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Enhancing Community Resilience Through Disaster-Safe Market Preparedness in Kelud Volcanic Hazard Zone

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Article Information

History Article:
Received, 27/11/2025
Accepted, 05/11/2026
Published, 09/11/2026

Keywords:
Disaster Preparedness, Community Empowerment, Evacuation Simulation, Volcanic Hazard, Market Traders

Abstract

This community service program aimed to enhance disaster preparedness among market traders and stakeholders in the Kelud volcanic hazard zone through education, skills training, and evacuation simulations. The activity employed a participatory action research (PAR) approach, involving Wage Market vendors, market managers, the Blitar City Regional Disaster Management Agency (BPBD), and the Blitar City Disaster Risk Reduction Forum (FPRB) as technical partners. The program included planning, action, observation, and reflection to develop a sustainable Disaster-Safe Market model. Initial outreach sessions provided basic disaster education, self-evacuation procedures, and first aid using counseling and audio-visual presentations. Knowledge gains were measured through pre- and post-tests, while practical skills in evacuation and first aid were trained via demonstrations and hands-on exercises using Standard Operating Procedures (SOPs) and evaluated with an SOP skills checklist. A miniature Wage Disaster Preparedness Market was used for table-top simulations to visualize market structure, evacuation routes, and assembly points. The final stage involved a full-scale evacuation simulation, resulting in the establishment of a Wage Market Disaster Preparedness Team. Among 30 participants, knowledge scores increased from 54.3 to 88.7, 82% achieved skilled competency in SOP-based procedures, and evacuation routes proved effective. A key outcome of this program was the establishment of a Wage Market Disaster Preparedness Team, reflecting strengthened local capacity and institutional readiness. Additionally, the use of a miniature disaster preparedness market model and full-scale simulations enhanced participants' situational awareness and coordination during emergencies. This model demonstrates a replicable approach to community-based disaster preparedness in eruption-prone areas.

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DOI: https://doi.org/10.26699/jcsh.v7i2.ART.p071-078
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INTRODUCTION

Communities in Blitar Regency, Kediri Regency, and the western part of Malang Regency are located in an area at high risk of eruptions from Mount Kelud—one of the most active stratovolcanoes in Indonesia, with a history of more than 30 eruptions since the 11th century (Nihayatul, U., Supriyono, A., & Rinardi, 2017). The major eruption of Mount Kelud in 1919 claimed approximately 5,110 to 5,190 lives and caused extensive damage to residential areas and local socio-economic infrastructure (Dibyosaputro et al., 2015). A subsequent eruption in 1966 also caused hundreds of lives and damage to public facilities and agricultural land (Hadri, 2021). The 1990 eruption produced heavy ashfall, pyroclastic flows, and extensive damage to buildings and public facilities (Nihayatul, U., Supriyono, A., & Rinardi, 2017). The 2007 eruption, although more effusive, demonstrated that Mount Kelud still poses a significant threat to the surrounding community (Badan Nasional Penanggulangan Bencana, 2025).

The impact of the eruption not only resulted in physical damage to homes, agricultural land, infrastructure, and public facilities, but also impacted the economic sector and livelihoods. communities, especially market traders and small business owners who are highly dependent on the continuity of trade activities (Tampubolon, J., Nainggolan, H. L., Ginting, A., & Aritonang, 2018). Household-level evidence from the 2021 Mount Semeru eruption likewise shows substantial socio-economic impacts, which are lower where household resilience is higher (Kusumawardani et al., 2023). Many recorded disaster victims are from informal sector workers, such as market traders, due to limited access to mitigation information and a lack of skills in emergency preparedness (Hidayati et al., 2019). This situation demonstrates the importance of disaster education and disaster risk reduction for communities in market areas as densely populated economic and social spaces.

Efforts to increase disaster mitigation knowledge through outreach and preparedness training are essential to improve the community's rapid response and capacity to deal with emergencies (Rosen et al., 2023). People-centered approaches that are tailored to different community groups are recommended for strengthening disaster risk reduction around Indonesian volcanoes (Mutiarni et al., 2022). A community empowerment-based approach and cross-sector collaboration—such as with the Regional Disaster Management Agency (BPBD), the Disaster Risk Reduction Forum (FPRB), and community organizations like Blitar Nursing Care (BNC)—are crucial strategies for creating a collective protection system, particularly in public spaces like Pasar Wage, Blitar (Sejati et al., 2019). Based on a preliminary study at Pasar Wage, it was found that no training on Mount Kelud eruption preparedness had been conducted by either the market management or the BPBD, and there were no evacuation routes or safety markers within the market area (Sejati et al., 2019). Pasar Wage is located in Disaster Prone Area (KRB) I, approximately 15 km from Mount Kelud, making it potentially vulnerable to lava flows, ashfall, and ejections of incandescent material in the event of an eruption (Bappeda Provinsi Jawa Timur, 2014).

Given these conditions, the "Community Empowerment in Efforts to Create a Disaster-Safe Market at Mount Kelud with Blitar Nursing Care" program is a strategic step to reduce community vulnerability and strengthen disaster risk reduction capacity, as well as building community resilience in facing the threat of Mount Kelud eruption.

METHODS

This community service activity employed a Participatory Action Research (PAR) approach involving Wage Market vendors, market managers, the Blitar City Regional Disaster Management Agency (BPBD), and the Blitar City Disaster Risk Reduction Forum (FPRB) as technical partners. Each stakeholder contributed specific roles to ensure the effectiveness and sustainability of the program. Wage Market vendors participated as primary beneficiaries and active actors in identifying risks, engaging in training, and implementing preparedness practices. Market managers facilitated coordination, provided access to infrastructure, supported policy alignment, and ensured integration of preparedness measures into market operations. The Blitar City BPBD contributed technical expertise in disaster risk management, including hazard identification, development of evacuation procedures, and supervision of simulation activities. Meanwhile, the FPRB played a key role in community mobilization, participatory facilitation, and strengthening community-based disaster risk reduction strategies.

The PAR cycle consisted of four stages: planning, action, observation, and reflection, aiming

to develop a sustainable Disaster-Safe Market model. During the planning stage, an initial needs assessment and coordination meeting were conducted to identify potential hazards related to Mount Kelud eruptions, existing preparedness gaps, and institutional roles within the market environment. Based on this assessment, educational materials, training modules, and evaluation instruments were developed. The action stage began with an outreach and educational session focusing on eruption hazards, disaster risks, preparedness principles, and disaster management institutional structures. Disaster education was delivered through lectures, counseling sessions, and audio-visual presentations. Participants' knowledge was measured using a structured knowledge test administered before (pre-test) and after (post-test) the intervention.

The knowledge test instrument was a self-administered questionnaire consisting of 20 multiple-choice questions covering three domains: (1) hazards and risks of Mount Kelud eruptions (7 items), (2) evacuation procedures and safe behavior during disasters (7 items), and (3) basic first aid in disaster situations (6 items). Each correct answer was scored 1, and incorrect answers were scored 0, with total scores ranging from 0 to 20. The questionnaire was developed based on national disaster preparedness guidelines and relevant literature. Prior to implementation, the instrument underwent content validity testing by three experts in disaster management and emergency nursing. Minor revisions were made based on expert feedback to improve clarity and relevance. A pilot test was conducted among 15 market vendors outside the study location, resulting in a Cronbach's alpha coefficient of 0.82, indicating good internal consistency reliability.

Skills training on self-evacuation and first aid was conducted through demonstrations and hands-on practice facilitated by BPBD and FPRB. Participants were trained to follow Standard Operating Procedures (SOPs) for market evacuation and initial victim care. Skills performance was evaluated using an SOP-based observation checklist consisting of 15 items, including correct identification of evacuation routes, use of assembly points, and proper execution of basic first aid steps. Each item was rated as "performed correctly" or "not performed correctly." To enhance understanding and situational awareness, a miniature Wage Disaster Preparedness Market was used as a visual and practical learning tool. The miniature illustrated market layout, evacuation routes, assembly points, and safe zones, and was used during table-top simulations to practice decision-making in disaster scenarios. The observation and reflection stages involved an evaluative evacuation simulation to assess overall preparedness. Final evaluation was conducted through direct observation, participant feedback discussions, and assessment of evacuation route effectiveness. The activity concluded with a mutual agreement to establish a Wage Market Disaster Preparedness Team. The results of this program are expected to serve as a replicable model for Disaster-Safe Markets in other eruption-prone areas, supporting the national community-based Disaster Risk Reduction (DRR) strategy.

RESULTS

The community service program was successfully conducted through disaster education, emergency response skills training, and simulation. A total of 30 participants were involved, consisting of market traders, market managers, and community representatives located within the Kelud volcanic hazard zone.

Table 1. Characteristics of participants (n=30)

Characteristics	Frequency	Percentage (%)
Gender		
Female	24	80
Male	6	20
Age Group		
< 30 years	6	20
31–40 years	11	36,7
41–50 years	9	30
> 50 years	4	13,3

Characteristics	Frequency	Percentage (%)
Occupational Status		
Market Traders	24	80
Market Management Staff	2	6,7
FPRB Volunteers	2	6,7
BPBD Representatives	2	6,6
Previous Disaster Training Experience		
Yes	4	13,3
No	26	86,7

Source: Primary Data

Table 1 presents the characteristics of 30 participants involved in the community empowerment program for disaster-safe market preparedness. The majority of participants were female (80%), while male participants represented 20% of the total. Based on age distribution, the largest proportion of participants fell within the 31–40 years age group (36.7%), followed by those aged 41–50 years (30%), under 30 years (20%), and over 50 years (13.3%). In terms of occupational background, market traders comprised the highest proportion (80%), while market management staff, FPRB volunteers, and BPBD representatives each represented 6.7%. This composition indicates high involvement of the primary at-risk group (market traders), along with key disaster management stakeholders providing technical support and coordination. Regarding prior exposure to disaster training, only 4 participants (13.3%) reported having previous training experience, whereas the remaining 86.7% had never received disaster preparedness training.

Table 2. Improvement of Disaster Preparedness Knowledge of Participants (n = 30)

Variable	Pre-Test Mean Score	Post-Test Mean Score	Difference	Percentage Increase (%)
Disaster Preparedness Knowledge	54.3	88.7	+34.4	63.4

Source: Primary Data

The educational interventions conducted during the program demonstrated a substantial increase in participant knowledge regarding volcanic disaster risk, safe self-evacuation procedures, and basic first aid management. Based on the evaluation results, the average knowledge score increased from 54.3 (pre-test) to 88.7 (post-test).

Table 3. Skills Training Outcomes Based on SOP Skills Checklist (n = 30)

SOP Skill Domain	Skills Performance Category	Frequency	Percentage (%)	Description
Evacuation Skills	Skilled	27	90	Able to independently identify evacuation routes, move toward assembly points, and follow evacuation procedures according to SOP
	Moderately Skilled	3	10	Able to perform evacuation procedures with minor guidance
	Needs Improvement	0	0	Unable to perform evacuation procedures independently
First Aid Skills	Skilled	22	73	Able to independently perform wound care, bandaging, and splinting according to SOP

SOP Skill Domain	Skills Performance Category	Frequency	Percentage (%)	Description
	Moderately Skilled	6	20	Able to perform first aid procedures with occasional correction
	Needs Improvement	2	7	Unable to perform first aid procedures independently and requires additional training
Statistical comparison	Evacuation (skilled category) vs First Aid (skilled category)			p = 0.031

Note:
p-value obtained from the McNemar test, comparing paired skill performance between evacuation and first aid domains.
A p-value < 0.05 indicates a statistically significant difference.

The results indicate that evacuation skills were acquired at a higher level, with 90% of participants categorized as skilled and able to independently identify evacuation routes, move toward assembly points, and follow evacuation procedures according to SOP standards. In contrast, first aid skills showed relatively lower performance, with 73% of participants classified as skilled, while those requiring guidance primarily experienced difficulties in wound dressing and splinting techniques that demand greater procedural accuracy. A paired comparison analysis using the McNemar test demonstrated a statistically significant difference between the two domains, indicating superior performance in evacuation skills compared to first aid skills (p = 0.031).

Implementation of Evacuation Simulation

The evacuation simulation conducted at the final stage demonstrated effective mobilization and coordination among participants. The average evacuation time recorded was 12 minutes, measured from the market area to the designated assembly point, with an approximate travel distance of 350–400 meters. The simulation was carried out under moderate market density conditions, reflecting typical daily trading activities to ensure realistic evacuation dynamics. Based on observations and consultation with the Blitar City Regional Disaster Management Agency, this evacuation duration falls within an acceptable response time for community-based evacuation drills, considering the characteristics of the market environment, participant demographics, and the need to maintain orderly crowd movement. Field observations confirmed that evacuation routes were accessible, clearly marked, and unobstructed, allowing participants to move safely and continuously toward the assembly point without bottlenecks or congestion.

DISCUSSION

The community service program aimed at disaster-safe market preparedness effectively improved both knowledge and practical skills among participants. The majority of participants were market traders (80%), representing the most vulnerable group within the Kelud volcanic hazard zone. Engaging primary at-risk populations is a core principle of community-based disaster risk reduction, which emphasizes empowerment and active participation of local stakeholders to enhance resilience (Nindy et al., 2022). The predominance of participants aged 31–50 years (66.7%) contributed positively to program outcomes due to their physical readiness and high involvement in daily market activities; moreover, the dominance of female participants (80%) has important implications for gender-responsive Disaster Risk Reduction (DRR) strategies. In market settings, female traders often play dual roles as economic actors and caregivers, positioning them as effective agents in calming crowds, organizing orderly evacuation, securing merchandise, and disseminating preparedness knowledge within their social networks. Recognizing and strengthening these roles can enhance community-based preparedness by integrating women's leadership and situational awareness into disaster response mechanisms (Iqra, 2022). Studies in volcanic areas of East Java also

show that women's participation in disaster forums remains limited by patriarchal norms and domestic responsibilities, underscoring the need for gender-inclusive preparedness (Ida et al., 2025).

The low prior exposure to disaster training (13.3%) underscores the urgent need for targeted preparedness interventions. The program's educational activities resulted in a significant knowledge increase, with mean scores rising from 54.3 to 88.7, or a 63.4% improvement. This demonstrates the effectiveness of structured, context-specific disaster education in increasing understanding of volcanic hazards, evacuation protocols, and basic first aid (Ummah et al., 2025). Studies have shown that structured training significantly enhances disaster literacy and encourages proactive behavior in risk-prone communities (Suardana & Mertha, 2019).

Skill acquisition was another major outcome. Most participants (82%) achieved the "skilled" level in performing evacuation procedures, wound care, and splinting independently, demonstrating high competency in practical emergency response. Only a small proportion (5%) required additional guidance, suggesting that combining theoretical instruction with hands-on simulation is an effective strategy to build operational skills (Hawsawi & Thobaity, 2025). Experiential learning theory supports this, indicating that simulation-based training not only improves technical skills but also builds confidence and self-efficacy among participants, which is crucial during real emergencies (Fatoni et al., 2022).

The evacuation simulation reinforced the practical application of knowledge and skills. An average evacuation time of 12 minutes indicates that pathways were accessible, routes were clearly marked, and participants were able to coordinate effectively under simulated stress conditions. Simulation exercises in previous studies have consistently demonstrated improved crowd management, quicker response times, and better decision-making during disaster events (Chang et al., 2024). Progressive training and exercises have also been shown to increase the effectiveness of planned evacuation actions (Russo & Rindone, 2024).

Beyond technical competencies, the program also had psychosocial benefits. Participants reported increased awareness of risk, reduced fear of disaster events, and a sense of empowerment to act effectively, which are important determinants of community resilience (Santoso et al., 2025). Engaging participants in interactive simulations and group exercises fostered teamwork and social cohesion, critical factors that support coordinated response in real disaster situations (Power, 2018). A systematic review further indicates that social capital strengthens community disaster resilience through social learning, collective action, and preparedness (Zhao et al., 2025).

The inclusion of market management staff, FPRB volunteers, and BPBD representatives not only provided technical guidance but also strengthened institutional collaboration. Literature highlights that multi-stakeholder involvement ensures sustainability and institutional support for community-led disaster preparedness programs, facilitating regular drills, knowledge sharing, and reinforcement of SOP adherence (Beco, 2024; Chang et al., 2024). From a sustainability perspective, periodic refresher training, integration of disaster preparedness into market management routines, and expansion of programs to other at-risk markets are essential to maintain and strengthen the gains achieved. Additionally, leveraging technology such as mobile-based alert systems, educational videos, or virtual simulations could further enhance community readiness and engagement (Vandika, 2024).

Comparatively, similar programs in other hazard-prone regions have reported analogous findings: structured disaster education combined with hands-on simulation improves both knowledge and behavior, enhances social cohesion, and supports sustainable preparedness practices (Hawsawi & Thobaity, 2025). These findings reinforce the notion that community-focused, participatory approaches are more effective than top-down interventions, particularly in densely populated, high-risk environments like markets.

Overall, the program successfully combined knowledge enhancement, practical skill development, psychosocial empowerment, and institutional collaboration. Such a holistic approach aligns with best practices in disaster risk reduction and sets the stage for broader implementation across other vulnerable communities, enhancing overall resilience and preparedness.

CONCLUSION

The community service program on disaster-safe market preparedness effectively enhanced both knowledge and practical skills of participants,

particularly among market traders as the primary at-risk group. Knowledge scores improved significantly from 54.3 to 88.7, while 82% of participants achieved skilled competency in emergency response procedures. The evacuation simulation demonstrated effective coordination and readiness, with functional pathways and timely execution. Overall, the program successfully combined educational interventions, practical skill development, and stakeholder collaboration, contributing to improved community resilience in the Kelud volcanic hazard zone.

SUGGESTION

A Wage Market Disaster Preparedness Team was established, consisting of market management, traders, and community volunteers, with technical guidance from the Blitar City BPBD. The team is formally recognized and responsible for coordinating preparedness activities, including periodic training and evacuation drills integrated into routine programs. To support the sustainability of behavioral changes, disaster preparedness practices are integrated into daily market operations, such as consistent use of evacuation routes, display of signage, and clear role assignments during emergencies. These repeated practices are expected to strengthen habitual preparedness behaviors over the medium term. Institutional support and peer coordination within the team are essential to maintain long-term engagement. Continuous capacity building through refresher training and simulations is needed to sustain skills and readiness. Program expansion to other markets is encouraged, supported by appropriate technologies such as mobile-based information systems. Ongoing monitoring and evaluation should focus not only on immediate outcomes but also on medium-term indicators, including consistency of SOP implementation, participation in drills, and adherence to preparedness behaviors.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to all participants, including market traders, market management staff, FPRB volunteers, and BPBD representatives, for their active involvement in this program. We also acknowledge the support from local authorities and institutions that facilitated the implementation of disaster education, skills training, and simulation activities. This program would not have been possible without their cooperation and dedication.

FUNDING

This community service program was supported and funded by Poltekkes Kemenkes Malang. The funding covered materials, training equipment, and logistical support for the implementation of disaster education, skills training, and evacuation simulations.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest related to this activity.

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