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Original Article

The Past, Present, and Future: Investigating Community Resilience in Tsunami Affected Coastal Areas after the 2018 Anak Krakatau Eruption

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ABSTRACT
The southern coast of Lampung is highly vulnerable to tsunamis, particularly in the aftermath of the 2018 Sunda Strait event, which caused severe physical destruction and lasting psychological trauma. This study employed a mixed-methods approach to examine the psychological impacts on survivors, disaster literacy among vulnerable groups, and the role of local wisdom in mitigation efforts. Quantitative data were obtained through surveys of 80 children aged 10–12 years, while qualitative data were collected via interviews with community elders, women, older adults, and local residents. The findings indicate that survivors continue to experience trauma in the form of fear, anxiety, and recurring nightmares, although family support and religious activities have facilitated recovery. Children's disaster literacy was found to be at a moderate level, whereas women and older adults demonstrated higher preparedness through their knowledge of evacuation routes and participation in simulations. Local wisdom including the interpretation of natural signs, oral folklore, and communal prayers remains influential, despite the gradual decline of certain traditions. These findings highlight the importance of integrating local wisdom with technology, education, and institutional support to strengthen mitigation strategies in coastal areas.

KEYWORDS
tsunami; community preparedness; disaster literacy; local wisdom; Lampung

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INTRODUCTION

Indonesia's vast coastal regions face significant environmental and social challenges (Putri et al., 2024). High risk areas include Java the country's most densely populated island southern Sumatra, and the surrounding smaller offshore islands. These risks stem from the interaction between the Indo Australian and Eurasian

tectonic plates, where the Indo Australian Plate subducts beneath the Eurasian Plate, forming a subduction zone (Jumadi et al., 2025). Coastal communities are typically exposed to two types of hazards: those that occur gradually, such as sea level rise, and those that manifest abruptly, including cyclones and storm surge induced flooding (Sahan et al., 2023).

Lampung Province covers a land area of 34,623.80 km^2 and has a coastline stretching 1,105 km, featuring two major bays: Lampung Bay and Semangka Bay. Semangka Bay lies in the western part of the province, bordering Tanggamus Regency, while Lampung Bay is situated in the east, adjacent to Bandar Lampung City, South Lampung Regency, and Pesawaran Regency (Susanti et al., 2023). The southern coast of Sumatra, including Lampung, lies in close proximity to the Sunda megathrust, a seismic zone that poses a high risk of earthquakes and tsunamis (Febrina et al., 2021).

The proximity of southern Sumatran coastal cities, including those in Lampung, to the active subduction zone renders them highly vulnerable to earthquake and tsunami hazards (Triyoso et al., 2024). Key parameters used to assess environmental vulnerability to tsunamis include land elevation, slope, land use, and distance from the shoreline (Muzani, 2024). The western coast of Lampung Province directly borders the Eurasian Plate, thereby increasing the likelihood of earthquakes followed by tsunamis in this region (Mardika, 2024). Kalianda District, a densely populated coastal area in South Lampung, lies only 323.6 km from the Sunda Strait megathrust convergence zone, making it particularly susceptible to tsunami disasters (Gelfi et al., 2021).

The coastal areas surrounding Semangka Bay and Lampung Bay, characterized by steep topography and high weathering intensity, represent additional factors contributing to landslide susceptibility, particularly when triggered by heavy rainfall. Even small scale, localized landslides entering the sea can generate tsunami potential (Fauzi, 2024). Tsunamis are geological hazards that occur as part of the Earth's natural processes and form a recurring component of the disaster cycle for coastal communities (Triatmadja, 2024). Globally, catastrophic tsunamis resulting in mass casualties or severe damage to civil infrastructure occur on average twice per year (Spröer et al., 2025). After several months of volcanic activity in the Sunda Strait, Indonesia, the Anak Krakatau volcano erupted on December 22, 2018, causing the collapse of its southwestern flank. This event triggered a tsunami with a relatively short wave period (~7 minutes), devastating the western coast of Banten and the southern coast of Lampung, and claiming 437 lives (Lahcene, 2021).

On the same date, the tsunami struck the Sunda Strait coastline, destroying or severely damaging more than 1,600 houses, while an additional 600 homes sustained partial damage, forcing over 16,000 people to evacuate. The disaster claimed more than 400 lives and left over 14,000 injured (Firdaus et al., 2022). This event was triggered by the partial collapse of Mount Anak Krakatau, which generated a major tsunami (Dogan et al., 2021). The tsunami also had adverse impacts on the livelihoods of coastal communities, particularly by reducing fishers' catches from 41.35 kg/month to 16.35 kg/month—a decline of approximately 60.5%. Damage extended to critical infrastructure, clean water supplies, sanitation systems, fishing settlements, and fishery facilities (Riantini et al., 2021). Historical records further underscore the recurrence of volcanic activity in the region, as exemplified by the 1883 Krakatoa eruption and the 2018 Anak Krakatau eruption, both of which generated tsunamis that heavily impacted Lampung and Banten (Ibtihaj et al., 2022). The Sunda Strait itself remains an active subduction zone, characterized by complex tectonic structures and frequent seismic activity over the past four decades (Suhadha et al., 2022).

The Sunda Strait segment of the megathrust subduction zone has the potential to generate tsunamis with a run up height of 5.99 meters and a golden time of 40 minutes and 19 seconds (Ponangsera et al., 2021). In fact, the Lampung Bay region is highly susceptible to both tectonic and volcanic activity from Mount Anak Krakatau, as evidenced by the catastrophic events of 1883 and 2018 (Rezaldi et al., 2021). Disasters represent conditions that exceed local capacities and therefore necessitate national or even international assistance due to their profound impacts (Genc et al., 2022).

Several previous studies have specifically examined historical aspects, disaster literacy, and local wisdom in the context of tsunami mitigation in coastal regions. Affandi et al. (2024) investigated climate change–induced disaster risk management in East Teluk Betung, Bandar Lampung, using a spatial approach with ArcGIS. Their findings indicated that the coastal areas of Lampung fall within the super priority intervention zone for disaster risk reduction, underscoring the relevance of designating priority regions in the present study. Another study by Agustanti et al. (2022) explored community preparedness in Kunjir and Waymuli Villages, South Lampung, which were directly affected by the 2018 tsunami. While community knowledge and attitudes were found to be

relatively strong, family level preparedness particularly among women and children remained limited, highlighting the need to strengthen disaster literacy among vulnerable groups.

Meanwhile, Asbi et al. (2025) conducted tsunami run up modeling along the coast of Bandar Lampung and found that more than 37% of the area falls within a high hazard zone. This finding reinforces the urgency of implementing mitigation planning based on actual risk zonation. From a socio cultural perspective, Irwansyah et al. (2024) demonstrated that post tsunami strategies in Banda Aceh relied not only on physical approaches but also actively engaged local communities through culture based recovery, community education, and the strengthening of locally rooted infrastructure.

In the context of community based preparedness, Utariningsih et al. (2023) highlighted mitigation practices in Muara Batu, North Aceh, which integrate traditional early warning systems, such as mosque sirens (*meunasah*), with community education. Nevertheless, the mobilization of local resources remains insufficient and requires further enhancement. Amri et al. (2024) investigated evacuation behavior among beach visitors in Bantul, revealing that most participants lacked knowledge of natural tsunami indicators and tended to rely primarily on strong ground shaking as a warning sign, underscoring weak risk literacy particularly among non local groups and women.

At the international level, Dhellemmes et al. (2021) demonstrated in New Zealand that heightened tsunami awareness does not necessarily translate into actual preparedness, as many residents continued to wait for official warnings even after experiencing a major earthquake. This finding resonates with local evidence in Indonesia, which emphasizes the necessity of experience based education and hands on drills. Meanwhile, Rahayu et al. (2024) developed an Area Business Continuity Planning model in the Pangandaran tourism area, emphasizing collaboration among government agencies, business actors, and local communities to foster disaster resilient tourism destinations.

Furthermore, Primastuti et al. (2023) explored the role of local wisdom such as *sedekah laut* (sea offerings), natural signs, and customary prohibitions in disaster risk reduction within traditional communities in West Java and Banten. These findings underscore the potential of cultural approaches as a strategic foundation for future disaster mitigation. Finally, Kendall et al. (2024), through a scientific study in Australia, emphasized the importance of tsunami modeling based on topographic and probabilistic data to support the development of evacuation zones and evidence based mitigation systems. Collectively, these studies provide strong conceptual and methodological contributions that serve as a foundation for developing mitigation strategies grounded in historical experience, vulnerable group literacy, and local wisdom in the coastal areas of Lampung.

Nevertheless, most studies remain fragmented, separating technical approaches from socio cultural perspectives, and few have sought to develop an integrated mitigation model that brings together indigenous knowledge, local risk perceptions, and community adaptive strategies within a system responsive to the geographic characteristics and social vulnerabilities of coastal Lampung.

This study adopts a novel approach to tsunami risk mitigation in the coastal areas of Lampung by integrating several key elements: the historical psychological impacts of tsunamis on affected communities, disaster literacy levels among vulnerable groups such as women, children, and the elderly, and the role of local wisdom as a strategic foundation for future mitigation efforts.

METHODS

Study Area

The research was conducted in the coastal areas of Lampung, designated as priority zones for tsunami risk mitigation. The study area was determined through geospatial data processing, taking into account several parameters, including Digital Elevation Model (DEM) data, land use data, marine topography, projected tsunami wave impact scenarios, seismic gap data, and historical earthquake records.

Based on the categorization analysis for identifying priority areas at risk of tsunamis along the South Lampung coast, 41 villages were classified as high priority zones. From this list, three villages Kunjir, Way Muli, and East Way Muli were selected as study sites. These villages were chosen because they were among the most severely affected during the 2018 tsunami. Accordingly, a focused investigation was carried out to identify the psychological impacts on local communities, assess tsunami disaster literacy among vulnerable groups, and examine the persistence of local wisdom as well as its role in developing community based mitigation strategies.

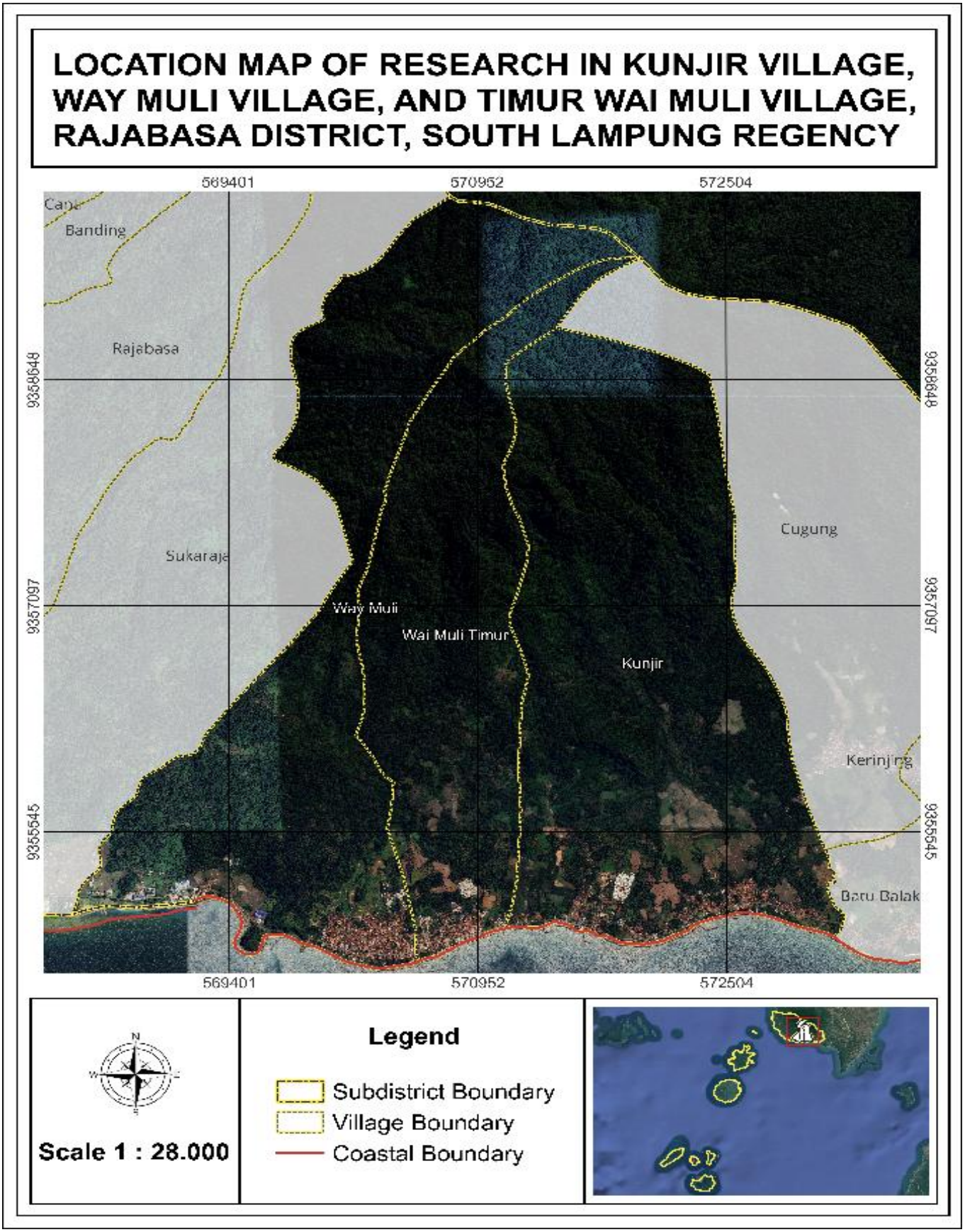

Figure 1. Map of the Study Area.

Research Approach.

This study employs a mixed methods approach, which integrates the strengths of both quantitative and qualitative methodologies within a unified research framework. This approach was selected to generate a more comprehensive, in depth, and valid understanding of the phenomena under investigation, particularly within the disaster context that encompasses historical, social, and cultural dimensions.

In practice, the mixed methods approach was operationalized through the use of surveys as the primary data collection method. The survey method was chosen for its ability to capture information from a broad population within a relatively short period, while simultaneously enabling deeper exploration through qualitative instruments such as interviews and documentation. Thus, this approach was considered effective for uncovering both statistical data and contextual insights from the research subjects.

Research Procedure.

The research procedure commenced with an exploration of the context and background related to the research problem. This stage was followed by the formulation of research questions and objectives, which were systematically developed based on field conditions. A comprehensive literature review was then conducted to strengthen the theoretical foundation and provide an academic basis for analyzing the phenomena under study. Subsequently, the data collection phase was carried out through in depth interviews and literacy tests designed to capture information from different community groups. The collected data were analyzed qualitatively, with particular emphasis on interpreting meanings, understanding local perspectives, and capturing community experiences in facing disaster threats.

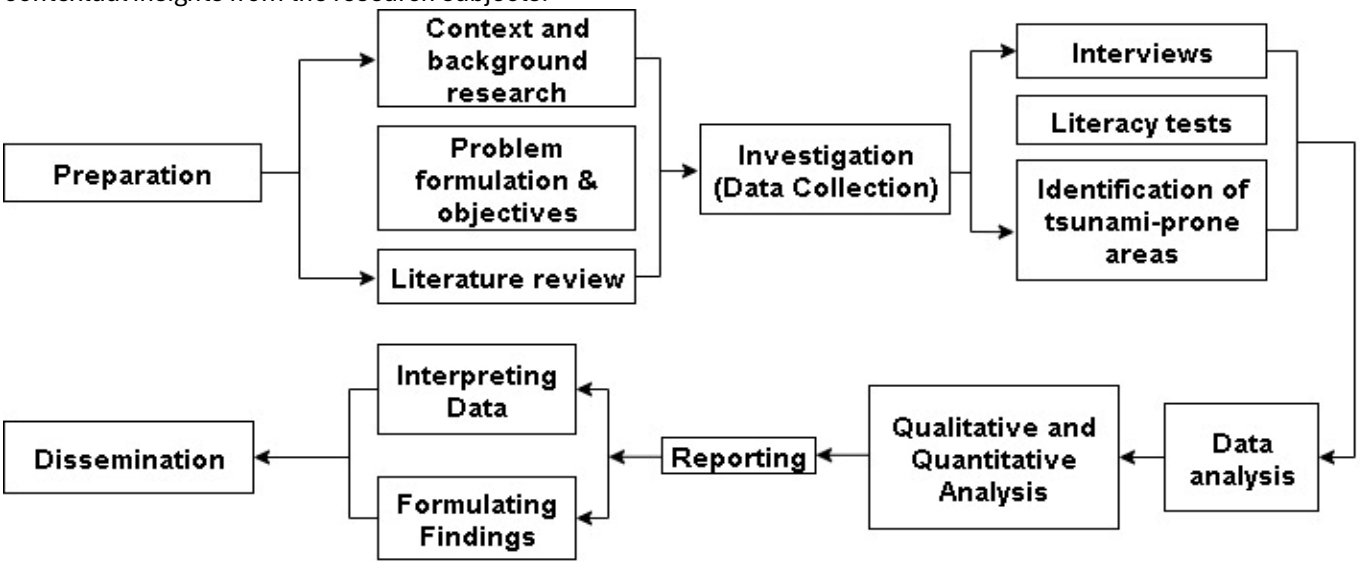

Figure 2. Conceptual Framework

Data Collection Instruments.

The data collection instruments in this study were carefully aligned with the type of information required to address the research objectives, with an emphasis on a qualitative approach. Several complementary techniques were employed, including in depth interviews, literacy assessments, structured interview guidelines, and documentation analysis. The choice of instrument was determined by the nature of the information sought and the characteristics of the data sources, thereby ensuring methodological rigor and contextual relevance.

Data Analysis.

The data analysis procedures were designed to correspond with the objectives of the study, the types of data collected, and the methodological framework adopted. A qualitative analytical approach was applied, focusing on the interpretation of meaning embedded within the data. The analytical process encompassed three stages: data reduction, data display, and conclusion drawing. Through this iterative process, the study generated an in depth understanding of community experiences, perceptions, and local wisdom in addressing tsunami hazards. This analytical strategy not

only enabled the identification of emergent themes but also ensured the validity and depth of insights within the socio cultural context of disaster risk reduction.

RESULTS AND DISCUSSION

The findings of this study indicate that residents along the southern coast of Lampung continue to experience lasting psychological trauma following the 2018 tsunami. Several respondents reported recurrent nightmares vividly depicting the disaster, while feelings of fear resurface particularly during periods of heavy rainfall or strong ocean waves. These results highlight that the psychological consequences of the tsunami are not transient but instead persist over time, shaping a form of collective memory within the community.

This observation aligns with the work of Wahab et al. (2021), who reported that post traumatic stress disorder (PTSD) represents the most prevalent mental health condition among disaster survivors. Similarly, Wang et al. (2025), in their study of recurring disasters in Zhengzhou, China, emphasized that as social vulnerability intensifies in parallel with trauma, the recurrence of disasters exacerbates the psychological burden borne by affected populations. Such findings underscore the interconnectedness between environmental hazards, social vulnerability, and long term psychological well being.

The strategies adopted by the community to cope with trauma are diverse. Some individuals believe that time serves as the primary healer, allowing their fear to gradually diminish without specific interventions. Family support also plays a critical role as a safe space for sharing emotions, particularly for children who are more vulnerable to anxiety. In addition, religious practices are frequently employed as a means of achieving inner peace, while others choose to confront their fears directly for example, continuing to engage in fishing activities at sea despite lingering feelings of apprehension.According to Subarno et al. (2022), disaster education is essential for helping communities cope with trauma by providing guidance before, during, and after a disaster. Chernysh et al. (2025) further highlighted that post disaster education can accelerate psychological recovery. This suggests that disaster related trauma rarely disappears completely but can be mitigated through social support, spiritual practices, and continuous learning.

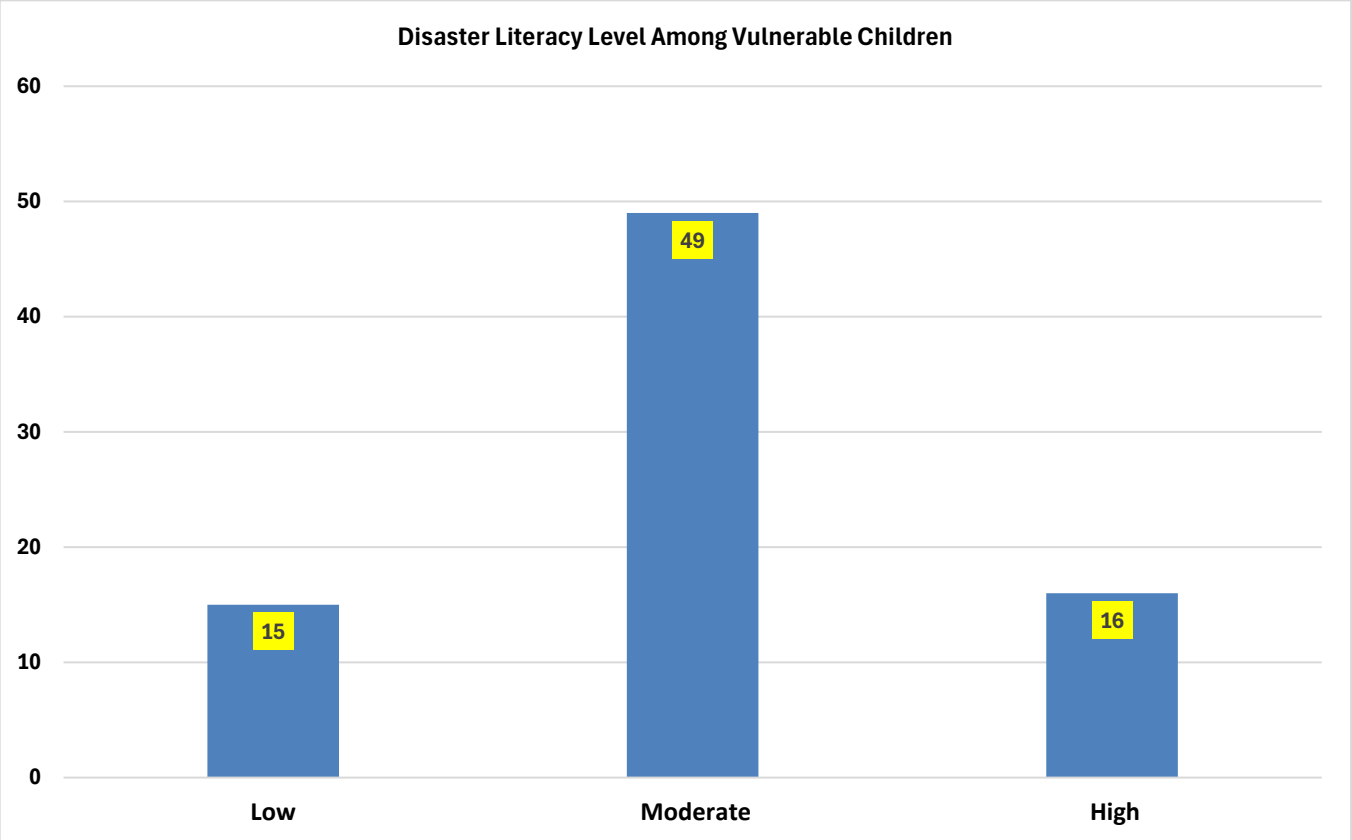

Figure 3. Disaster Literacy Categorization of Vulnerable Children.

A survey of 80 children aged 10–12 years indicated that most demonstrated moderate disaster literacy. They understood basic warning signs and evacuation steps but lacked the capacity to apply them independently, remaining reliant on adult guidance due to their age and limited physical ability.

The distribution of questionnaire scores revealed notable variations in disaster literacy. The majority of respondents fell within the moderate to high categories, suggesting a foundational level of knowledge that can be further strengthened. Nevertheless, approximately one fifth remained in the low category, indicating persistent gaps in access to information and participation in disaster education initiatives. These findings suggest that while literacy programs are in place, their implementation has not been uniformly effective. Targeted efforts are therefore needed to enhance disaster literacy, particularly through school based education, family engagement in supporting children, and child friendly community simulations aimed at improving both psychological readiness and practical response capacity.

A relatively high level of preparedness was observed in interviews with 11 respondents from women and elderly groups. Most were aware that South Lampung's coastal areas are tsunami prone, recognized evacuation routes, and had self rescue strategies. Nonetheless, due to limited resources or knowledge, some had not yet prepared a disaster emergency kit containing essential supplies.

Although evacuation drills are infrequent and have not reached all segments of the community, preparedness was nonetheless evident among participants. To protect vulnerable groups, evacuation practices prioritized the safety of children and the elderly. Preparedness extended beyond physical readiness to include post disaster health measures, such as maintaining hygiene, managing stress, and engaging in spiritual activities to strengthen psychological resilience. Women and older adults involved in environmental recovery further demonstrated that they are not merely vulnerable groups but also key agents in social reconstruction.

The findings also underscore the continued relevance of local wisdom in coping with tsunami hazards. Traditional knowledge, including natural signs, folklore, and inherited social practices, remains embedded in community life. Annual collective prayer rituals reinforce social bonds and preserve collective memory of past disasters. However, the 2018 tsunami, which occurred without conventional natural warning signs, fostered a new awareness that local knowledge alone is insufficient.

In addition, the original evacuation routes leading to the hills, long recognized by the community, continue to be used, now reinforced with official signage provided by the government. Historiographical accounts, such as narratives of the 1883 Krakatoa eruption, have enabled intergenerational understanding of tsunami threats. These practices demonstrate that the values embedded in local wisdom remain essential for strengthening community preparedness, even though certain traditions—such as the use of stilt houses—are gradually being abandoned.

Overall, many countries adopt similar strategies, such as *Smong* in Simeulue, *tsunami ishi* in Japan, and the active involvement of women in Samoa. These examples highlight how local wisdom significantly enhances community preparedness. In Indonesia, several regions have successfully integrated cultural knowledge into disaster mitigation. For instance, in West Sumatra, folklore, proverbs, myths, and architectural symbols serve as vehicles for transmitting mitigation messages. Ramadhan et al. (2024) illustrate this through the proverb *"Sakali aia gadang, sakali tapian barubah"* ("a great flood changes the riverbanks"), which conveys the transformative impact of disasters on social life, while traditional stilt houses such as *Rumah Gadang* exemplify culturally rooted structural mitigation.

In Mentawai, maintaining a safe distance from the shoreline and constructing elevated dwellings reflects a lifestyle centered on risk reduction. Meanwhile, the Bajo Tiworo community in Sulawesi relies on ecological interdependence with the sea and spiritual awareness expressed through myths, rituals, and taboos transmitted orally to strengthen resilience (Marhadi et al., 2024; Akhmad et al., 2024). Similarly, Erlina et al. (2023) emphasize that Lampung Province, with its rich cultural heritage, embodies local wisdom through values such as *nemui nyimah* (hospitality), *nengah nyappur* (sociability), *piil pesenggiri* (self respect), and *sakai sambayan* (mutual cooperation), all of which contribute to social resilience. Consequently, disaster mitigation strategies in South Lampung should integrate local wisdom with modern technology, disaster education, and supportive government policies.

Disaster mitigation can generally be classified into two categories. Structural mitigation refers to the development of physical infrastructure such as evacuation routes, seawalls, and evacuation signage that directly support emergency response. Non-structural

mitigation, by contrast, encompasses traditional practices, oral narratives, legends, and ritual ceremonies that preserve collective memory of disaster risk across generations. When integrated with institutional support and modern early warning technologies, these approaches collectively enhance community resilience against tsunami hazards.

Structural mitigation specifically emphasizes the provision of physical facilities that can be readily utilized during an emergency. Examples include designated evacuation routes leading to higher ground, seawalls designed to reduce wave impact, and strategically placed evacuation signs in coastal villages. Such infrastructure provides clear, tangible reference points during crisis situations, thereby facilitating timely evacuation and reducing the potential for casualties.

According to Oetjen et al. (2022), structural mitigation remains one of the most effective strategies for reducing tsunami risk. Breakwaters, seawalls, and coastal dikes are among the most widely implemented infrastructures, each proven to dissipate or reduce wave energy before it reaches the shoreline. Although their effectiveness depends on wave height and design conditions, seawalls and coastal embankments have demonstrated strong performance in delaying tsunami inundation and extending evacuation time. Breakwaters, in particular, can reduce wave height by 30–90%, though poorly planned designs may generate strong currents in adjacent open areas.

Pringgana et al. (2023) further emphasize that innovative designs, such as V-shaped barriers, can provide comparable protection to seawalls at lower costs, provided that site orientation and surrounding infrastructure are carefully considered. These findings underscore that structural mitigation should not be limited to conventional infrastructure but must evolve toward efficient, adaptive designs tailored to the socio-geographical context of coastal regions.

Field observations conducted by the researchers revealed the presence of structural mitigation measures already implemented along the southern coast of Lampung. These include the installation of evacuation route signs, which serve as critical directional guides during emergencies, and the construction of embankments designed to absorb and reduce the impact of incoming tsunami waves. Such physical infrastructures provide tangible references for communities during evacuation and reflect the concerted efforts of both government and local stakeholders to strengthen disaster preparedness and resilience.

Figure 4. Evacuation Route Signage

Figure 5. Tsunami Seawall

Figure 6. Stilt House

Unlike structural measures, non-structural mitigation emphasizes fostering awareness and preparedness through social and cultural heritage. Traditional practices, folklore, legends, and customary rituals serve as media for transmitting vigilance across generations. This knowledge is typically conveyed orally within families or community forums, thereby shaping the collective memory of local societies regarding tsunami threats and strategies for coping with them.

Nathan et al. (2023) identified three key non-structural interventions that proved effective in enhancing tsunami evacuation outcomes in Guam, United States: reducing departure delays, increasing travel speed, and managing vegetation to establish new evacuation routes. Among these, minimizing departure delays emerged as the most influential factor, outweighing improvements in travel speed or the creation of new pathways. Importantly, the study demonstrated that all three strategies can be implemented concurrently to reduce the number of individuals unable to evacuate in time.

Field observations and in-depth interviews in coastal Lampung revealed a gradual decline in some aspects of local wisdom, while others persist. One example is the use of stilt houses, historically built as an adaptive response to tidal flooding and small waves. Today, however, stilt houses are becoming rare, as many residents favor permanent masonry structures, although a few households still maintain them. This shift reflects evolving livelihood needs, economic pressures, and the influence of modernization.

CONCLUSION

This study reveals that coastal communities in South Lampung continue to experience profound trauma from the 2018 Sunda Strait tsunami. Psychological impacts persist in the form of fear, anxiety, and recurring nightmares, which are alleviated through family support, religious practices, and the resilience to return to the sea.

Most children demonstrated a moderate level of disaster literacy. While they understood basic warning signs, they still required adult guidance during emergencies. In contrast, women and older adults displayed stronger preparedness, including awareness of evacuation routes and active involvement in post disaster recovery.

Local wisdom remains a vital asset for strengthening resilience, even though certain traditions, such as stilt houses, are being abandoned. Natural signs, folklore, and collective prayer rituals continue to serve as intergenerational reminders of tsunami risks. However, the 2018 event—marked by the absence of conventional natural indicators—underscored that local knowledge alone is insufficient. An integrated strategy combining local wisdom, modern technology, disaster education, and institutional support represents the most effective approach to coastal disaster mitigation.

The study is limited by its relatively narrow scope and small number of respondents, restricting the generalizability of its findings to other coastal villages in South Lampung or tsunami prone regions. Moreover, the use of descriptive tools such as interviews and questionnaires did not capture deeper relationships between variables, such as disaster literacy and preparedness.

Future research should broaden its geographical coverage by involving more coastal communities to enhance representativeness. Additionally, examining the effectiveness of integrating local wisdom with modern technology will be essential to developing adaptive and sustainable disaster mitigation systems.

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Conflict of interest The author has no competing interests to declare that are relevant to the content of this article.

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