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MANGROVE PLANTING AND EARTHQUAKE EDUCATION AS NATURAL DISASTER MITIGATION EFFORTS

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ABSTRACT

Background: Java Island is a highly disaster-prone area in Indonesia due to its location in the convergence zone, where two tectonic plates meet. Mangrove planting and earthquake education are two natural disaster mitigation efforts that complement each other in reducing the risk and impact of disasters, especially in coastal areas that are vulnerable to earthquakes and tsunamis. **Objectives:** The purpose of this activity is to increase community knowledge by educating about natural disaster mitigation and earthquakes, as well as preventing sea abrasion disasters through mangrove planting. **Method:** The method of implementing community service activities includes education with lecture methods and mangrove planting. The activity was attended by approximately 28 people in Klayar Hamlet, Sidokelar Village, Paciran Subdistrict, Lamongan, East Java. **Results:** The post-test results showed an increase in knowledge about earthquake disaster mitigation. Mangrove planting activities totaling 110 trees ran smoothly. Evaluation and follow-up are carried out with a questionnaire while tree planting is evaluated once a year to see the results. **Conclusion:** Mangrove planting activities totaling 110 trees ran smoothly. Evaluation and follow-up are carried out with a questionnaire while tree planting is evaluated once a year to see the results.

Keywords: Education; Mitigation; Earthquakes; Mangroves

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A. BACKGROUND

Indonesia is located within the Pacific Ring of Fire, making it one of the countries most vulnerable to natural disasters, particularly earthquakes and

tsunamis. Positioned atop three major tectonic plates—the Indo-Australian, Eurasian, and Pacific plates—earthquakes occur regularly across the archipelago, with some events capable of triggering tsunamis (Harijoko et al., 2024). Java Island is especially prone to disasters due to its location within a convergence zone, where the Eurasian Plate in the north meets the Indo-Australian Plate (Lestari, Muzani, & Setiawan, 2023). This tectonic interaction has resulted in the formation of volcanoes and frequent seismic activity. Consequently, Java's proximity to this convergence zone renders it a high-risk area, characterized by numerous active volcanoes and recurrent earthquakes (Maulana et al., 2024).

The Bawean Island earthquake of 2024 exemplifies seismic activity in the Java Sea, particularly in East Java. Occurring offshore approximately 35 km (22 miles) from Bawean Island, Gresik Regency, the earthquake struck on March 22, 2024, at 15:52:58 local time. According to Indonesia's Meteorology, Climatology, and Geophysics Agency (BMKG), the earthquake registered a magnitude of 6.5 at a depth of 10 km (6 miles). Meanwhile, the United States Geological Survey (USGS) reported a magnitude of 6.4 at a depth of 9.5 km (6 miles). The disaster resulted in four injuries, the destruction of 774 houses, damage to 3,905 additional homes, and the impairment of 303 public facilities in northern-central East Java. Tremors were moderately felt in Tuban, Sidoarjo, and Surabaya for approximately 15 seconds, while in Rembang they lasted between 5 and 20 seconds. Vibrations extended as far as Bali, Central Java, and Jakarta. Although earthquakes of this magnitude are relatively rare in the Java Sea, seismologists consider such events unsurprising, classifying them as aseismic earthquakes with a frequency of 229 occurrences (BMKG, 2024).

Planned and systematic mitigation measures are essential to reduce earthquake disaster risks. With the increasing frequency and intensity of seismic events in Indonesia, preparedness is critical in managing emergency situations (Sopacua & Salakay, 2020). Communities residing in coastal and earthquake-prone zones must be equipped with knowledge of natural warning signs that may serve as early indicators of disasters (Putranta et al., 2024). Dissemination of information through education enhances public awareness of earthquake hazards (Roza et al., 2020). Adequate disaster mitigation knowledge enables communities to respond appropriately during emergencies. Early disaster education is therefore vital, ensuring that individuals understand initial self-

rescue measures when disasters occur (Rakuasa & Mehdila, 2023). Given that earthquakes often strike suddenly without prior prediction, proactive efforts are required to minimize their impacts (Subagia, 2019).

Mitigation activities constitute a crucial component of disaster management, focusing on reducing potential impacts of future hazards (Jokowinarno, 2011; Elya et al., 2022). Coastal areas, as transitional ecosystems influenced by both land and sea, are particularly vulnerable. Frequent exposure to seawater leads to abrasion, causing land erosion and reduction in coastal area, which facilitates seawater intrusion (Utomo et al., 2023). Abrasion poses severe threats to coastal communities, as continuous erosion can destroy residential settlements (Elya et al., 2022). Sustainable disaster mitigation is therefore necessary, with mangrove planting recognized as one of the most effective strategies to counter coastal abrasion.

A preliminary study conducted on November 25, 2024, in Klayar Hamlet, Sidokelar Village, Paciran District, Lamongan Regency, revealed that the area is highly susceptible to both earthquakes and coastal abrasion. One of the local beaches, Putri Klayar Beach, exemplifies this vulnerability. Knowledge dissemination is a key component of disaster mitigation; thus, educational initiatives must be directed toward coastal communities in Klayar Hamlet. Despite the critical role of mangrove trees in mitigating coastal abrasion, their presence remains limited. Consequently, this study emphasizes the importance of disaster education on earthquake preparedness while simultaneously promoting mangrove planting as a preventive measure against coastal erosion.

To enhance community knowledge of earthquake disaster mitigation, educational activities employing lecture-based methods combined with mangrove planting are proposed (Putranta et al., 2024). The primary challenges in Klayar Hamlet include limited understanding of earthquake mitigation despite the area's high vulnerability, and the community's dependence on coastal livelihoods. Over time, environmental changes and human activities along Putri Klayar Beach have exacerbated abrasion risks. However, low public awareness and limited participation in mangrove planting remain significant obstacles. Mangroves serve as vital ecosystems, providing wave protection, erosion control, intrusion prevention, habitats for diverse species, and resources for human use (Vitasari, 2020).

Based on these challenges, the priority issues addressed in this community engagement initiative are the lack of public understanding regarding earthquake disaster mitigation and the benefits of mangrove planting. The objective is to provide education on earthquake preparedness and promote mangrove planting as a preventive measure against coastal abrasion.

B. METHOD

The implementation of this community service program was carried out in collaboration with several partners, including the Forestry Agency of Bojonegoro, the local community and village officials of Sidokelar (the Village Head of Sidokelar and the Hamlet Head of Klayar), youth organizations, and the UMDC Student Activity Unit of Universitas Muhammadiyah Lamongan. The program consisted of four stages: (1) planning, (2) implementation, (3) evaluation, and (4) article preparation.

1. Planning Stage

At this stage, the team prepared the proposal and conducted an initial survey to coordinate with partners regarding permits and scheduling of activities.

2. Implementation Stage

The first session involved mangrove planting along a 30-meter stretch of Putri Klayar Beach. This activity aimed to prevent coastal abrasion and reduce the impact of strong sea winds reaching inland areas. The second session focused on disaster education through lectures and discussions on earthquake mitigation and preparedness. Prior to the educational session, participants completed a pre-test questionnaire to assess their baseline knowledge of earthquake disaster mitigation. This was followed by the delivery of educational material and a post-test to measure knowledge improvement.

3. Evaluation Stage

The evaluation of participants' understanding was conducted using pre-test and post-test instruments. The evaluation was carried out at the beginning and end of the program to identify changes in knowledge related to earthquake disaster mitigation. The stage concluded with the preparation of a final activity report.

C. RESULTS AND DISCUSSION

The program was conducted on January 16, 2025, and was divided into two stages: magrove planting and educational activities.

Stage One: Mangrove Planting

Mangrove planting was carried out along a 30-meter stretch of Putri Klayar Beach, beginning at 06:00 and continuing until completion. The activity involved the Forestry Agency of Bojonegoro, the Head of Klayar Hamlet, the local community of Klayar, and the UMDC Student Activity Unit of Universitas Muhammadiyah Lamongan. The primary objective of this planting initiative was to mitigate coastal abrasion and reduce the impact of strong sea winds reaching inland areas. A total of 110 trees were successfully planted in the designated area, consisting of 100 mangrove trees and 10 pule trees.

Mangrove trees thrive in coastal ecosystems influenced by tidal fluctuations and possess unique physiological adaptations that enable them to tolerate saline conditions within their tissues. They also exhibit specialized root systems that anchor them in fine sediment and facilitate oxygen transport from the atmosphere to the roots. As a distinctive ecosystem, mangroves serve multiple ecological functions. They are considered renewable natural resources and are widely distributed across Indonesian waters. Physically, mangroves stabilize coastlines, protect beaches and riverbanks from erosion and abrasion, and act as natural barriers against strong sea winds. They also contribute to land formation by periodically trapping sediment, serve as buffers against seawater intrusion into terrestrial areas, and function as natural filters that reduce salinity, thereby supporting freshwater availability (Purlilaiceu et al., 2023).

In addition to providing high-value timber, mangrove planting offers significant ecological benefits by reducing the impact of large ocean waves reaching inland areas. Mangrove cultivation serves as an effective measure to prevent coastal abrasion while simultaneously mitigating tidal flooding. The ecological role of mangroves is particularly important in carbon sequestration and storage, contributing positively to climate regulation. Furthermore, mangroves function as natural barriers against tsunamis, protecting coastal zones from erosion caused by waves and strong winds, while also controlling seawater intrusion into terrestrial areas (Alam, 2020).

Figure 1. Mangrove Planting Activities

Stage Two: Educational Activities

The second activity consisted of an educational session delivered through lectures and discussions on earthquake mitigation and disaster preparedness. The session was conducted from 09:00 to 12:00 at the Klayar Hamlet Hall, Sidokelar Village, Paciran District, Lamongan Regency. A total of 28 participants attended, comprising 15 invited guests and 13 local residents.

Figure 2. Educational Activities

Prior to the delivery of materials, participants completed a pre-test questionnaire to assess their baseline knowledge of earthquake disaster mitigation. The lecture was presented using PowerPoint media for 30 minutes, followed by a 15-minute question-and-answer session. After the presentation and discussion, participants completed a post-test questionnaire to evaluate knowledge improvement. Pre-test results indicated 9 participants scored 45, 3 participants scored 65, and 1 participant scored 80. post-test Results showed that out of the 28 attendees, 13 participants completed the post-test. Based on the assessment criteria—good (≥76 – 100%), fair (60 – 75%), and poor (≤60%)—the following outcomes were recorded: 10 participants achieved an average score

of 90% (good) and 3 participants achieved an average score of 70% (fair) as indicated by Table 1 below.

Table 1. The Results of Pre-test and Post-test

No.	Criteria	***Pre-test***		***Post-test***	
		n	*%*	*n*	*%*
1.	Good	1	7.7	10	76.9
2.	Fair	3	23.1	3	23.1
3.	Poor	9	69.2	0	0
Total		13	100	13	100

These findings in the above Table 1 indicate a significant improvement in participants' knowledge following the educational intervention, highlighting the effectiveness of combining lecture-based delivery with interactive discussion in enhancing disaster preparedness awareness.

D. CONCLUSION AND SUGGESTION

Overall, the program was successfully implemented and proceeded smoothly. The activities were conducted in two sessions: mangrove planting and community education. The mangrove planting along the coast of Putri Klayar Beach was carried out effectively with the participation of local residents, students, and the Forestry Agency, resulting in the successful planting of 110 seedlings (100 mangrove trees and 10 pule trees). The educational session demonstrated positive outcomes, with 76% of participants achieving a "good" level of knowledge regarding earthquake disaster mitigation.

It is recommended that the local community become more active and enthusiastic in preserving their surrounding environment. While students can initiate tree planting, long-term sustainability requires collaboration with local residents to ensure that the planted trees are properly maintained and allowed to grow. Furthermore, the program should be continued with periodic evaluations at least once a year, accompanied by follow-up efforts from the village authorities to maintain and expand mangrove planting areas.

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