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Building school resilience in high-risk disaster zones: Slamet volcano eruption mitigation education and simulation

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Abstract
Schools located in volcanic disaster-prone areas require high levels of preparedness, yet they are often hindered by a lack of practical training. This community service program aims to enhance the disaster mitigation capacity of the school community at SDN Kecil Munggangsari, Banyumas, situated only 8 km from the summit of Mount Slamet. The implementation utilized a participatory educational approach consisting of two stages: disaster management knowledge transfer and practical self-evacuation simulations for students and teachers. Evaluation results showed a significant surge in disaster literacy and skills. Participants' understanding of mitigation procedures increased from 11% to 100%, while practical simulation experience rose from 6% to 100%. These findings confirm that integrating routine simulations into the educational environment is highly effective in transforming theoretical knowledge into actionable life-saving skills. This program recommends the establishment of a sustainable local mitigation curriculum for schools located in primary volcanic danger zones.

Keywords: Disaster mitigation; Volcanic eruption; School resilience; Mount Slamet

Contributions to SDGs



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Membangun resiliensi sekolah di kawasan rawan bencana: Edukasi dan simulasi mitigasi erupsi Gunung Slamet

Abstrak
Sekolah yang berada di kawasan rawan bencana (KRB) gunung api memerlukan kesiapsiagaan tinggi, namun seringkali terkendala oleh minimnya pelatihan praktis. Program pengabdian ini bertujuan meningkatkan kapasitas mitigasi bencana warga sekolah di SDN Kecil Munggangsari, Banyumas, yang berjarak hanya 8 km dari puncak Gunung Slamet. Metode pelaksanaan menggunakan pendekatan edukasi partisipatif yang terdiri dari dua tahap: pemaparan materi manajemen bencana dan praktik simulasi evakuasi mandiri bagi siswa serta guru. Hasil evaluasi melalui angket menunjukkan lonjakan signifikan dalam literasi dan keterampilan mitigasi. Pemahaman peserta mengenai prosedur mitigasi meningkat dari 11% menjadi 100%, sementara pengalaman praktik simulasi meningkat dari 6% menjadi 100%. Hasil ini menegaskan bahwa integrasi simulasi rutin ke dalam lingkungan pendidikan sangat efektif dalam mentransformasi pengetahuan teoritis menjadi keterampilan penyelamatan diri yang nyata. Program ini merekomendasikan adanya kurikulum mitigasi lokal yang berkelanjutan bagi sekolah-sekolah di zona bahaya utama gunung api.

Kata Kunci: *Mitigasi bencana; Gunung meletus; Resiliensi sekolah; Gunung Slamet*

1. Introduction

Indonesia is often characterized as the world's "disaster laboratory" due to its position at the meeting point of three major tectonic plates. This geological setting makes the archipelago highly vulnerable to seismic and volcanic activities, forcing its population to live with persistent disaster risks. Java, in particular, hosts the highest density of volcanoes, with approximately 35 active peaks (Hafida, 2019). Among these, Mount Slamet, the highest mountain in Central Java, borders the Banyumas Regency and remains a significant volcanic threat (Nugroho et al., 2023). Given this reality, enhancing the capacity of local communities and students to manage and reduce volcanic risks is not merely an educational goal, but a survival necessity (Nugroho et al., 2025; Suartama et al., 2020).

The urgency of disaster mitigation is underscored by the severe long-term impacts on vulnerable groups. Elementary school children are particularly at risk; experiencing a disaster can lead to chronic emotional distress, trauma, and various health issues (Çifçi & Kilinç, 2024; Demiröz et al., 2025; Llorente-Marrón et al., 2021; Oshiro et al., 2022; Raccanello et al., 2017). Comparative research in Peru, Croatia, and Japan reveals that earthquake and disaster victims often suffer from persistent trauma and depression long after the event (Petrović et al., 2025; Sodeyama et al., 2022; Valladares-Garrido, Zapata-Castro, Domínguez-Troncos, et al., 2022; Valladares-Garrido, Zapata-Castro, Peralta, et al., 2022). Consequently, preparedness education for elementary and early childhood students is vital (Chen et al., 2022; Wahyuni & Efastri, 2023). Schools serve as the primary vehicle for this education, fostering a resilient culture through systematic mitigation training (Fauzan et al., 2024; Rahiem & Widiastuti, 2020). As evidenced by studies in Mexico, the effectiveness of these programs relies heavily on the active support and leadership of teachers (Rodrigo et al., 2024).

Despite the clear benefits, a significant gap remains in practical implementation. Many educational institutions in disaster-prone zones still play a minimal role in imparting tangible mitigation skills (Astuti et al., 2023; Harahap, 2019; Wijayanti et al., 2025). This lack of preparedness is a regional challenge; migrants in Tokyo and various Southeast Asian countries face similar vulnerabilities due to inadequate infrastructure, poor communication, and weak early warning systems (Adu-Gyamfi & Shaw, 2022; Ayuningtyas et al., 2021; Samad et al., 2025). Bridging this gap requires fostering "resilient students" who possess both the knowledge and the technical skills to navigate emergency situations (Sugara et al., 2018). There is a direct, significant correlation between a resident's knowledge and their attitude toward volcanic eruption preparedness (Nugroho et al., 2023).

While general mitigation studies are extensive (Nurjanah et al., 2022; Yuandi et al., 2024), there is a localized shortage of training programs that specifically involve both teachers and students in the high-risk zones of Banyumas. This community service program was conducted at SD Negeri Kecil Munggangsari, located in Baturraden District. Situated only 8 kilometers from the peak of Mount Slamet, the school is exceptionally vulnerable to volcanic activity. Initial assessments revealed that despite its location, the school had never received formal training on natural disaster mitigation.

Recognizing this critical need, the community service team collaborated with the school to deliver a program focused on both theoretical knowledge and hands-on simulation.

While natural disasters are inherently unpredictable (Nugroho, 2018), their impact can be minimized when a community possesses robust mitigation skills (Nuriman et al., 2022). By empowering teachers to pass on this knowledge, the program aims to cultivate a disaster-aware and responsive generation capable of effective self-evacuation and risk reduction (Muhame et al., 2024).

2. Method

The community service program focused on volcanic disaster mitigation was implemented through a participatory socialization and simulation model. The activity was strategically held at SD Negeri Kecil Munggangsari, Baturraden District, Banyumas Regency. This location was selected due to its high-risk geographical position, situated only 8 km from the summit of Mount Slamet, which makes the school highly vulnerable to volcanic eruption hazards.

The program involved 24 participants, comprising all teachers at the school and students from grades 4 and 5. By involving both educators and students, the activity aimed to create a comprehensive school resilience ecosystem. The implementation followed a structured three-stage approach.

a. Pre-Implementation. This phase began in December 2023 with a field survey and initial coordination to analyze partner needs. This was followed by the development of a strategic activity plan and the preparation of educational materials tailored to the local volcanic risk profile.
b. Implementation. The core activity was conducted in June 2024. It started with a socialization session to transfer knowledge regarding disaster mitigation, followed by a practical self-evacuation simulation. This simulation was designed to test the participants' readiness and response speed in an eruption scenario.
c. Evaluation. At the end of the simulation, the team distributed questionnaires to measure the increase in participants' literacy and practical skills. The data were then recapitulated and analyzed to determine the effectiveness of the training.

3. Results and Discussion

3.1. Identifying partner needs and strategic planning

The initial stage of this community service involved a direct visit to SD Negeri Kecil Munggangsari in Baturraden District to identify specific needs and local challenges. Geographically, the school's location, only 8 km from the summit of Mount Slamet, renders it highly vulnerable to the catastrophic impacts of volcanic eruptions. Interviews and initial field identifications revealed that the school community had no prior experience or formal training in volcanic disaster mitigation. Based on this critical gap, the team and the school stakeholders reached a consensus to implement a comprehensive socialization and training program tailored for the residents of SD Negeri Kecil Munggangsari.

Following the identification stage, the team developed a structured activity plan. It was agreed that the intervention would combine theoretical socialization by experts with practical mitigation simulations. The target participants included the principal, all teachers, and students from the 4th and 5th grades. To ensure readiness, the PKM team

prepared all necessary equipment, supplies, and educational materials, including presentations, videos, interactive modules, and evaluation questionnaires designed to support a robust learning process.

3.2. Program implementation

The implementation at SD Negeri Kecil Munggangsari was divided into two core sessions: knowledge transfer and practical simulation. The resource persons, consisting of lecturers from Universitas Muhammadiyah Purwokerto (UMP) specializing in disaster education, delivered material followed by reflection and pre/post-test evaluations. The atmosphere of the socialization session is captured in Figure 1.

The program then transitioned into two distinct volcanic eruption mitigation simulations (Figure 2). Prior to the exercise, experts provided technical guidance on evacuation procedures. By integrating audio-visual support, the simulation ran smoothly, and participants demonstrated high enthusiasm in practicing the life-saving steps they had just learned.



Figure 1. Implementation of IbM Socialization



Figure 2. Simulation practice by students

3.3. Monitoring and evaluation

The effectiveness of the intervention was measured through pre- and post-tests, with the results summarized in Table 1. Banyumas Regency, which directly borders Mount Slamet, faces a persistent threat of volcanic eruptions. Our survey data at SD Negeri Kecil Munggangsari, a school in the high-risk zone, showed that 89% of students had never received formal disaster mitigation education. This is a serious concern, as residents in disaster-prone areas must possess a fundamental understanding of mitigation to survive (Koem et al., 2021; Lestari et al., 2021; Restu & Priyo, 2020). Disaster

preparedness is not merely about theoretical knowledge; it requires skills that must be honed through continuous practice. Regular simulations increase confidence and the ability to make rapid, correct decisions during emergencies.

Table 1. Pre-test and Post-test Results

Indicator	Pre-test	Post-test
Understanding of Mitigation (Knowing)	11%	100%
Disaster Simulation Experience (Ever)	6%	100%
Integration in Curriculum (Ever)	67%	
Method Enjoyment (Very Enjoyable/ Enjoyable)		100%
Clarity of Material (Very Clear/Clear)		71%

Our findings indicated that prior to this intervention, 94% of participants had never participated in a simulation, and 89% lacked basic mitigation information. This lack of participation is consistent with patterns found in Aceh and Purbalingga (Asiah et al., 2023; Syamsidik et al., 2021). Previous studies have consistently proven that disaster simulations are powerful tools for increasing public readiness (Leutualy et al., 2023; Pradana et al., 2021; Subekti et al., 2022; Suku et al., 2022; Wirmando et al., 2022). Furthermore, our results align with research showing that targeted education significantly boosts the knowledge and preparedness of students (Hayati & Wirda, 2023; Leutualy et al., 2023; Pradana et al., 2021; Suku et al., 2022; Triantoro et al., 2023; Wirmando et al., 2022; Xu et al., 2019).

While 67% of teachers reported integrating mitigation into their lessons, a stronger synergy between schools and families is required to foster a resilient environment (Nugroho et al., 2021; Stix & Heiken, 2022). Mitigation materials should be woven into routine subjects like Science or Civics to cultivate long-term habits among students (Nugroho, 2020; Putra et al., 2024). The high satisfaction rate (100% enjoyable) of our participants confirms that interactive approaches, including games and experiments, are appropriate strategies for children, helping to foster a resilient generation from an early age (Arifianto et al., 2025; Kusuma et al., 2025; Setiawan et al., 2024). Even visits to geoheritage sites can serve as effective educational means (Agastya et al., 2024).

Ultimately, a deep understanding of disaster protocols is expected to minimize risks, including physical trauma, the need for extensive rehabilitation, and potential fatalities (Budiarti & Rahmasari, 2018; Fahmida et al., 2022; Fujimaki et al., 2023; Kotozaki et al., 2022; Tsuboi et al., 2022; Zheng et al., 2022). As disasters are unpredictable (Nugroho, 2020; Setyowati et al., 2021), the capacity to recognize risks and manage situations is key to safety (Aprillya et al., 2024; Lamjiry & Gifford, 2022; Rachman et al., 2023; Zhao et al., 2023). Strengthening community awareness through traditional signs, evacuation routes, and tradition-based practices is essential for long-term resilience (Markolinda et al., 2025; Mukherjee et al., 2022; Suarmika et al., 2022; Wijayanti et al., 2025). Through such early education initiatives, Indonesia can build a more disaster-responsive society capable of reacting appropriately to earthquakes or volcanic eruptions.

4. Conclusion

The community service program implemented at SD Negeri Kecil Munggangsari, Baturraden, Banyumas, was executed successfully, resulting in a significant

transformation of the school community's disaster preparedness. By bridging the gap between theoretical knowledge and practical action, this initiative achieved a 100% literacy rate in disaster mitigation procedures among participating teachers and students. The shift from 89% ignorance to full comprehension, and from near-zero simulation experience to complete practical mastery, demonstrates that participatory education is a vital necessity for schools located in high-risk volcanic zones.

Through these disaster awareness campaigns and hands-on simulations, this program makes a tangible contribution to local disaster risk reduction efforts, particularly for the community living on the slopes of Mount Slamet. The findings emphasize that integrating routine simulations into the school environment is an effective strategy for transforming abstract fear into actionable life-saving skills. The success of this program encourages the expansion of similar activities more widely and sustainably across other disaster-prone areas. Ultimately, establishing a sustainable, local mitigation curriculum is recommended to ensure that the next generation remains resilient and responsive to the unpredictable nature of volcanic activities.

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Author Contribution

Activity implementers: AN, LM, DI; Article preparation: AN; Analysis of the impact of community service: AN, APW; Presentation of community service results: AN, LM, DI; Article revision: AN, APW.

Conflict of Interest

The authors state that there is no conflict of interest in the publication of this article.

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