REKA ELKOMIKA: Jurnal Pengabdian kepada Masyarakat
ISSN(p): 2723-3235 | ISSN(e): 2723-3243 | Vol. 6 | No. 3 | Pages 269 - 281
DOI : 10.26760/rekaelkomika.v6i3.269-281 November 2025

Disaster Mitigation Strategies to Enhance Community Preparedness for Earthquake Hazards in Liang Village, Salahutu District, Central Maluku

HENRY J. WATTIMANELA[1], ALEXANDER YOSEP ELAKE[2], EKA TRIYANA[3]

[1] Statistics Study Program, Pattimura University, Indonesia
[2]Physic Study Program, Pattimura University, Indonesia
[3]Mathematics Education Study Program, Pattimura University, Indonesia
Email: hwattimanela@yahoo.com

Received 19 August 2025 **|** Revised 14 September 2025 **|** Accepted 29 September 2025

ABSTRACT

The initiative to promote earthquake disaster mitigation strategies in Liang Village is designed to enhance the community's awareness and readiness in the face of potential earthquakes. This effort is crucial due to Maluku's earthquake-prone geographical characteristics, underscoring the need to equip residents with essential knowledge and mitigation skills. The approach includes socialization, engaging discussions, and training in using basic technologies like the Avenza Maps and INATEW. Residents from various hamlets participated, with support from the Maluku Provincial BPBD. The outcomes reveal a notable improvement in participants' comprehension, as shown by the increase in pretest and posttest scores. Furthermore, the community's active involvement in establishing disaster preparedness groups reflects heightened collective awareness. The use of simple technology also enhances residents' capability to map their surroundings. This initiative has effectively become an educational, practical, and innovative model for community-based disaster risk reduction.

Keywords: *disaster mitigation, earthquake, avenza maps, INATEWS*

1. INTRODUCTION

Indonesia, an archipelago, is strategically positioned at the convergence of three significant tectonic plates: the Indo-Australian, Eurasian, and Pacific Plates. This unique geological setting makes Indonesia one of the most tectonically active regions globally **(Hutama et al., 2025; Irsyam et al., 2020).** The continuous movement and interaction of these plates lead to various geological events, including earthquakes, volcanic eruptions, and tsunamis **(Gunawardana et al., 2024; Malusà et al., 2024)**. For instance, the subduction zone along western Sumatra, southern Java, and Nusa Tenggara is where the Indo-Australian Plate moves northward, subducting beneath the Eurasian Plate **(Kusky, 2020; Mitchell et al., 2022).** This subduction process is responsible for forming a series of active volcanoes

stretching from western to eastern Indonesia **(Benyshek & Taylor, 2021).** Tectonic activity in this area often results in significant earthquakes, such as the 2004 Aceh earthquake, which caused a catastrophic tsunami **(Pribadi et al., 2021).** In the eastern part of Indonesia, particularly the Maluku Islands, there is also a high susceptibility to geological hazards. This region is where the Eurasian, Australian, and Pacific Plates converge, creating a seismically active collision zone. The collision leads to substantial deformation of the Earth's crust, potentially triggering major tectonic earthquakes and tsunamis. Additionally, the Maluku Sea Plate is subducting beneath the surrounding plates, heightening the risk of earthquakes and volcanic activity. The high seismicity in Indonesia, especially around Maluku, is a direct result of tectonic plate movements. Seismic data indicates frequent earthquakes, both shallow and intermediate, along with high-frequency tremors in this area. Moreover, Indonesia's more than 120 active volcanoes are primarily formed due to this subduction activity. These geological conditions, while posing a high risk of natural disasters, also offer significant geological potential, such as mineral resources, geothermal energy, and fertile volcanic soil beneficial for agriculture. Consequently, it is crucial for the government and communities to continuously improve preparedness, monitoring, and disaster mitigation, particularly in earthquake-prone areas like the Maluku Islands. Understanding tectonic plate dynamics and seismic zone distribution is essential for developing disaster-resilient and sustainable development policies for the future **(Jufriansah et al., 2021; Muryani et al., 2024).**

On September 26, 2019, a 6.5 magnitude earthquake struck Ambon Island and its vicinity. The earthquake's epicenter was pinpointed at 3.43° South Latitude and 128.46° East Longitude, located on Seram Island, with a depth of merely 10 km. This shallow depth caused the tremors to be intensely felt on the surface, particularly in regions near the epicenter. The shaking's intensity, measured on the Modified Mercalli Intensity (MMI) scale, ranged from V to VI, signifying that it was strong enough to damage buildings and infrastructure **(Rahmawan et al., 2024; Vassilakis et al., 2022)**. The earthquake's impact was profound, both physically and socially. Hundreds of homes were demolished, leaving many families without shelter. Besides residential properties, public infrastructure like roads and bridges sustained significant damage, impeding mobility and the delivery of humanitarian aid. Liang Village and Ambon City were among the hardest-hit areas. In Liang Village, numerous homes and public facilities were heavily damaged. Meanwhile, in Ambon City, the earthquake severely disrupted community and government operations. Additionally, the earthquake triggered secondary disasters, such as landslides in several locations, complicating the situation and hampering evacuation efforts and aid distribution. Other environmental damages, including ground fissures and shifts in surface contours, were also reported in various affected areas. This event illustrates how earthquakes can not only cause structural damage but also lead to secondary natural disasters that worsen their effects **(Goda et al., 2019; Omira et al., 2019).** Regarding casualties, the National Disaster Management Agency (BNPB) reported that 20 people lost their lives due to the earthquake. Furthermore, hundreds of others were injured, ranging from minor to severe injuries. Many injuries were caused by falling debris or falls while attempting to escape. Most injured individuals received treatment at nearby hospitals, although healthcare facilities were overwhelmed by the influx of patients **(Gunawan et al., 2024; Rachman et al., 2022).** The earthquake also induced psychological trauma among residents, particularly children and the elderly, who experienced prolonged fear. Many families

opted to evacuate to safer locations, such as open fields or refugee tents established by the government and humanitarian organizations. The post-disaster recovery process demands significant time, including infrastructure repairs, the rehabilitation of homes, and the restoration of the social and economic conditions of the affected communities **(Olorunfemi & Adesunloye, 2024)**. The 2019 earthquake in Ambon serves as a crucial reminder of the importance of disaster preparedness, earthquake-resistant spatial planning, and the construction of resilient infrastructure to withstand seismic shocks. Additionally, solidarity among residents and collaboration between the government, humanitarian organizations, and volunteers are essential for effectively addressing the impact of disasters **(Wattimanela, 2023).**

The utilization of Avenza Maps technology makes a significant contribution to supporting disaster mitigation efforts and disaster management in Indonesia. Avenza Maps is a mobile-based mapping application that allows users to download, manage, and use georeferenced maps (maps with geographic coordinates) directly on their smartphones or tablets. The main advantage of this application is its ability to function offline, without requiring an internet connection or cellular network **(Avenza Systems Inc. (n.d.). Firefighting, n.d.; Buwono et al., 2024).** This makes Avenza Maps highly relevant for use in remote areas with minimal telecommunications infrastructure, or in emergency situations when communication networks are disrupted due to natural disasters. Thus, this application not only facilitates access to spatial information but also enhances community preparedness and response to potential disasters **(Ismail et al., 2024).**

Additionally, Indonesia has developed INATEWS (Indonesia Tsunami Early Warning System) as a national tsunami early warning system operated by the Meteorology, Climatology, and Geophysics Agency (BMKG). This system functions to detect seismic activity in the ocean that could potentially trigger a tsunami by monitoring seismic sensors, buoys, and tide gages distributed across various Indonesian waters **(Husrin et al., 2022**). The recorded data was then analyzed quickly and accurately, enabling BMKG to disseminate warnings to authorities, disaster management agencies, and the general public thru various communication channels. The presence of INATEWS is a vital component in life-saving efforts, as early information can provide time for communities to evacuate and reduce the risk of casualties **(Alexander Pasaribu et al., 2024; Atika, 2019).**

The community service initiatives focused on earthquake disaster mitigation training serve as a strategic approach to reduce casualties and minimizing adverse impacts. This training involves various community groups, including village officials, Negeri Liang, teachers, Community Youth Development, the Family Welfare and Empowerment Organization, and the Negeri Liang community, to foster collaboration in disaster management. Through these activities, participants gain a comprehensive understanding of earthquake risks and learn effective response and risk-reduction techniques. The training includes evacuation drills, familiarization with safety equipment, and the development of local emergency response plans. The main objective is to enhance the community's awareness, knowledge, and skills in managing emergencies. By actively engaging the community, the goal is to build a strong and

lasting culture of disaster response. Furthermore, this initiative improves inter-agency coordination and strengthens local capacity in disaster mitigation efforts. As a result, the training not only facilitates knowledge sharing but also empowers the community to become more prepared, alert, and resilient in the face of potential future disasters risks.

2. METHOD

The implementation of community service activities in Liang Village, Salahutu District, Central Maluku began with an opening, socialization, training, and assistance. This training was conducted using methods such as lectures, discussions, and hands-on practice regarding earthquake disaster mitigation. The stage of implementing community service is

2.1 Preparation stage

The first step in executing community service is preparation, which starts with conducting field surveys to pinpoint issues and identify partners who will participate. This process involves gaining an understanding of the community, assessing the availability of infrastructure, and gathering information related to earthquake disaster mitigation. This data forms the foundation for program planning. During this phase, coordination is undertaken with relevant parties such as village officials, community leaders, and youth organizations to foster synergy and ensure the smooth execution of activities. This collaboration is crucial to guarantee that the program is well-targeted and can be embraced and supported by the local community.

2.2 Implementation stage

The second phase will involve the implementation of community service activities to enhance community preparedness in facing earthquake disasters. The program for the implementation of community service is as follows:

2.2.1 Socialization of Earthquake Disaster Mitigation Strategies

The goal of educating the public about earthquake risks is to improve awareness and readiness for potential disasters. The information shared covers the causes of earthquakes, maps highlighting areas susceptible to them, possible effects, and steps for mitigation before, during, and after an earthquake. The community is urged to create a family emergency plan, keep essential supplies on hand, and be familiar with rescue procedures to follow when an earthquake strikes. After an earthquake, it is crucial to be cautious of debris and steer clear of damaged zones. This information is delivered through engaging media like guidebooks, brochures, posters, and videos to ensure it is easily understood and to promote a collective responsibility in minimizing disaster risk.

2.2.2 Disaster Mitigation Strategy Training

Conducting training and evacuation simulations is a crucial part of mitigating sudden events that can lead to extensive damage and loss of life. These activities are vital for ensuring that the community is well-prepared to handle potential earthquakes. They help train individuals to react swiftly and accurately during such events and teach them how to protect themselves and assist others. During these simulations, participants engage in self-evacuation drills, such as the "Drop, Cover, and Hold On" technique. This practice instructs people to immediately find a secure spot, like beneath a sturdy table or in a room corner away from windows, when they sense an earthquake tremor. Additionally, the earthquake simulation helps the community remain composed and avoid panic in stressful situations. Following this, a comprehensive evacuation plan is created, involving all community members, to ensure they are aware of the necessary actions during an earthquake. This plan includes details about safe evacuation

routes, designated assembly points, and the procedures everyone must follow. As a result, the community becomes more resilient and better equipped to handle an earthquake disaster.

2.2.3 The Application of Technology as a Disaster Mitigation Step

Technological tools that can be prepared for disaster mitigation include communication radios, disaster reporting apps, and social media platforms. Communication radios are independent of internet networks and electricity, allowing them to operate even when other communication systems are down. Disaster reporting apps, like PetaBencana.id, enable the public to report disaster incidents in real-time to authorities. People can send images or videos of the damage, the locations of victims needing help, or other crucial information. Social media technology is employed to boost community readiness, speed up the spread of early warning information, and aid in coordination and collaboration among various parties involved in disaster response. Integrating social media platforms like Twitter or WhatsApp facilitates the broader and quicker dissemination of early warning information to the public. Information from early warning apps or related agencies can be shared via social media to reach a larger audience. Additionally, social media can also be used to enhance communication and coordination among the community during emergencies.

2.3 Evaluation stage

The program undergoes regular assessments and enhancements. The evaluation framework focuses on:

a. Progress and accomplishments relative to the objectives of each phase.
b. Challenges faced during the program's execution.
c. Actions taken following the program's implementation.

3. RESULT AND DISCUSSION

The Implementation Team engaged in community service initiatives in Liang Village by actively involving local residents. Their efforts centered on disaster mitigation strategies to improve the community's preparedness and resilience against potential disaster risks.

3.1 Preparation stage

The process of organizing community service activities focused on disaster mitigation strategies in Liang Village started with discussions with village officials, assessing potential disaster risks, and collaborating with the officials of Liang Village (figure 1).

Figure 1. The Service Team Coordinating with The Liang Village Officials

3.2 Implementation stage

The first step in the implementation stage is the socialization of earthquake disaster mitigation strategies, which focuses on informing and educating the community about

essential preparedness measures (figure 2). On Saturday, July 19, 2025, Liang Village hosted an event focused on earthquake disaster mitigation strategies. Held at the village meeting hall, the gathering attracted residents from various hamlets across Liang Village. This initiative, spearheaded by Universitas Pattimura, aimed to enhance community awareness and readiness for potential earthquakes, as the area has been identified as an earthquake-prone zone by the Meteorology, Climatology, and Geophysics Agency (BMKG).

The success of the event was marked by the active involvement of various community stakeholders, including village officials, teachers, the Youth Development group, the Family Welfare and Empowerment Organization (PKK), and other members of the Negeri Liang community. The event commenced with remarks from the Head of Liang Village and the head of the service team, both of whom emphasized the importance of this activity as an initial effort towards fostering a culture of disaster resilience. A team from the Regional Disaster Management Agency (BPBD) of Maluku Province delivered the socialization material, explaining the fundamental concepts of earthquakes, their causes, and possible impacts. They also discussed mitigation strategies applicable at both the household and community levels. The session was interactive, allowing residents to ask questions and voice their concerns.

The socialization stressed the necessity of establishing disaster preparedness groups at the village level, which would be responsible for monitoring, disseminating information, and coordinating evacuations during disasters. The idea was well-received by the attendees, who willingly selected representatives from each hamlet to join the team. This socialization marks a tangible step in enhancing the collective awareness of the Liang Village community about the importance of earthquake disaster mitigation. With active community involvement, it is anticipated that Liang Village will evolve into a disaster-resilient community, better equipped to handle natural risks in the future.

Figure 2. Implementation of Disaster Mitigation Socialisation in Liang Village

Training the community in earthquake-prone areas on technology usage is a crucial step in disaster mitigation efforts. Thru training involving the community, village officials, and volunteers, participatory mapping of evacuation routes and safe gathering points was

conducted using the Avenza Maps application. In this activity, residents were actively encouraged to mark evacuation routes as well as important locations such as mosques, schools, healthcare facilities, and high ground safe from tsunamis. With the offline GPS feature, people can use maps in emergency situations, thereby Increasing preparedness and spatial awareness. Additionally, by utilizing evacuation simulation facilitation synchronized with INATEWS warning scenarios, the public can practice responding to notifications from communication media such as radio, television, and official SMS (figure 3).

Figure 3. The Service Team Conducts Training Activities on the Use of Technology for Disaster Mitigation in Liang Village

Following the completion of socialization and disaster mitigation training, participants were administered a post-test to evaluate their skills in disaster mitigation and its practical application. This post-test aims to gauge the community's comprehension of the material covered. The questions in the post-test mirror those from the pre-test material. Table 1 displays the outcomes of both the pre-test and post-test.

Table 1. Pre test dan Post test Score Result

No	Code	Pre test	Post test
1	KL- 1	5	8
2	KL- 2	6	6
3	KL- 3	5	7
4	KL- 4	5	7
5	KL- 5	8	10
6	KL- 6	6	8
7	KL- 7	8	10
8	KL- 8	8	10
9	KL- 9	5	9
10	KL- 10	8	10
11	KL- 11	7	10
12	KL- 12	5	10

No	Code	Pre test	Post test
13	KL- 13	6	9
14	KL- 14	5	9
15	KL- 15	6	10
16	KL- 16	8	10
17	KL- 17	6	10
18	KL- 18	7	10
19	KL- 19	7	10
20	KL- 20	6	8
21	KL- 21	6	9
22	KL- 22	7	9
23	KL- 23	5	8
24	KL- 24	7	9

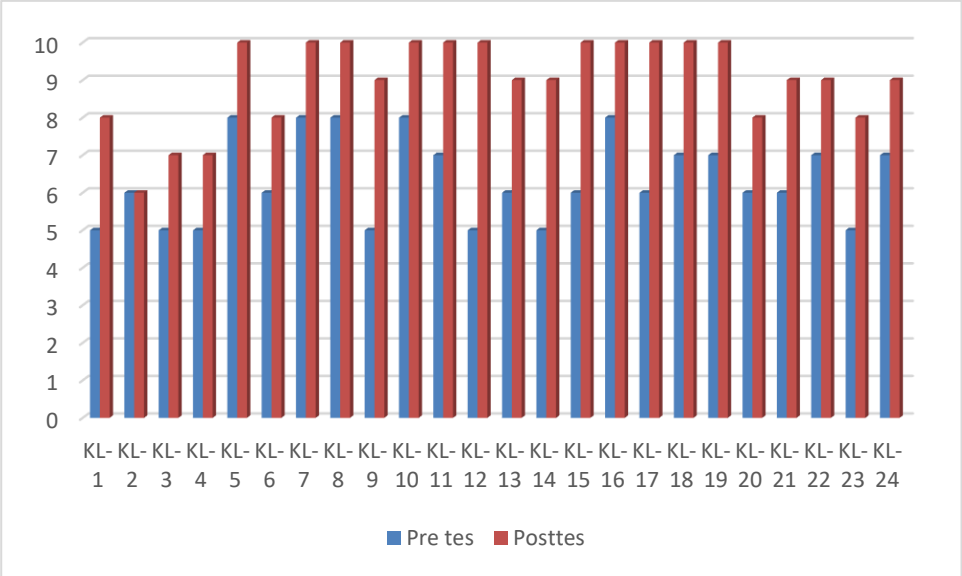

Figure 4. Pretest and post test score graph

Community service activities centered around "Disaster Mitigation Strategies" were carried out, engaging 24 participants from diverse backgrounds. To assess the activity's effectiveness, evaluations were conducted using pretests and posttests for all participants. The evaluation results clearly demonstrate an increase in participants' knowledge following the series of materials and training provided. According to the data collected as shown in figure 4, pretest scores ranged from 5 to 8, with an average score of 6.38, indicating that participants initially had a low to moderate understanding of disaster mitigation. In contrast, posttest results showed a marked improvement, with the highest score reaching 10 and the lowest at 6, resulting in an average posttest score of 8.92. This reflects an average increase of 2.54 points between the pretest and posttest, signifying enhanced understanding and knowledge among participants after the service activity. Individually, 22 out of 24 participants improved their scores, suggesting that most participants effectively absorbed the material presented. Notably, participant KL-12 showed the most significant improvement, with a score increase from 5 to 10, a gain of 5 points. Other participants, such as KL-9 and KL-14, also experienced similar improvements, each increasing from a score of 5 to 9. However, one participant, KL-2, showed no change in score, and another participant showed minimal improvement, which warrants further evaluation, considering potential personal challenges or unsuitable teaching methods. From an achievement standpoint, it can be concluded that the training materials were well-structured and effectively received by most participants.

3.2.1 Installation of evacuation direction signs

The execution of this community service initiative also involves setting up evacuation direction signs to lessen the impact (figure 5). The goal is to offer residents clear and swift directions to reach assembly points or safe areas during an earthquake. These signs are placed at key locations, such as road junctions and paths leading to open spaces designated for evacuation. The signs are designed with contrasting colors and universally recognized symbols, making them easily understandable for everyone, including children and newcomers. Additionally, the materials used are weatherproof, ensuring visibility in both rain and sunshine. Furthermore, mapping evacuation routes, identifying safe points, and assessing the effectiveness of these routes were also conducted.

Figure 5. The service team together with the community are installing evacuation direction signs.

The delivery of interactive and contextual material appears to be a crucial factor in the success of this activity. Additionally, the participants' enthusiasm contributed to fostering an active learning process during the training sessions. The consistent increase in posttest scores also indicates that the training approach was well-adapted to the participants' initial understanding levels. The evaluation results provide strong evidence that such community service activities are highly effective in enhancing community disaster literacy. Therefore, it is highly recommended to replicate this approach in other areas with similar disaster vulnerability levels. Furthermore, to optimize training outcomes, follow-up activities such as advanced training, disaster simulations, or the formation of local disaster preparedness communities are recommended. Periodic evaluations are also essential to ensure the sustainable enhancement of community capacity. This activity serves as proof that disaster education can be transformed into concrete actions that bolster community resilience against future disaster risks.

4. CONCLUSIONS

The socialization activities for earthquake disaster mitigation strategies in Liang Village play a crucial role in enhancing community awareness and readiness for potential earthquake threats. This community service initiative engages residents from various hamlets, aiming not only to share information but also to deepen their understanding of the significance of both individual and collective preparedness in the face of disasters. The Maluku Provincial BPBD provides material that covers a fundamental understanding of earthquakes and mitigation strategies applicable at both household and community levels. The community's enthusiasm is evident through their active participation in discussions and their eagerness to establish disaster preparedness groups, coordinate efforts, and evacuate when necessary.

Training using Avenza Maps technology is beneficial in monitoring and assessing damage after disasters, where volunteers can mark damaged buildings, blocked roads, or areas directly affected in the field with brief descriptions and photo documentation. The data generated can be shared with the authorities to expedite aid coordination and can be used to determine locations, evacuation routes, gathering points, and vulnerable areas. INATEWS technology is also utilized to enhance community preparedness for potential earthquake and tsunami disasters. The integration of Avenza Maps technology with INATEWS is expected to strengthen disaster mitigation strategies in Indonesia, particularly in terms of information dissemination, evacuation planning, and raising public awareness of the potential dangers of tsunamis.

Moreover, the use of technology, such as the Open Camera app, demonstrates how simple innovations can significantly support disaster mitigation efforts. Training in this application equips the community with new skills for accurately documenting and mapping environmental

conditions. The app's geotagging and timestamp features facilitate the collection of visual data, which is instrumental in creating maps of disaster-prone areas and village contingency plans. This represents a tangible step towards a more responsive and participatory community-based early warning system. The integration of educational approaches with technology makes this initiative an effective model for local-level disaster risk reduction. By enhancing the community's capacity with relevant knowledge and tools, Liang Village is now better positioned to become a disaster-resilient community.

The success of this initiative underscores the importance of collaboration between educational institutions, local government, and the community in establishing a sustainable mitigation system. Based on the series of socialization and earthquake disaster mitigation training activities in Liang Village, it is evident that this program has effectively heightened the community's awareness and understanding of the importance of disaster preparedness. Through a participatory and interactive approach, residents not only received information passively but also actively engaged in discussions and simulations, which reinforced their comprehension of the material presented. The effectiveness of this initiative is clearly demonstrated by the pretest and posttest evaluations, which showed an average score increase of 2.54 points. Most participants exhibited a significant improvement in their understanding, reflecting the success of the contextual and practical material delivery method. This improvement also confirms that well-designed disaster education can have a positive impact in a short time. Thus, this community service activity not only serves as a medium for knowledge transfer but also as an initial step in building the resilience of village communities against disaster risks. In the future, the sustainability of this program is highly recommended through advanced training, disaster simulations, and strengthening local institutions to create an adaptive, responsive, and community-based mitigation system.

ACKNOWLEDGEMENT

The team expresses gratitude for the financial support provided by the Pattimura University, under contract number 019.05.4H/SPK-PJ/UN13-PPBJ/PPU-LPPM/2025. The people of Liang village, Salahutu sub-district, Maluku Tengah, for their participation in this activity.

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