merapi's Disaster-Prone Zone (KRB) is Dukun Sub-district in Magelang Regency. Dukun Sub-district is located on the western slope of Mount Merapi. Its topographical conditions are heavily influenced by the volcanic hazards of Mount Merapi. The disaster potential in Dukun Sub-district is not only affected by volcanic hazard factors, but also by the vulnerability and capacity of the local community (Ardi et al., 2017).

In this context, community capacity becomes a key factor in minimizing the negative impacts of volcanic activity. The level of knowledge, preparedness, and the ability of the community to recognize and respond to threats greatly determines the effectiveness of disaster risk reduction (DRR) efforts. When communities possess adequate capacity, they are able to anticipate and respond to disasters quickly, appropriately, and independently. Research on community capacity in disaster-prone areas such as Dukun Sub-district is highly relevant, as it serves as a basis for formulating contextual, participatory, and sustainable policies. Studies on this theme have been conducted previously; however, the present research covers a broader geographical scope, allowing us to examine community capacity within each Disaster-Prone Area (KRB) in facing volcanic eruptions. Moreover, the sampling technique in this study was carried out based on the strata of each area, which cannot be generalized, as they possess different statuses.

Community readiness plays a vital role in minimizing the risks and adverse effects associated with volcanic eruptions such as those from Mount Merapi. A well-prepared community can substantially lessen the consequences of natural hazards. Critical components include local understanding of eruption indicators, designated evacuation routes, and safe shelter locations. Strengthening early warning systems, evacuation protocols, and the capacity for community-level response enhances overall resilience and helps mitigate the broader impacts of volcanic events (Istijono et al., 2025).

2. Method

A. Research Location

The research was conducted in Dukun Sub-district, Magelang Regency, Central Java Province, Indonesia. This area is located on the western slope of Mount Merapi and is classified into three Disaster-Prone Zones (KRB I, II, and III). The sampling area was determined using a cluster random sampling method through a lottery system based on the disaster risk zones. The selected sample villages include Sengi, Keningar, and Krinjing in KRB III; Mangunsoko and Dukun in KRB II; and Ngadipuro in KRB I.

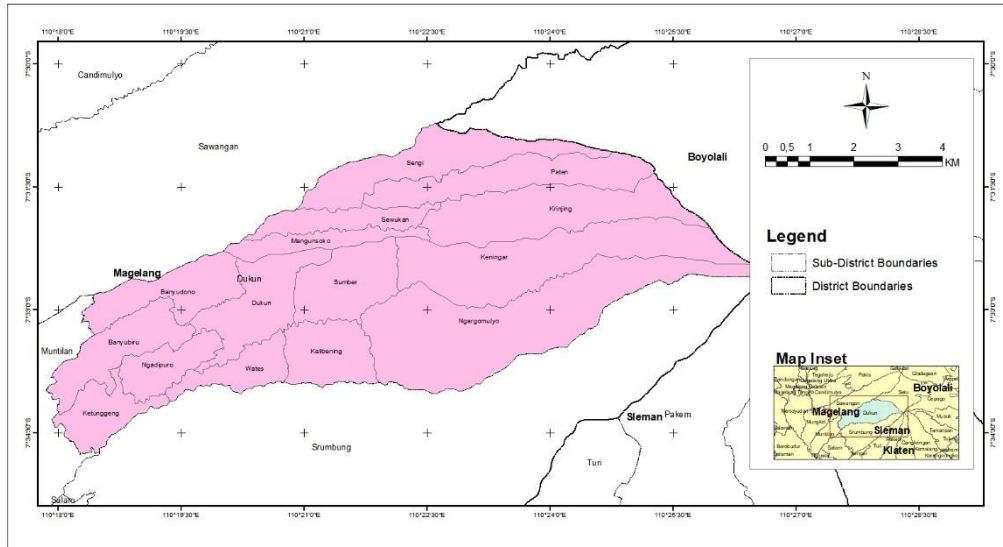


Figure 1. Research Location Map

B. Research Approach

This study uses a descriptive quantitative approach, which is based on scientific principles that include empirical or concrete characteristics, objectivity, measurability, rationality, and systematic structure (Sugiyono, 2023). The method used in this research is the survey method. A survey is a data collection technique aimed at obtaining information from a population through structured instruments such as questionnaires or a list of questions, which can be delivered directly through face-to-face interviews or through other communication media, such as telephone (Yusuf, 2017).

C. Research Procedure

To produce a final result in the form of a community capacity map, the required data consists of the capacity index and the threat level. The capacity index was obtained from scoring the questionnaire responses collected from 99 respondents across 6 villages located in the three KRB (Disaster-Prone Zones). Scoring was conducted using a formula issued by BNPB (National Disaster Management Authority). Scoring analysis is carried out by assigning scores to each variable used (Armaya & Hizbaron, 2015).

The respondents were selected through the following sampling techniques: The population of this study comprises household heads in Dukun Sub-district, totaling 16,767 households distributed across 15 villages. The sampling technique employed was cluster random sampling, with villages within each Disaster-Prone Area (KRB) serving as the sampling clusters. The draw resulted in the following: KRB III includes three villages, Keningar, Krinjing, and Sengi with a total of 2,560 households; KRB II consists of two villages, Mangunsoko and Dukun with 2,481 households; and KRB I consists of one village, Ngadipuro with 940 households.

The sample size for this study was determined using the stratified random sampling technique. The total number of samples was calculated with Yamane's formula at a 10% margin of error, selected because the population size is already known (Sugiyono, 2023).

$$n = \frac{N}{1 + N(e)^2}$$

$$n = \frac{16.767}{1 + 16.767(10\%)^2}$$

$$n = 99$$

Where n represents the required sample size, N refers to the total population, and e denotes the margin of error. The sample size for each Disaster-Prone Area (KRB) was determined using the following formula:

$$n^1 = \frac{N^1}{N} \times n$$

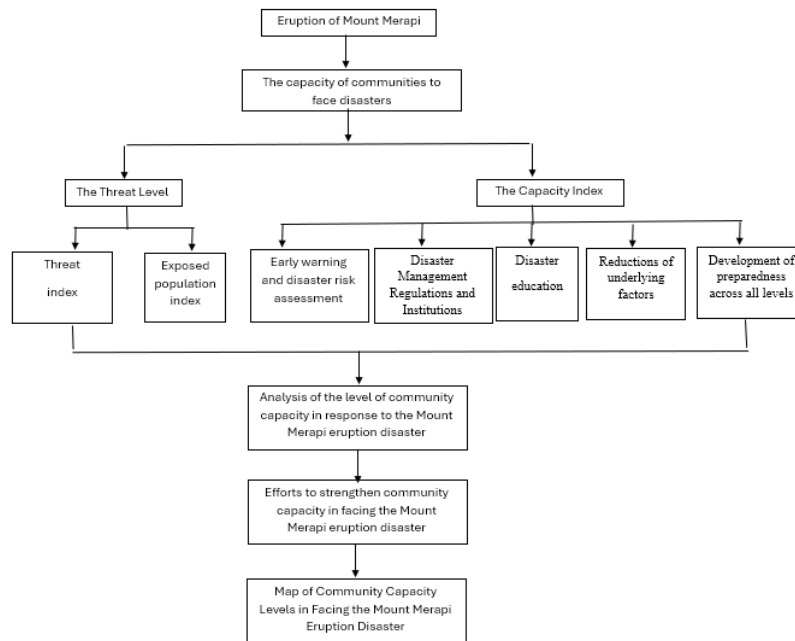
Where n_1 represents the sample size for each stratum, n denotes the total sample size, N_1 refers to the population size within each stratum, and N indicates the total population size.

Table 1. Sample Size

KRB	Sample Size
III	$n^1 = \frac{7936}{16.767} \times 99$ = 47
II	$n^1 = \frac{7135}{16767} \times 99$ = 42
1	$n^1 = \frac{1696}{16767} \times 99$ = 10
Total	99

The threat level was derived from the threat index and the exposed population index. The threat index refers to the categorization or classification of villages based on their KRB zones. Meanwhile, the exposed population index consists of the population density score and the vulnerable group score. Indicators used to assess vulnerable groups include the gender ratio, poverty ratio (i.e., the number of people or households receiving village assistance), disability ratio, and dependency ratio

All values of these variables will be matched against the community capacity level matrix

**Figure 2.** Conceptual Framework

D. Data Collection Instruments

The instrument used in this research is a questionnaire adapted from the Hyogo Framework for Action (HFA). The questionnaire consists of 88 items. This questionnaire is designed to measure the level of regional capacity in dealing with disaster risk. The determination of the capacity level is carried out through the integration of the Regional Capacity Priority Index values, each of which is obtained from the calculation of the Regional Capacity Indicator Index.

E. Data analysis

1) Capacity Index Analysis

The capacity index analysis uses five parameters/priorities based on BNPB Regulation No. 2 of 2012 (Badan Nasional Penanggulangan Bencana, 2012) which consists of 22 indicators. The capacity index assessment is carried out by having the respondents who were previously selected as samples fill out a questionnaire. The results of the questionnaire responses are then scored and calculated using a specific formula to obtain a value that can be classified into a capacity index category.

Table 2. Capacity Index Parameters

No	Parameter	Weight	Classification		
			Low	Medium	High
1	Early Warning Systems and Disaster Risk Assessment	100%	<0,33	0,33-0,66	>0,66
2	Disaster Management Regulations and Institutions				
3	Disaster Education				
4	Reduction of Underlying Risk Factors				
5	Development of Preparedness Across All				

Levels

$$\text{Capacity Index} = 1.0 \times \text{capacity score}$$

Source: BNPB Regulation No. 2 of 2012

2) Threat Level Analysis

The threat level is determined based on the threat index and the exposed population index indicators

A) Threat Index

The disaster threat index is developed by considering two main components: the probability of a threat occurring and the level of impact recorded from past disaster events. Therefore, this index is constructed based on historical data and the record of previous disasters that have occurred in a particular area. This approach provides a strong foundation for understanding the potential hazards that may reoccur in the future (Badan Nasional Penanggulangan Bencana, 2012).

Table 3. Exposed Population Index

Disaster Type	Threat Index Class			Weight
	High	Medium	Low	
Volcanic Eruption	KRB III	KRB II	KRB I	100%

Source: BNPB Regulation No. 2 of 2012

B) Exposed Population Index

The Exposed Population Index is determined based on the social and cultural aspects of communities living in areas potentially affected by disasters. This index is calculated using two main indicators: population density and the proportion of vulnerable groups in the area. These two indicators reflect the extent to which the population in a given region is likely to experience direct impacts when a disaster occurs.

Table 4. Exposed Population Index Class

Disaster Type	Indicator	Exposed Population Index Class			Weight
		High	Medium	Low	
Volcanic Eruption	Population	>1000	500-1000	<500	60%
	Density	people/km ²	people/km ²	people/km ²	
	Vulnerable Groups	>40%	20-40%	<20%	40%

Source: BNPB Regulation No. 2 of 2012

- *Population Density*

Population density is the ratio between the total population and the area of a region. In this study, it is calculated based on the population and land area of each sample village in Dukun Sub-district.

- *Vulnerable Groups*

The vulnerable groups in this study refer to social vulnerability based on BNPB Regulation No. 2 of 2012, which includes gender ratio, poverty ratio, disability ratio, and dependency ratio.

Table 5. Vulnerable Groups Classification

Ratio	Class	Score
>40%	High	3

20-40%	Medium	2
<20%	Low	1

Source: BNPB Regulation No. 2 of 2012

To determine the class of the exposed population index, a total score must first be calculated for each exposure parameter. This is done by multiplying the score of each parameter by its respective weight, then summing them. The total score of the exposed population index is then calculated and classified into three categories, which will be used for the threat level analysis.

Total Score of Exposed Population Index =

(Population Density Score×60%)+(Gender Ratio Score×10%)+(Poverty Ratio Score×10%)+(Disability Ratio Score×10%)+(Dependency ratio Score×10%)

$$\text{interval} = \frac{\text{total highest score} - \text{total lowest score}}{\text{total class}}$$

$$= 3-1=2 \quad =2:3= 0,7$$

Table 6. Exposed Population Index Interval

Exposed Population Index Classification	Class		
	High	Medium	Low
Score	>2,3	1,6-2,3	<1,6

Sumber: Data processing

Once the threat index class and the exposed population index class have been determined, the level of threat can then be derived using the following matrix calculation:

Table 7. Threat Level Matrix

Threat Level		Exposed Population Index		
		Low	Medium	High
Threat Index	Low			
	Medium			
	High			

Source: BNPB Regulation No. 2 of 2012

	High threat level
	Medium threat level
	Low threat level

C) Community Capacity Level Analysis

Adaptive capacity refers to a system's ability to adjust or modify its characteristics in order to respond more effectively to both current and potential future stresses (Walandouw et al., 2019).

The analysis of community capacity level is derived from the variables of threat level and capacity index. This capacity level will later be used as the basis for mapping community capacity in relation to disaster risk. The classification of capacity levels can be determined using the following matrix:

Table 8. The Capacity Level Matrix

Capacity Level		Capacity Index		
		High	Medium	Low
Threat Level	Low			
	Medium			
	High			

Source: BNPB Regulation No. 2 of 2012

	Low capacity level
	Medium capacity level
	High capacity level

3. Result and Discussion

A. Research Area Description

Dukun Sub-district is one of the administrative regions in Magelang Regency, located approximately 18 kilometers from the regency's administrative center. Astronomically, Dukun is situated between 110°01'51''–110°12'48'' East Longitude and 7°19'13''–7°35'99'' South Latitude. The total area covers 53.40 km². Dukun Sub-district borders the sub-districts of Srumbung, Salam, Muntilan, and Sawangan.

Based on demographic data, Dukun Sub-district is divided into 15 villages, 145 hamlets, 154 neighborhood associations (RW), and 470 community units (RT). The total population is 47,871 people, consisting of 23,894 females and 23,977 males. The majority of the population in Dukun Sub-district work in the agricultural sector (BPS Magelang, 2024).

Dukun Sub-district features a wide range of elevations, from 400 meters to 2,918 meters above sea level (masl). The lowest areas, with elevations between 400–500 masl, are found in the western part of the sub-district, such as the villages of Ketunggeng, Banyubiru, and Ngadipuro. Most villages are situated at elevations between 500–1,000 masl. Meanwhile, villages located above 1,000 masl include Krinjing, Paten, Sengi, and Ngargomulyo, with Ngargomulyo being the highest due to its close proximity to Mount Merapi's summit.

B. Threat Level and Community Capacity Index

1) Threat Level

Disaster impacts can be minimized if the community and the broader social systems have sufficient capacity to manage the threats they face (Prihananto, Fuad Galuh; Muta'ali, 2013).

The level of threat is one of the indicators used to assess the level of community capacity. This threat level consists of several indicators, namely the hazard index and the exposed population index. The threat index is an assessment based on the village's location within the Disaster Prone Area (KRB).

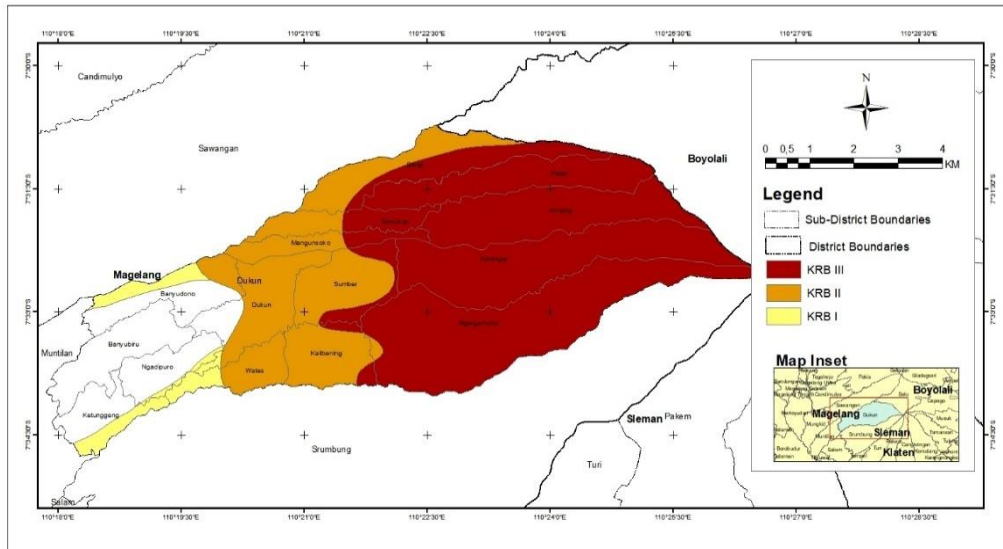


Figure 3. Maps of the Disaster-Prone Area (KRB) Zones for Mount Merapi (source: Ina Geospasial, made by Ulya, 2025)

Table 9. Threat Index of Research Area

KRB	Village	Class	Score
III	Krinjing Keningar Sengi	High	3
II	Dukun Mangunsoko	Medium	2
I	Ngadipuro	Low	1

Source: Data Analysis, 2025

The threat index consists of two indicators: population density, which carries a weight of 60%, and population vulnerability, which carries a weight of 40%.

Population density analysis aims to identify the population density in each sample village. High population density will increase the exposed population index, as areas with large populations are at greater risk of disaster impacts, both in terms of loss of life and material losses. Furthermore, population density also significantly impacts evacuation effectiveness (Permatasari, 2018).

Table 10. Population Density of Research Area

KRB	Village	Population Density	Class	Score
III	Krinjing	369	Low	1
	Keningar	99	Low	1
	Sengi	1160	High	3
II	Dukun	1658	High	3
	Mangunsoko	1240	High	3
I	Ngadipuro	1637	High	3

Source: data analysis, 2025

The scores for each Disaster-Prone Area (KRB) zone can thus be determined as follows

- 1) KRB III: $(1+1+3):3 = 1,6 = 2$ (medium)
- 2) KRB II: $(3+3):2 = 3$ (high)
- 3) KRB I: 3 (high)

As the zone with the highest hazard level, KRB III is not permitted to be densely populated. Therefore, in the research area, this zone is primarily utilized for agricultural activities and sand mining. Meanwhile, KRB II, which also has a significant potential for eruption impact, is found to have a high population density. KRB I in Dukun Sub-district covers only a small portion of the area, and it is reasonable for the population density to be relatively high, considering that the potential impact of an eruption in KRB I is lower compared to KRB III.

The population vulnerability indicators consist of several factors, namely the sex ratio, poverty ratio, disability ratio, and dependency ratio.

A) Sex Ratio

The sex ratio is the comparison of the number of males to females in a population, generally expressed as the number of males per 100 females. A high sex ratio indicates a predominance of the female population in a given area. A larger number of women may affect the effectiveness of the evacuation process, as women generally require more physical support from men during emergency situations (Permatasari, 2018). This is due to the assumption that women are considered more vulnerable when facing disaster threats, both in terms of decision-making and physical limitations during evacuation, compared to men. Therefore, the higher the proportion of female population in an area, the more likely that area is to be considered more vulnerable (Armaya & Hizbaron, 2015).

Table 11. Sex Ratio of Research Area

Village	Number of Females	Number of Males	Ratio (%)	Class	Score
Krinjing	1080	1168	108,1	High	3
Keningar	326	325	99,7	High	3
Sengi	2256	2232	100,4	High	3
Dukun	2714	2692	99,2	High	3
Mangunsoko	831	868	104,4	High	3
Ngadipuro	1405	1411	100,4	High	3

Source: data analysis, 2025

The scores for each Disaster-Prone Area (KRB) zone can thus be determined as follows

- KRB III: $(3+3+3):3 = 3$
- KRB II: $(3+3):2 = 3$
- KRB I: 3

All sample villages have a high category sex ratio index. Therefore, greater effort is required during the evacuation process in the event of a disaster.

B) Proverty Ratio

A high poverty ratio will hinder the post-disaster recovery process. Impoverished communities face various limitations, both economically and socially, which hinder their ability to survive during crises. The absence of protections such as insurance increases their vulnerability and poses greater challenges in recovering their lives after a disaster

(Amanah et al., 2017).

Table 12. Poverty Ratio of Research Area

Village	Poor Households	Total Households	Ratio (%)	class	Score
Krinjing	242	755	32	Medium	2
Keningar	48	232	20,6	Medium	2
Sengi	126	1573	8,01	Low	1
Dukun	781	1894	41,2	High	3
Mangunsoko	192	587	32,7	Medium	2
Ngadipuro	100	940	10,6	Low	1

Sumber: data analysis, 2025

The scores for each Disaster-Prone Area (KRB) zone can thus be determined as follows

- 1) KRB III: $(2+2+1):3 = 1,7 = 2$
- 2) KRB II: $(3+2):2 = 2,5 = 2$
- 3) KRB I: 1

C) Disability Ratio

Persons with disabilities require substantial support and additional assistance during the post-disaster recovery phase (Maharani et al., 2020). A low ratio of people with disabilities indicates that the village has a relatively small number of vulnerable groups. Individuals with physical or mental limitations generally require assistance from others during emergencies, such as disasters. This condition makes them more vulnerable compared to other residents (Amanah et al., 2017).

Table 13. disability ratio of research area

Village	People of disabilities	Population	Ratio (%)	Class	Skor
Krinjing	8	2248	0,35	Low	1
Keningar	2	651	0,31	Low	1
Sengi	4	4488	0,09	Low	1
Dukun	16	5406	2,93	Low	1
Mangunsoko	4	1699	0,23	Low	1
Ngadipuro	2	2816	0,07	Low	1

Sumber: data analysis, 2025

The scores for each Disaster-Prone Area (KRB) zone can thus be determined as follows

- 1) KRB III: $(1+1+1):3 = 1$
- 2) KRB II: $(1+1):2 = 1$
- 3) KRB I: 1

D) Dependency Ratio

This analysis aims to identify the dependency ratio of the elderly population (over 65 years old) and children (under 15 years old). A high percentage in these two age groups indicates limitations in the evacuation process, as they are still dependent on the productive age group (15–64 years old). The higher the dependency ratio, the greater the

risk of fatalities caused by the eruption of Mount Merapi (Habibi & Buchori, 2013). A high dependency ratio will lead to an increased demand for assistance during emergency situations (Maharani et al., 2020).

The age group ratio is used to assess the level of dependency among children and the elderly during disaster situations. These two groups are considered vulnerable, as they require support from others when a disaster occurs. Limitations in mobility and capacity to respond to disasters are the main factors contributing to their heightened vulnerability (Amanah et al., 2017).

Table 14. Dependency Ratio of Research Area

KRB	Village	Ratio	Class	score
III	Krinjing	45,8	High	3
	Keningar	50,2	High	3
	Sengi	44,9	High	3
II	Dukun	46	High	3
	Mangunsoko	47,8	High	3
I	Ngadipuro	80,2	High	3

Sumber: data analysis, 2025

The scores for each Disaster-Prone Area (KRB) zone can thus be determined as follows

- 1) KRB III: $(3+3+3):3 = 3$
- 2) KRB II: $(3+3):2 = 3$
- 3) KRB I: 3

To obtain the threat level data for each Disaster Prone Area (KRB), it is necessary to calculate the total score of the exposed population index

- Exposed Population Index of KRB III:
 $(2 \times 60\%) + (3 \times 10\%) + (2 \times 10\%) + (1 \times 10\%) + (3 \times 10\%) = 2,1 = \text{Medium}$
- Exposed Population Index of KRB II:
 $(3 \times 60\%) + (3 \times 10\%) + (2 \times 10\%) + (1 \times 10\%) + (3 \times 10\%) = 2,7 = \text{High}$
- Exposed Population Index of KRB 1:
 $(3 \times 60\%) + (3 \times 10\%) + (1 \times 10\%) + (1 \times 10\%) + (3 \times 10\%) = 2,6 = \text{High}$

Based on the data from the calculation of the exposed population index and the threat index, the threat level of each KRB zone can be determined using the threat level matrix.

Table 15. Threat Level of Research Area

KRB	Exposed Population Index	Threat Index	Threat Level
III	Medium	High	High
II	High	Medium	High
I	High	Low	Medium

Source: Data Analysis, 2025

2) Capacity Index

The community capacity index is an assessment derived from questionnaire responses based on the 2012 BNPB Regulation. The following are the assessment results from each sampled village.

Table 16. Capacity Index of Krinjing Village

No	Priority	Priority Index	Regional Capacity Index	Class
1	Early Warning Systems and Disaster Risk Assessment	0,6	0,536	Medium
2	Disaster Management Regulations and Institutions	0,5		
3	Disaster Education	0,425		
4	Reduction of Underlying Risk Factors	0,555		
5	Development of Preparedness Across All Levels	0,6		

Source: Data analysis, 2025

Table 17. Capacity Index of Keningar Village

No	Priority	Priority Index	Regional Capacity Index	Class
1	Early Warning Systems and Disaster Risk Assessment	0,6	0,563	Medium
2	Disaster Management Regulations and Institutions	0,55		
3	Disaster Education	0,425		
4	Reduction of Underlying Risk Factors	0,615		
5	Development of Preparedness Across All Levels	0,6		

Source: Data analysis, 2025

Table 18. Capacity Index of Sengi Village

No	Priority	Priority Index	Regional Capacity Index	Class
1	Early Warning Systems and Disaster Risk Assessment	0,8	0,628	Medium
2	Disaster Management Regulations and Institutions	0,5		
3	Disaster Education	0,475		
4	Reduction of Underlying Risk Factors	0,64		
5	Development of Preparedness Across All Levels	0,725		

Source: Data analysis, 2025

Table 19. Capacity Index of Dukun Village

No	Priority	Priority Index	Regional Capacity Index	Class
1	Early Warning Systems and Disaster Risk Assessment	0,75	0,657	Medium
2	Disaster Management Regulations and Institutions	0,625		
3	Disaster Education	0,625		

4	Reduction of Underlying Risk Factors	0,535
5	Development of Preparedness Across All Levels	0,775

Source: Data analysis, 2025

Table 20. Capacity Index of Mangunsoko Village

No	Priority	Priority Index	Regional Capacity Index	Class
1	Early Warning Systems and Disaster Risk Assessment	0,725	0,61	Medium
2	Disaster Management Regulations and Institutions	0,475		
3	Disaster Education	0,425		
4	Reduction of Underlying Risk Factors	0,675		
5	Development of Preparedness Across All Levels	0,75		

Source: Data analysis, 2025

Table 21. Capacity Index of Ngadipuro Village

No	Priority	Priority Index	Regional Capacity Index	Class
1	Early Warning Systems and Disaster Risk Assessment	0,575	0,518	Medium
2	Disaster Management Regulations and Institutions	0,45		
3	Disaster Education	0,525		
4	Reduction of Underlying Risk Factors	0,515		
5	Development of Preparedness Across All Levels	0,525		

Source: Data analysis, 2025

Based on the capacity index data of each village, the capacity index will be calculated according to the Volcanic Hazard Zone (KRB):

- KRB III = 0,575 = Medium
- KRB II = 0,63 = medium
- KRB I = 0,518 = medium

Based on the data analysis above, the capacity level of each Volcanic Hazard Zone (KRB) can now be determined.

Table 22. Capacity Level of Each KRB

KRB	Capacity Index	Threat Level	Capacity Level
III	Medium	High	Low
II	Medium	High	Low
I	Medium	Medium	Medium

Source: data analysis, 2025

The early warning system in the research area is still very limited. In this region, eruption warnings are still based on traditional methods, such as observing the behavior

of livestock or animals descending the mountain, interpreted as a sign of rumbling from the volcano's core. To alert the community of an eruption, they rely on announcements made through mosque loudspeakers and traditional bamboo slit drums (*kentungan*) located at mosques or neighborhood watch posts. Some villages coordinate using handy talkies during disasters, especially when internet access is unavailable. However, there is still no advanced equipment in place that can provide early warnings for Mount Merapi eruptions, which would enable residents to evacuate before conditions worsen.

According to the National Action Plan for Disaster Risk Reduction outlined in Government Regulation No. 21 of 2008 on the Implementation of Disaster Management, every region with potential disaster risk is encouraged to establish a Disaster Risk Reduction Forum (FPRB) as a social institution developed by and for the local community. However, in the research area, the naming of such forums varies between villages (Septiyani et al., 2024). In the sample villages, disaster risk reduction forums or institutional organizations are generally present. For example, Sengi and Krinjing Villages have Disaster Risk Reduction Forums (FPRB), while Mangunsoko Village has 'Guyub Rukun'. Such organizations are highly beneficial in both preparedness efforts and during disaster events.

Disaster education is occasionally conducted at the elementary school level. Preparedness development is carried out through the establishment of a Sister Village Memorandum of Understanding (MoU) with villages outside Dukun Sub-district, such as Deyangan Village in Mertoyudan Sub-district. In addition, temporary and permanent evacuation shelters have been provided. The local government has also prepared evacuation route maps.

Financial resources play a vital role in managing volcanic crises, as they are essential for various stages: before an eruption for preventive actions such as education, infrastructure development (e.g., dams, roads, signage); during the eruption for emergency response (e.g., evacuation, relocation, and medical assistance); and after the event for recovery efforts including compensation, rehabilitation, and reconstruction. However, insufficient economic and financial capacity has been identified as a limitation to Mount Merapi's adaptive resilience. In Indonesia, disaster-related funding is typically allocated on a case-by-case basis both prior to and following an event. Since these funds are not consistently available, local governments often need to seek assistance from private enterprises (such as television broadcasters) or international organizations (such as NGOs). In the event of a major disaster, the central government provides compensation using a hierarchical, top-down distribution system—from the district level, then to sub-districts, villages, and finally to the affected individuals. However, bureaucratic delays often hinder the timely disbursement of aid, forcing communities to depend on mutual support through material donations like food and clothing. Communities living near Mount Merapi have developed coping mechanisms, such as maintaining livestock as a form of financial savings, which can be sold in times of crisis. Some also keep communal savings in the form of cash or livestock. The current system could benefit from the institutionalization of foundational mechanisms like contingency reserves and solidarity funds at both local and national levels. While the idea of allocating funds for uncertain future events may be difficult to accept in developing countries, it is necessary considering Indonesia's frequent volcanic activity. Conventional insurance is generally not viewed as a feasible risk mitigation strategy due to high premium costs relative to the

population's income and the significant cultural shifts required. Currently, only limited micro-insurance programs targeting flood risks are available in certain regions of Indonesia (Bakkour et al., 2015).

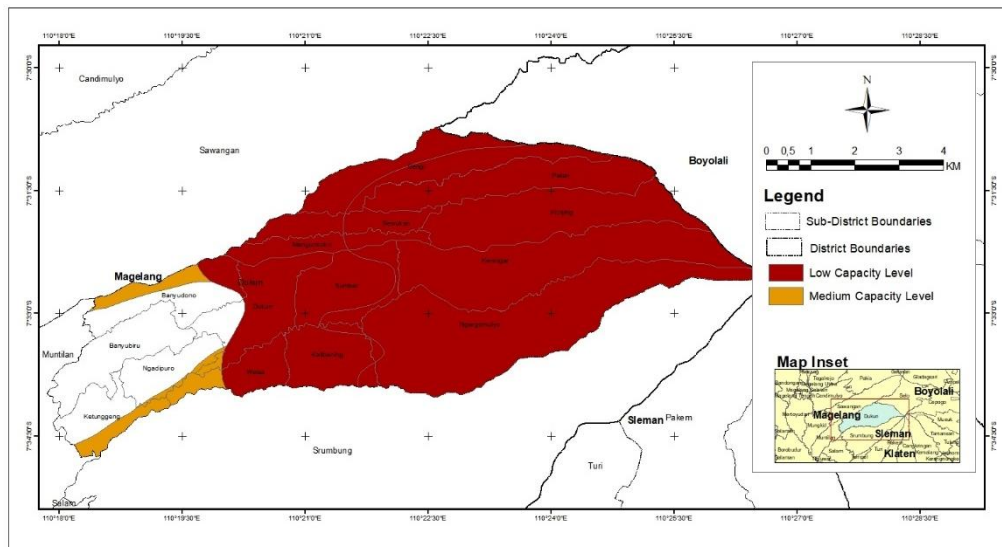


Figure 4. Maps of Capacity Level (source: Ina Geospasial, made by Ulya, 2025)

3) *Efforts to Enhance Community Capacity*

A resilient community is able to utilize its resources and adaptive capacity in a proactive and preemptive manner, while a non-resilient or less resilient community can only take action after the changes caused by the impact occur (or may not take any action at all) (Dillashandy & Panjaitan, 2019).

Population density levels must be reduced so that the potential impact of disasters does not affect many residents. Community participation through empowerment programs in disaster risk reduction serves as a strategy to reduce the level of threats and vulnerabilities, while simultaneously strengthening preparedness capacity. The entire process is planned and implemented by the community itself as the main actor (Handayani et al., 2022).

Developing a Disaster-Prepared School Program. This program involves integrating disaster-related materials into the school curriculum, conducting disaster simulation training, forming school-based emergency response teams, and encouraging the active involvement of teachers and parents in fostering a culture of disaster preparedness. Through this program, students are not only recipients of knowledge but also act as agents of change who can spread awareness and preparedness within their families and communities (Hardian et al., 2025).

In addition, a more advanced early warning system is needed to accurately detect the condition of Mount Merapi, so that information can be effectively communicated and accessed by all residents of Dukun Sub-district. This includes the installation of CCTV cameras and sirens that can reach all segments of the population. An information system accessible via smartphones is also necessary to ensure that residents who are away from their area can stay informed about the latest conditions.

Developing tailored risk information and content designs suited to various age groups, along with transforming the Disaster Risk Reduction Forum (FPRB) model from a community-based disaster risk reduction framework into one that is more oriented toward families or neighborhood units, may enhance the program's reach across broader segments of the population and promote a more integrated, multisectoral approach (Mutiarni et al., 2022).

4. Conclusion

The findings indicate that the threat level in KRB III and II falls into the high category, while in KRB I it is classified as medium. Although the capacity index across all KRBs is generally high, the actual capacity level in KRB III and II remains low, whereas in KRB I it is medium. The early warning system in the study area is still very limited. In the sample villages, disaster risk reduction forums or institutional organizations are generally established. Community preparedness has been strengthened through the establishment of Sister Village Memoranda of Understanding (MoUs) with villages outside Dukun Sub-district. Efforts to enhance community capacity should be directed toward reducing population density, developing a more advanced early warning system, and implementing disaster-prepared school programs across all levels of education. These findings highlight the need for integrated disaster risk reduction strategies that simultaneously improve technical systems and strengthen community resilience in volcanic hazard-prone areas.

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