



PLANNING MALAYSIA:

Journal of the Malaysian Institute of Planners

VOLUME 23 ISSUE 4 (2025), Page 691 – 706

ASSESSING THE RESILIENCE INDEX OF VILLAGES AFFECTED BY THE SEMERU ERUPTION IN LUMAJANG, INDONESIA

**Mohamad Mambaus Suud¹, Syamsul Bachri², Sumarmi³,
I Komang Astina⁴, Anisatu Nadhiroh⁵**

*^{1,2,3,4,5}Department of Geography, Social Faculty,
UNIVERSITAS NEGERI MALANG*

Abstract

Thousands of villages in Indonesia are at risk of and affected by cyclical disasters, such as the Mount Semeru volcanic eruption, making it necessary to measure the resilience index (RI) of such villages. This research was aimed at assessing the RIs of villages facing cyclical disasters. A quantitative approach with the adoption of the Baseline Resilience Indicators for Communities (BRIC) and Resilience Index Measurement and Analysis (RIMA) models was used in this study to calculate the index by means of five sub-resilience indices (SUBs) and 18 indicators. The data was obtained through the collection of secondary data, surveys, and focus group discussions (FGDs) with 12 participants. The study measured the RIs of six villages after the eruption. Sumbermujur Village had the highest RI (62.14), while Sumberwuluh Village had the lowest RI (39.34). Pronojiwo Village obtained an index of 55.28, while Oro-oro Ombo Village and Sumberurip Village obtained indices of 49.63 and 43.94, respectively. The RI of a village is not only contributed by the components of disaster preparedness or access to basic services but also the ability to build infrastructure, strengthen social aspects, and increase economic productivity. This study contributes to efforts to utilise more secondary data from villages and sub-districts that were provided annually to assess the RIs of villages based on the BRIC and RIMA models.

Keywords: Village Resilience Index, Assessment, RIMA, BRIC, Semeru Eruption

¹ Corresponding author. Email: suud.mms@gmail.com

INTRODUCTION

A volcanic area is like two sides of a coin. On the one hand, it attracts people to depend on it for their livelihood, and on the other hand, volcanic eruptions seriously threaten the livelihood of the people. Brown et al. (2017) recorded that more than 29 million people worldwide live within just 10 km of an active volcano and about 800 million people live within 100 km of one. There were 278368 fatalities due to volcanic eruptions between the period of 1500 and 2017. Indonesia has 13% or 127 of the world's volcanoes, which pose a constant threat to the community. Preparedness efforts, through continuous monitoring and assessing of the resilience index (RI), are essential to deal with volcanic eruptions, especially in countries such as Indonesia.

Preparedness efforts to deal with volcanic eruptions should not only come from the community but the government also has a significant role to play in developing knowledge and preparedness systems to enable the community to respond adequately (Bachri et al., 2015; Kurata et al., 2022). In Indonesia, the village is the smallest government unit. It can be the first line in supporting the preparedness and resilience of the community. According to data from the Central Statistics Agency (BPS), there are 83971 villages in Indonesia. The National Board for Disaster Management (BNPB) mentioned that 60.7% (50970) of the villages in Indonesia are located in disaster-prone areas. The government of Indonesia has launched the Disaster Resilient Villages program for implementation in villages at risk of disasters. It is being supported with village funds that are disbursed annually. Therefore, it is crucial that a study on the RI be conducted to monitor the participation of the villages in developing community resilience in Indonesia.

The eruption of the Semeru volcano on 4 December 2021 had a significant impact on the people's livelihood. According to data from the Regional Disaster Management Agency (BPBD), the eruption hit parts of six villages in two sub-districts, resulting in casualties, and the destruction of livelihood assets, the economy, infrastructure, environment, and social assets. The eruptions, which continued in 2022 and 2023, have been a part of the life cycle of the people for a long time. So, the best choice for the community is to coexist with the volcanic eruptions by developing their preparedness management and providing mechanisms to support the preparedness of the community. This study aimed to assess the RIs of six villages affected by the 2021 Mount Semeru volcanic eruption.

LITERATURE REVIEW

Resilience Index (RI)

The concept of resilience is often based on the basic idea of CS Holling (1973), which considered resilience as a measure of the persistence of a system and its ability to absorb changes and disturbances and maintain the exact relationship

between population or country variables (Karsai et al., 2020). The idea of resilience has contributed positively to reducing disaster risk and increasing the capacity of people and communities. However, there are still differences of opinion on resilience. Resilience has been developed as an essential reference in formulating government policies, programs, and strategies. Resilience is a relatively measurable concept that helps to understand how communities, households, and regions cope with shocks and disruption triggers (Altieri et al., 2015; Khusna et al., 2023).

Village Resilience can be defined as how villages and community institutions respond to economic, social, or environmental shocks (Irawan, Farihah, Prasetyo, Devy, et al., 2024). The mechanism is to recognise threats in the territory and organise community resources to reduce vulnerabilities while increasing the capacity to reduce the risk of a disaster. A disaster-resilient village is defined as one that can independently adapt to and face disaster threats and can quickly recover from any adverse effects if it is hit by a disaster (Bachri et al., 2023; Nurmala et al., 2023). In Indonesia, the Village Resilience Policy has been formulated in the Regulation of the Head of BNPB Number 1 of 2012 concerning disaster-resilient villages in the context of post-disaster recovery.

Resilience measurement of the village using social, economic and environmental indicators that together form a resilience capacity structure (Imbach et al., 2017; Mondal et al., 2023). Village resilience data will help decision-makers develop more effective measures to increase community resilience. Resilience assessments also improve understanding of which regions or communities have the lowest and highest resilience and can be used to track the progress of community resilience (Borda-Rodriguez & Vicari, 2015). In reducing vulnerabilities and risks, resilience assessments can guide the allocation of resources, the development of infrastructure and the protection of sensitive areas against cyclic disasters (Fuchs et al., 2012). However, it is still very difficult to build a paradigmatic village resilience assessment evaluation tool for cyclic disasters and reveal the driving factors underlying it.

The RI has been translated into several models with different contexts. In the context of cities, a city/urban RI model has been developed that accommodates the characteristics of urban disasters, including climate change adaptation (Suárez et al., 2016). In Portugal, the SoResiliere has been developed to measure the RI specific to social resilience (Jacinto et al., 2023). The district/province RI is a familiar measuring tool in Indonesia. This index is measured at the provincial and district levels as a variable for calculating the disaster risk index. This index is measured using 71 indicators covering aspects of development and disaster risk management in the province or district (BNPB, 2018). However, this index cannot be used for the lower levels, namely the village level. So, the challenge in this study was to develop an RI at the village level, which is the lowest level of the government system in Indonesia.

The Baseline Resilience Indicators for Communities (BRIC) and Resilience Index Measurement and Analysis (RIMA) Models

The Hazard & Vulnerability Research Institute at the University of South Carolina developed the BRIC, which is a comprehensive hierarchical index consisting of 49 indicators divided into six subdomains of resilience, among others: social, economic, institutional, infrastructure and housing, community capital, and the environment. The BRIC uses indicators to describe demographic characteristics, especially in its approach to disasters. For example, working-age people are generally better able to help themselves and others than minors, children, or people with disabilities. The BRIC also uses indicators of access to basic services that affect resilience. For example, good access to transportation facilities or communication infrastructure can be critical during and after a disaster (Scherzer et al., 2019).

The variables in the BRIC include (a) social resilience, which is directed at community involvement in groups, such as youth groups, religious groups, and sports groups. This indicator is intended for active community involvement. It is assumed to form social networks that often provide informal support during disasters and recovery; (b) economic resilience, which focuses on the benefits of a functioning and healthy economy for the community in a disaster situation, not solely the resilience of individual businesses; (c) institutional resilience, which is related to aspects of community governance and crisis management; (d) infrastructure and housing, which are related to housing quality, evacuation points and shelters, and the provision of emergency services; and (e) the environment, which has to do with natural capacities in relation to a community's exposure to specific hazards and previous experience of disasters (Burton, 2015; Cutter et al., 2010).

The RIMA is a resilience measurement instrument that is used by organisations related to the United Nations, such as the WFP and IFAD. It defines resilience capacity as the access to basic services, economic and livelihood assets, social safety nets, and adaptive capacity (Mondal et al., 2023). It is developed through four leading indicators: a) access to basic services, which shows the ability of people to meet their basic needs, including the quality, effectiveness, and accessibility of basic services. For example, access to drinking water, primary schools, livestock markets, transportation, and health services; (b) economic and livelihood assets, including productive and non-productive assets, which are indicators of people's life situations and affect people's behaviour when their assets are disrupted, for example, home ownership, jewellery ownership, and land; (c) social safety nets, which are a form of protection for all people affected by disasters; and (d) adaptive capacity, which is the ability of communities to adapt to disasters even with new scenarios as a result of environmental change. Adaptive capacity can be in the form of work diversification and participation in development activities that generate income (d'Errico et al., 2020).

The BRIC and RIMA have basically adopted village disaster resilience standards by adapting the disaster resilience of a place (DROP). Although DROP was designed for application in the United States, the similarities in the nature of disaster resilience make it applicable to the context of other countries. It has also been adopted and adapted in several other countries, such as Australia, Norway, Thailand, and Zimbabwe, to measure the RI within different contexts. The model assumes that natural systems interact with social systems, creating an inherent vulnerability and disaster resilience in those communities. The model has a comprehensive framework for assessing the overall disaster resilience of communities. It can pinpoint specific components that can improve or reduce disaster resilience (Scherzer et al., 2019). However, this method relies on primary data (surveys, focus group discussions (FGDs), and interviews) and not so much on secondary data. Meanwhile, villages in Indonesia always update their village profile data and information annually, which means these are worth using as secondary data. By utilising the village profile data and information, index measurements can be carried out more cheaply and easily, making it possible to reach villages in Indonesia.

Referring to the variables of RIMA and BRIC in the literature above, this study selected and combined several determinants from both that were relevant for the villages and communities to become more resilient after being affected by the Mount Semeru volcanic eruption. Indicators were chosen that could be supported by the secondary data from the villages or sub-districts. The selected indicators were: (a) access to services that could function and were available in the village to meet the basic needs of the community after the eruption, including health services, education, clean water, and transportation facilities; (b) the social capacity, including that of the working- and school-age groups, and social and religious institutions, to restore the social capital of the community after the eruption; (c) the economic capacity of micro, small, and medium enterprises (MSMEs), small industries, and agriculture to grow and restore the community's economy; (d) the infrastructure capacity in the form of road and communication networks to support all the activities in the community; and (e) village preparedness, which is a component of preparedness in dealing with cyclic disasters, including volunteer groups, early warning systems (EWSs), evacuation signs and instructions, and distance to BPBD offices.

RESEARCH METHODOLOGY

This study used a quantitative method to obtain information about the RI of villages through field surveys, secondary statistical data collection, and FGDs. The villages that were the units of analysis in this study were those affected by the Mount Semeru eruption in 2021.

As shown in figure 1. The location of the study is in six villages where directly affected by the Semeru Volcano Eruption in 2021. They are: Sumber

Wuluh, Sumber Mujur, Supiturang, Sumber Urip, Oro Oro Ombo, and Pronojiwo Village in Lumajang Regency, East Java Province.

Table 1: Impact of Eruption on Public Facilities and Houses at the Research Site

Sub-District	Affected Villages	Affected Public Facilities	Heavily Damaged Houses
Pronojiwo	Pronojiwo	1 district connecting bridge, one mosque	820 unit
	Oro-oro Ombo	2 Primary School, 1 Pre-School	
	Sumberurip	1 Junior High School	
	Supiturang	4 Primary School, 3 Pre-School, 1 Village health facility, 1 Integrated service post/Posyandu	
Candipuro	Sumberwuluh	4 Primary School, 2 Pre-School, 1 Village health facility	287 unit
	Sumbermujur	1 Junior High School, 1 Mosque	

Source: BPBD Lumajang Regency, 2022

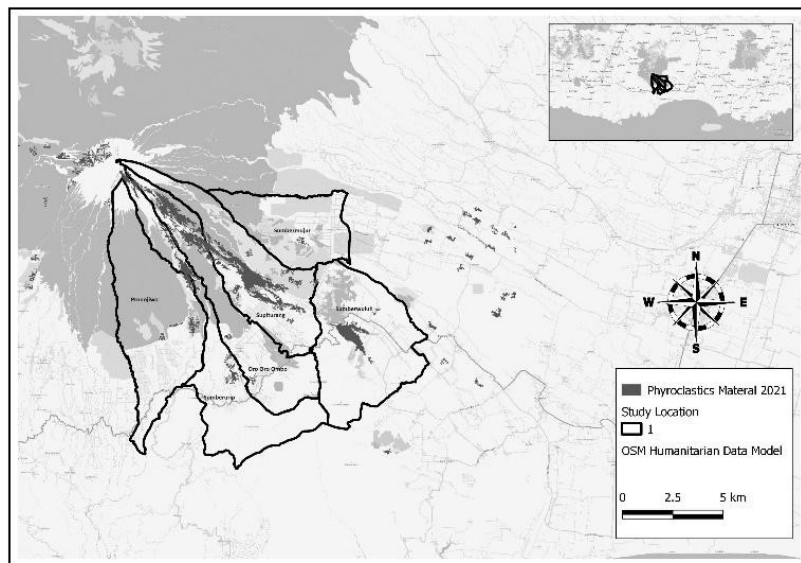


Figure 1. Research Location

Source: Researcher (2023)

Data Collection Procedure

This study made greater use of secondary data through the collection of village profile data and sub-district statistics. Field surveys were conducted to gather data on village preparedness, namely, EWSs, and village evacuation signs and instructions. FGDs were carried out to validate the secondary data that had been

collected and to gather the latest information about village preparedness. Updated data that had been missed in the village profile data and sub-district statistics were obtained through the FGDs. To validate the preparedness data, the FGD participants provided information on the EWS installation points, dissemination coverage, and evacuation signs and instructions. Researchers conducted a Focus Group Discussion (FGD) with 12 participants representing key stakeholders to provide information according to the selected indicators, as shown in Table 2.

Table 2. Participants in the FGD of Each Villages

Stakeholders	Element	Number
Sub-District Govt	Representatives of Sub District Government	1 person
Village Government	Head of Village	1 person
	Head of village development division	1 person
	Head of village welfare division	1 person
Hamlet Administrator	Head of hamlet (1 per hamlet)	3 persons
Others	village volunteers (man and women)	2 persons
	Women group	1 person
	Religious group	1 person
	MSME representatives	1 person
Total		12 persons

Indicators and Data Analysis

This study selected indicators inspired by the BRIC and RIMA that were relevant to the context of the research area and the availability of the data. The indicators of social capacity, economic capacity, and infrastructure capacity for this research were adopted from the BRIC model, while the variables of access to basic services and village preparedness were adopted from the RIMA model.

Table 3: The Variables Used to Measure Resilience Index (RI)

Variable / SUB	Indicators	Remarks	Sources(s)
Access to basic services	1. Access to education services	Percentage of schools to the total population of school-age residents.	(Hizbaron et al., 2018)
	2. Access to health facilities	Average number of health facilities for every 1000th of the population.	(Cox & Hamlen, 2015)
	3. Acces to clean water	Percentage of clean water service by the total number of households.	(Kaur & Singh, 2022)
	4. Acces to public transportation Facilities	Average number of public transportation services or every 1000th of the population.	(Scherzer et al., 2019)
Social capacity	5. Number of working-age residents	Percentage of labour force to the total population.	(Mondal et al., 2023)
	6. Gross school participation rate	Percentage of students to the total school-age population.	
	7. Number of social institutions	Average number of social institutions for every 1000th of the population.	
	8. Number of worship facilities		

Variable / SUB	Indicators	Remarks	Sources(s)
		Average number of worship facilities for every 1000th of the population.	
Economic capacity	1. Number of employees	Percentage of actively employed individuals to the total population of working-age individuals.	
	2. Number of MSME capacity	Average number of MSMEs to every 1000th member of the labour force.	
	3. Number of small industry	Average number of small industries to every 1000th member of the labour force.	
	4. Amount of agricultural land	Total amount of productive agricultural land per square kilometre (km ²) of land.	
Infrastructure capacity	5. Amount of main road network	Total amount of main roads per km of road.	
	6. Number of communication tower	Average number of communication towers for 1 every 1000th of the population.	
Village Preparedness	7. Number of village volunteers	Percentage of volunteers to the total population,	
	8. Amount early warning system coverage	Percentage of the population with access to EWSs.	
	9. Number of evacuation signs and instructions	Number of evacuation signs and instructions by the total main roads.	
	10. Proximity with BPBD	Distance to BPBD offices.	

Source: Researcher (2023)

Resilience Index (RI) Development

One of the advantages of adopting the BRIC or RIMA is its clear and easy-to-understand design. The analysis by BRIC or RIMA is based on adding hirers and average calculations (Scherzer et al., 2019). The resulting indicators are analysed by summing them in their SUBs in the min-max transform and averaging them to produce a SUB (Formula 1). The regenerated SUB scores are transformed in the min-max formula and then, added up to create the final community RI. All the indicators in the subdomain and all the SUBs are given equal weight. The formula for the calculation is given below:

$$\text{Min-Max Transformation: } X' = \frac{X - X_{\min}}{X_{\max} - X_{\min}} \quad (1)$$

$$\text{SUB score: } SUB = 1/n \sum_{i=1}^n X'i \quad (2)$$

$$\text{Village Resilience Score} = (n\text{Access basic services} + n\text{Social capacity} + n\text{Economic capacity} + n\text{Infrastructure capacity} + n\text{Village Preparedness}) \quad (3)$$

Formula 1 compiles all the values of an indicator (or subsequently a SUB) into a score range of 0-1. X shows the resultant value of each component

for a particular indicator, Xmin is the minimum value of the indicator, and Xmax is the maximum value of the indicator. Formula 2 explains the calculation of the SUB, where all the indicators (X') are sure subdomains that are added up and divided by the total number of n indicators in that subdomain. Formula 3 shows the calculation of the composite RI, which is the sum of six SUB scores consisting of (1) access to basic services, (2) social capacity, (3) economic capacity, (4) infrastructure capacity, and (5) village preparedness. IBM® SPSS® 21 was used to analyse the quantitative data.

ANALYSIS AND DISCUSSION

Indicators to measure the components of the village RI were compiled and produced, as shown in Table 4. The data that led to 18 indicators from the six villages produced a SUB that described the RI of each village. Figure 2a shows that Sumbermujur Village had the best access to basic services among the other villages, and health services and clean water were significant contributors to the basic services SUB. Oro-oro Ombo Village had the lowest access to basic services. Although educational services were very good, health facilities and clean water services were inadequate.

Figure 2b shows that Supiturang Village had the best social capacity among the other villages, adequate worship facilities, and a high level of school participation, which were significant contributors to the social capacity SUB. Oro-oro Ombo Village had the lowest social capacity due to the lack of social institutions and inadequate worship facilities.

Figure 2c shows that Sumberurip Village had the best economic capacity. This was contributed by the percentage of workers in the labour force and the number of MSMEs and small industries. In terms of infrastructure, roads, and good communication, Pronojiwo Village had the best infrastructure SUB among the other villages (Figure 2d). Meanwhile, for village preparedness (Figure 2e), Sumbermujur Village was the most prepared to face a disaster as it was equipped with village volunteer groups, evacuation signs and instructions, and adequate EWSs. However, ultimately, the RI was measured from the contribution of five SUBs to a composite RI to compare the RIs of the six villages.

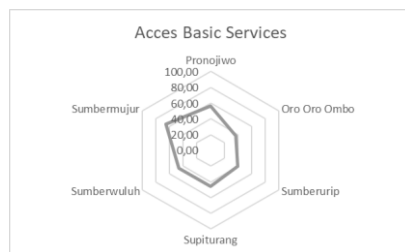
Table 4: Summary of Sub-Index Statistics and Village Resilience Indicators

Variable / Sub-Indeks	Indicator	Mean	Std. Dev.	Min.	Max.
Access basic services	Number of education facilities	0.76	0.13	0.5571	0.9223
	Number of health services	1.15	0.22	0.79	1.48
	Number of clean water services	26.89	32.58	1.51	69.42
	Number of public transportation services	2.02	0.61	1.21	2.85
Social capacity	Number of working-age individuals	68.08	2.30	64.82	70.37

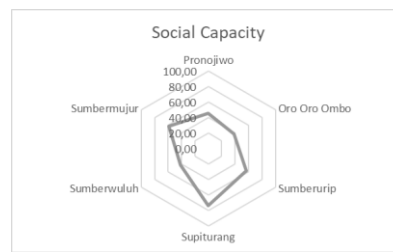
Variable / Sub-Indeks	Indicator	Mean	Std. Dev.	Min.	Max.
Economic capacity	Gross school participation rate	80.63	13.11	59.05	96.75
	Number of social institutions	0.47	0.17	0.22	0.67
	Number of worship facilities	6.81	1.67	5.12	9.61
	Number of employees	71.59	23.66	39.18	93.41
	Number of MSMEs	3.29	2.30	1.19	7.04
	Number of small industries	0.98	0.49	0.20	1.45
	Amount of agricultural land	9.51	8.08	2.65	23.24
Infrastructure capacity	Number of main road networks	59.17	19.91	21	74
	Number of communication towers	0.29	0.07	0.18	0.37
	Number of village volunteers	0.68	0.10	0.55	0.83
Village Preparedness	Number of EWSs	81.67	8.16	70	90
	Number of evacuation signs and instructions	0.27	0.12	0.15	0.48
	Proximity to BPBD offices	2.34	0.39	1.91	2.99

Source: Analysis (2023)

The preparedness aspect has been improving since the Mount Semeru eruption in 2021. For example, the villages have strengthened their disaster management groups/organisations and conducted various preparedness trainings, such as simulations. The EWS for eruptions has been strengthened through several electronic devices, radio, HT, and social media with mechanisms that are beginning to be structured. However, this does not seem massive and sustainable. The newly integrated EWS, which has been strengthened with the support of the BNPB, does not seem to have had a significant impact. The evacuation signs installed by the government are still insufficient to cover the entire village area.



(a)



(b)

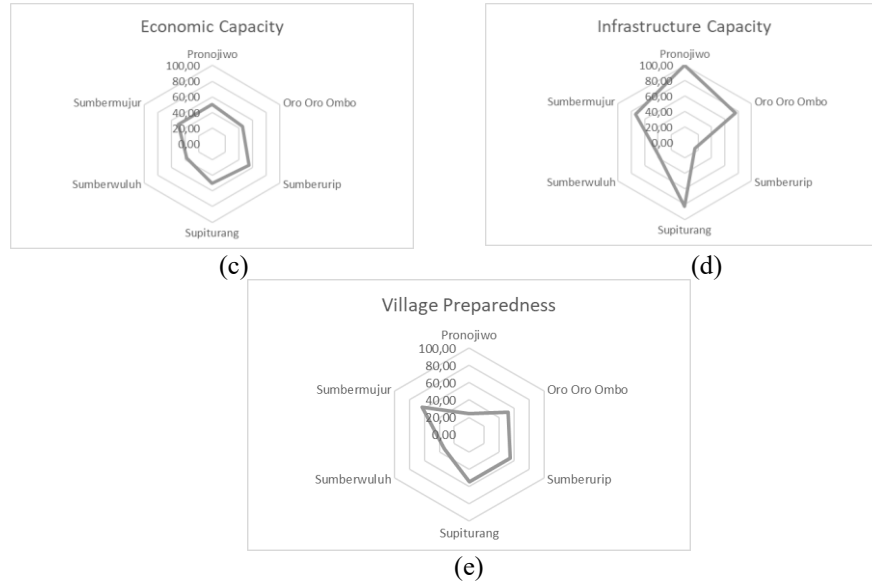


Figure 2: The Access to Basic Services SUB (a), Social Capacity SUB (b), Economic Capacity SUB (c), Infrastructure Capacity SUB (d), and (e) Village Preparedness SUB.
Source: Analysis (2023)

Resilience Indices (RI) of the Villages

The contribution of the five SUBs in Figure 2 resulted in the composite RI of each village. The average RI of the villages was 62.37, with a standard deviation of 9.32. Sumbermujur Village had the highest RI (62.14), slightly more than that of Supiturang Village (61.51). Sumbermujur Village is currently the destination for relocation development through the building of permanent shelters for residents affected by the eruption. Meanwhile, Sumberwuluh Village had the lowest RI (39.34). Pronojiwo Village, Oro-oro Ombo Village, and Sumberurip Village had RIs of 55.28, 49.63, and 43.94, respectively. In Figure 3, the degree of contribution of each SUB to the composite RI of each village is evident.

Table 5: The Resilience Indices (RI) of the Examined Villages

Village	Access to Basic Services	Social Capacity	Economic Capacity	Infrastructure Capacity	Village Preparedness	Composite RI
Pronojiwo	56,52	45,34	50,32	100,00	24,20	55,28
Oro Oro Ombo	37,38	37,86	44,53	76,12	52,26	49,63
Sumberurip	39,76	56,08	54,25	15,03	54,57	43,94
Supiturang	45,85	73,17	50,13	83,48	54,94	61,51
Sumberwuluh	46,20	41,95	37,16	37,74	33,67	39,34
Sumbermujur	65,77	58,79	50,00	73,52	62,61	62,14

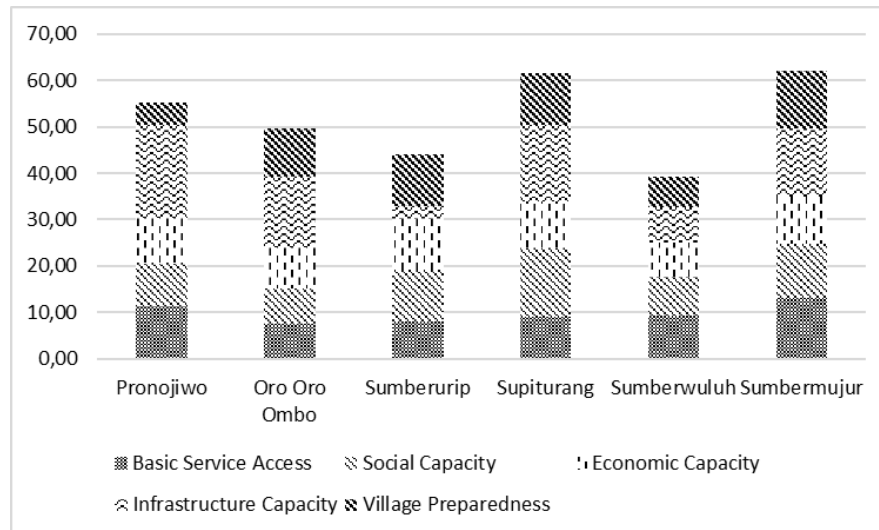


Figure 3. The Contribution of Each SUB to the Composite Resilience Index (RI)
 Source: Analysis (2023)

Due to their high village preparedness scores, Sumbermujur Village and Supiturang Village had the highest RI. The preparedness component of these villages was the best of the examined villages. The ratio of the number of disaster volunteers in the villages showed that these villages possessed a better personnel capacity compared to the other villages. The EWS and adequate evacuation signage allow people to use multiple routes to save themselves. The proximity to BPBD offices enables emergency assistance to be distributed more quickly. Good preparedness variables show that communities can adapt and develop resilience mechanisms to face disasters. The mechanism can be developed as a preparedness mechanism through information and data system governance, evacuation strategies, and disaster assistance management. This development is usually built through an organic mechanism in society, starting with the emergence of awareness, which later becomes community behaviour (Irawan, Farihah, Prasetyo, Azizah, et al., 2024; Kurniawan et al., 2022).

The access to basic services variable contributed significantly to the RI of Sumbermujur Village. Its facilities were better than those in the other villages, especially in terms of education, health, and clean water services. Health and education facilities are considered quite sensitive to the income and poverty conditions of village communities, which is one factor that contributes to the RI of villages. The construction of village health and education facilities that are easily accessible to the community provides opportunities for the community to save more, reduce expenses, and improve nutrition and nutrition standards (Naufal & Maret, 2023).

On the other hand, Supiturang Village, which had an RI that was similar to that of Sumbermujur Village, had social and infrastructure capacities that contributed significantly to its RI. Infrastructure does have a strong impact on supporting village resilience (Gromek & Sobolewski, 2020). The infrastructure capacity was contributed by the main roads and quite capable communication network. Meanwhile, the social capacity was mainly contributed by the optimal participation of schools and available worship facilities. Regarding the economic capacity, Sumbermujur Village was supported by good productive agricultural land as the community's main livelihood. Meanwhile, Supiturang Village was supported by its worker population in various sectors.

CONCLUSION

The evaluation of the RIs of villages affected by the eruption of the Mount Semeru volcano in 2021 was inspired by the BRIC or RIMA calculation models. By considering the context and availability of data, especially in the village and sub-district documents, six variables were adopted for the village RI, namely, (a) access to basic services, (b) social capacity, (c) economic capacity, (d) infrastructure capacity, and (e) village preparedness. This article successfully exposed the RIs of the six villages after the eruption. Sumbermujur Village had the highest RI (62.14), while Sumberwuluh Village had the lowest RI (39.34). The RIs of Pronojiwo Village, Oro-oro Ombo Village, and Sumberurip Village were 55.28, 49.63, and 43.94, respectively.

The contribution of each SUB to each village's composite RI, especially that of Sumbermujur Village and Supiturang Village, was unique. Disaster resilience is not always contributed by the preparedness component in dealing with disasters or access to good basic services such as in Sumbermujur Village. However, resilience can also be supported by adequate infrastructure and social capacities that allow communities to build social cohesion. It is also supported by worker productivity and the availability of workspaces in the village through agriculture, MSMEs, and small industries.

The RI in this study was successfully built by utilising secondary data, namely, village profile data and sub-district statistics. The data comprised village statistical data that are constantly being updated every year. This method allows village governments to independently compile the RI by measuring village resilience every year and formulating disaster management policies. This RI is sufficient for decision-making to formulate government policies, especially at the village level, for example, by building village infrastructure and basic community facilities oriented to long-term resilience by considering environmental, social, and economic variables. In addition, it is also integrated and continues to build preparedness at the village and community levels.

ACKNOWLEDGMENT

Gratitude is expressed to the Government of Lumajang Regency, local stakeholders, and survivors for positively contributing to this research and article. Thanks to the BPPT of the Indonesian Ministry of Education, Culture, Research, and Technology and the LPDP for funding this research.

REFERENCES

- Altieri, M. A., Nicholls, C. I., Henao, A., & Lana, M. A. (2015). Agroecology and the design of climate change-resilient farming systems. In *Agronomy for Sustainable Development* (Vol. 35, Issue 3). <https://doi.org/10.1007/s13593-015-0285-2>
- Bachri, S., Fathoni, M. N., Sumarmi, Masruroh, H., Wibowo, N. A., Khusna, N., Billah, E. N., & Yudha, L. (2023). Geomorphological mapping and landform characterization of Semeru volcano after the eruption in 2021. *IOP Conference Series: Earth and Environmental Science*, 1180(1), 012004. <https://doi.org/10.1088/1755-1315/1180/1/012004>
- Bachri, S., Stötter, J., Monreal, M., & Sartohadi, J. (2015). The calamity of eruptions, or an eruption of benefits? Mt. Bromo human–volcano system a case study of an open-risk perception. *Natural Hazards and Earth System Sciences*, 15(2), 277–290. <https://doi.org/10.5194/nhess-15-277-2015>
- BNPB. (2018). *Petunjuk Teknis Perangkat Penilaian Indeks Ketahanan Daerah* (1.1). BNPB. <https://sites.google.com/view/krb-bnpb/ikd>
- Borda-Rodriguez, A., & Vicari, S. (2015). Coffee co-operatives in malawi: Building resilience through innovation. *Annals of Public and Cooperative Economics*, 86(2). <https://doi.org/10.1111/apce.12075>
- Brown, S. K., Jenkins, S. F., Sparks, R. S. J., Odbert, H., & Auker, M. R. (2017). Volcanic fatalities database: analysis of volcanic threat with distance and victim classification. *Journal of Applied Volcanology*, 6(1), 15. <https://doi.org/10.1186/s13617-017-0067-4>
- Burton, C. G. (2015). A Validation of Metrics for Community Resilience to Natural Hazards and Disasters Using the Recovery from Hurricane Katrina as a Case Study. *Annals of the Association of American Geographers*, 105(1). <https://doi.org/10.1080/00045608.2014.960039>
- Cutter, S. L., Burton, C. G., & Emrich, C. T. (2010). Disaster Resilience Indicators for Benchmarking Baseline Conditions. *Journal of Homeland Security and Emergency Management*, 7(1). <https://doi.org/10.2202/1547-7355.1732>
- d’Errico, M., Garbero, A., Letta, M., & Winters, P. (2020). Evaluating Program Impact on Resilience: Evidence from Lesotho’s Child Grants Programme. *Journal of Development Studies*, 56(12). <https://doi.org/10.1080/00220388.2020.1746279>
- Fuchs, S., Birkmann, J., & Glade, T. (2012). Vulnerability assessment in natural hazard and risk analysis: Current approaches and future challenges. *Natural Hazards*, 64(3). <https://doi.org/10.1007/s11069-012-0352-9>
- Gromek, P., & Sobolewski, G. (2020). Risk-based approach for informing sustainable infrastructure resilience enhancement and potential resilience implication in terms of emergency service perspective. *Sustainability (Switzerland)*, 12(11). <https://doi.org/10.3390/su12114530>

- Imbach, P., Beardsley, M., Bouroncle, C., Medellin, C., Läderach, P., Hidalgo, H., Alfaro, E., Van Etten, J., Allan, R., Hemming, D., Stone, R., Hannah, L., & Donatti, C. I. (2017). Climate change, ecosystems and smallholder agriculture in Central America: an introduction to the special issue. In *Climatic Change* (Vol. 141, Issue 1). <https://doi.org/10.1007/s10584-017-1920-5>
- Irawan, L. Y., Farihah, S. N., Prasetyo, W. E., Azizah, V., Hartono, R., Masruroh, H., & Mapa, M. T. (2024). The effectivity of community-based early warning system on reducing Semeru eruption impact post-eruption 2021. *IOP Conference Series: Earth and Environmental Science*, 1314(1), 012037. <https://doi.org/10.1088/1755-1315/1314/1/012037>
- Irawan, L. Y., Farihah, S. N., Prasetyo, W. E., Devy, M. M. R., Hartono, R., Masruroh, H., & Mapa, M. T. (2024). The local disaster knowledge of local residents towards semeru eruption period 2021 in KRB III Semeru Volcano. *IOP Conference Series: Earth and Environmental Science*, 1314(1), 012039. <https://doi.org/10.1088/1755-1315/1314/1/012039>
- Jacinto, R., Sebastião, F., Reis, E., & Ferrão, J. (2023). SoResilire—A Social Resilience Index Applied to Portuguese Flood Disaster-Affected Municipalities. *Sustainability*, 15(4), 3309. <https://doi.org/10.3390/su15043309>
- Karsai, I., Schmickl, T., & Kampis, G. (2020). Resilience and Stability of Ecological and Social Systems. In *Resilience and Stability of Ecological and Social Systems*. <https://doi.org/10.1007/978-3-030-54560-4>
- Khusna, N. I., Sumarmi, Bachri, S., Astina, I. K., Susilo, S., & Idris. (2023). Social resilience and disaster resilience: A strategy in disaster management efforts based on big data analysis in Indonesian's twitter users. *Heliyon*, 9(9), e19669. <https://doi.org/10.1016/j.heliyon.2023.e19669>
- Kurata, Y. B., Prasetyo, Y. T., Ong, A. K. S., Nadlifatin, R., Persada, S. F., Chuenyindee, T., & Cahigas, M. M. L. (2022). Determining factors affecting preparedness beliefs among Filipinos on Taal volcano eruption in Luzon, Philippines. *International Journal of Disaster Risk Reduction*, 76, 103035. <https://doi.org/10.1016/j.ijdrr.2022.103035>
- Kurniawan, L., Zauhar, S., Maarif, S., & Mindarti, L. I. (2022). Strengthening Community Resilience At Balerante Village, Klaten Regency, Central Java Province (Study Case: Merapi Volcano Hazard). *Journal of Management Information & Decision Sciences*, 25(3).
- Maly, E., Vahanvati, M., & Sararit, T. (2022). People-centered disaster recovery: A comparison of long-term outcomes of housing reconstruction in Thailand, India, and Japan. *International Journal of Disaster Risk Reduction*, 81, 103234. <https://doi.org/https://doi.org/10.1016/j.ijdrr.2022.103234>
- Mondal, M., Biswas, A., Mandal, S., Bhattacharya, S., & Paul, S. (2023). Developing micro level resilience index for Indian Sundarban adopting resilience indicators for measurement and analysis (RIMA) methodology. *Geosystems and Geoenvironment*, 2(1), 100129. <https://doi.org/10.1016/j.geogeo.2022.100129>
- Naufal, H. A., & Maret, U. S. (2023). The Effect of Social Infrastructure on Rural Poverty in Indonesia with The Village Development Index As Moderation Variable. *EKO-REGIONAL: Jurnal Pembangunan Ekonomi Wilayah*, 18(1), 87–98. <https://doi.org/10.32424/1.erjpe.2023.18.1.3340>

- Nurmala, V. F., Pelita Panjaitan, B. S., & Subiyanto, A. (2023). The Importance of Village Resilience Assessment in Village Based Programs to Support Regional Resilience. *IOP Conference Series: Earth and Environmental Science*, 1173(1), 012059. <https://doi.org/10.1088/1755-1315/1173/1/012059>
- Scherzer, S., Lujala, P., & Rød, J. K. (2019). A community resilience index for Norway: An adaptation of the Baseline Resilience Indicators for Communities (BRIC). *International Journal of Disaster Risk Reduction*, 36(December), 101107. <https://doi.org/10.1016/j.ijdrr.2019.101107>
- Suárez, M., Gómez-Baggethun, E., Benayas, J., & Tilbury, D. (2016). Towards an Urban Resilience Index: A Case Study in 50 Spanish Cities. *Sustainability*, 8(8), 774. <https://doi.org/10.3390/su8080774>

Received: 2nd May 2025. Accepted: 10th September 2025