

## Transformative Disaster Education for Reducing the Knowledge Action Gap among Adolescents: Evidence Synthesis Based on Local Seismicity in West Sumatra

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### Abstract

*West Sumatra, Indonesia, faces a critical dual seismic hazard from the Sunda Megathrust and the active Sumatra Fault System, resulting in repetitive destructive earthquakes and high structural vulnerability. This study investigates the effectiveness of disaster preparedness among adolescents (aged 10–24), a strategic demographic group comprising over 25% of the population. Using Evidence Synthesis via a Descriptive-Qualitative Library Research approach, this paper analyzes the convergence of local seismotectonic risks and social preparedness models. The synthesis reveals a significant knowledge–action gap (preparedness paradox): while theoretical disaster knowledge among students is high, their practical readiness and self-efficacy are moderate to low. This discrepancy is primarily driven by the insufficient contextualization of education to specific local seismic threats. We argue that structural mitigation must be urgently complemented by strengthening social adaptive capacity. The study advocates for implementing transformative disaster education that formally integrates local seismic data, hazard maps, and scenario-based psychomotor training. This model is essential for fostering adaptive competence and leveraging adolescents as pivotal agents of long-term community resilience and disaster risk reduction in this high-risk environment.*

**Keyword:** seismicity, adaptive learning, adolescents, earthquake resilience, knowledge–action gap, West Sumatra.

## INTRODUCTION

Indonesia is one of the most seismically active countries in the world due to its position at the convergence of three major tectonic plates: the Pacific Plate, the Indo-Australian Plate, and the Eurasian Plate (Hutchings & Mooney, 2021). Along the western margin of Sumatra, the Indo-Australian Plate subducts beneath the Eurasian Plate through the Sunda megathrust, forming one of the most hazardous seismic belts globally. In addition to the megathrust system, West Sumatra is traversed by the 1,900-km-long Sumatra Fault System (SFS), which consists of 19 active segments, including the Sianok, Sumani, Suliti, and Angkola faults (Sieh & Natawidjaja, 2000). Each segment is capable of generating shallow crustal earthquakes with significant destructive potential.

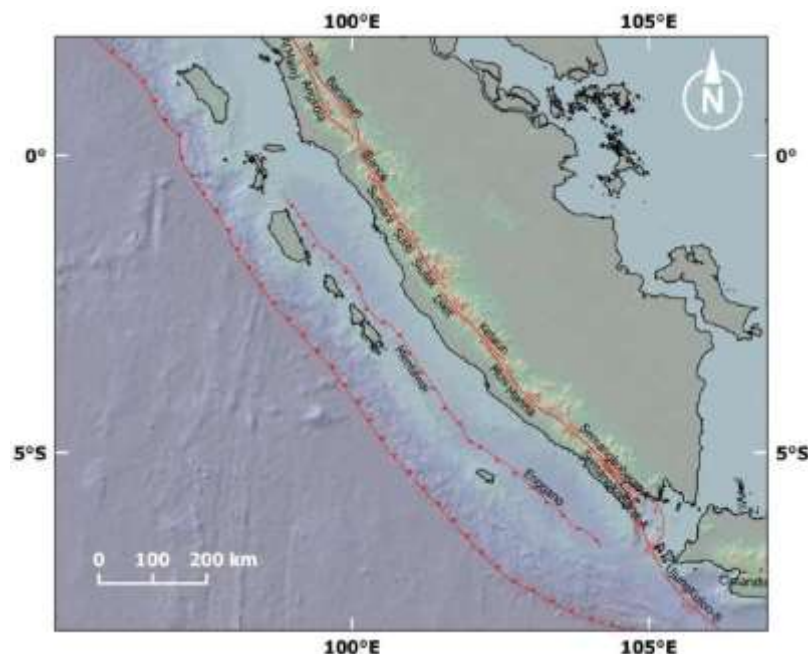


Figure 1. Seismic source zones of Sumatra (PuSGen, 2024)

The map highlights the distribution of major onshore strike-slip fault segments across central and western Sumatra, including Sianok, Sumani, Suliti, Angkola, and other key segments of the SFS. Offshore, the Mentawai Fault System and the highly coupled Sunda megathrust represent major subduction-related seismic sources capable of generating megathrust earthquakes and tsunamis. The combination of these tectonic features makes West Sumatra one of the most seismically active and hazardous regions in Indonesia.

The spatial distribution of these tectonic elements can be observed clearly through geomorphological features stretching from Teluk Semangko to Banda Aceh, characterized by

aligned valleys, offset river channels, fault scarps, and tectonic lakes that reflect active deformation processes (BMKG, 2024). This configuration places West Sumatra at persistent risk from both megathrust and crustal earthquakes, as illustrated in the regional seismic source map (Figure 1).

Historically, West Sumatra has experienced numerous damaging earthquakes, including the 2009 Padang–Pariaman earthquake (Mw 7.6) and the 2022 Pasaman Barat earthquake (Mw 6.1), which resulted in extensive structural damage and long-lasting socioeconomic impacts. According to the National Disaster Management Authority (BNPB, 2025), West Sumatra ranks among the six provinces with the highest disaster frequency in Indonesia. The recurrence of strong ground shaking underscores the urgency of strengthening societal resilience, particularly at the community and school levels.

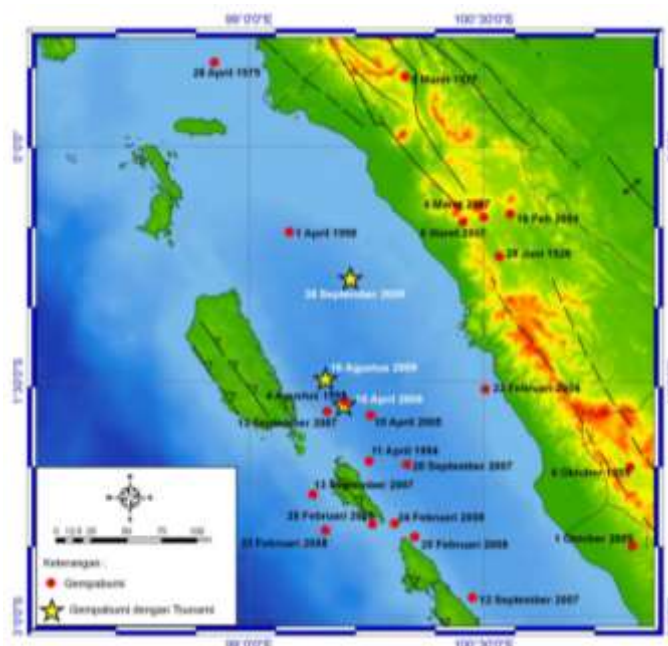


Figure 2. Distribution Map of Significant and Destructive Earthquakes, Including Tsunami-Generating Events, in West Sumatra and Jambi (1821–2009) (BMKG, 2010)

This map figure 2 illustrates the spatial distribution of major earthquakes that occurred in West Sumatra and Jambi over a 188-year period. Red dots represent significant inland earthquakes, while yellow stars indicate events that generated tsunamis along the western coast of Sumatra. The pattern of seismicity highlights the influence of both the Sumatra Fault System and the Sunda megathrust, demonstrating the long-term recurrence of destructive events affecting the region (BMKG, 2024).

The spatial pattern shown in Figure 2 demonstrates that West Sumatra and Jambi have been repeatedly affected by destructive earthquakes originating from both inland strike-slip faults and offshore megathrust sources. Inland seismicity is concentrated along the Sumatra Fault System, with clusters observed near active segments such as Sianok, Sumani, Angkola, and Suliti. These crustal earthquakes typically occur at shallow depths, producing intense ground shaking and structural damage in densely populated valleys and highland areas.

Historical events, such as the 1926 Padang Panjang earthquake (Mw 6.5, MMI VIII–IX) and the 2005 Mentawai earthquake (Mw 6.7), demonstrate the diversity of seismic sources affecting the region. The 2009 megathrust earthquake, which caused more than 1,100 deaths and damaged over 265,000 buildings, remains one of the most devastating disasters in recent Indonesian history (BMKG, 2024). The distribution of these significant events is summarized in Figure 2.

Damage records over the last two decades also reveal that moderate-magnitude earthquakes frequently result in serious structural losses due to dense settlements and the prevalence of non-earthquake-resistant buildings in coastal and valley areas. This trend emphasizes that structural mitigation alone is insufficient; comprehensive disaster risk reduction must also involve strengthening social capacity through formal education and community-based preparedness.

**Table 1. Building Damage and Casualties Caused by Earthquakes in West Sumatra**

| year | Main Location   | Magnitude | Damaged Houses |          |        | Casualties |            |
|------|-----------------|-----------|----------------|----------|--------|------------|------------|
|      |                 |           | Severe         | Moderate | Light  | Injured    | Fatalities |
| 2009 | Padang-Pariaman | 7,6       | 135.448        | 65.380   | 78.604 | 2.902      | 1.117      |
| 2016 | Pesisir Selatan | 6,5       | 114            | 612      | 1.905  | 18         | 1          |
| 2022 | Pasaman Barat   | 6,2       | 846            | 469      | 846    | 381        | 11         |
| 2023 | Kep. Mentawai   | 6         | 1              | 15       | 271    | 1          | -          |
| 2025 | Tanah Datar     | 5,8       | 2              | –        | –      |            |            |

From a demographic perspective, West Sumatra has a substantial youth population. In

2025, the province recorded approximately 5.53 million residents, with adolescents aged 10 – 24 years constituting more than 1.4 million individuals (24.42%) (BPS, 2025). This demographic profile positions adolescents as a strategic group in building future disaster-resilient communities. However, empirical studies show that although many students possess adequate disaster-related knowledge, their actual preparedness remains limited. Huriani et al. (2021) found that 55.4% of high school students in Padang demonstrated high knowledge, yet their overall preparedness remained at a moderate level. Similarly, Nurdawati et al. (2024) reported that students often lack comprehensive understanding of early warning systems and evacuation planning.

**Table 2. Population of West Sumatra by Age Group (2025)**

| Age Group (Years)    | Total (People) | Percentage (%) |
|----------------------|----------------|----------------|
| Children (0-9)       | 982.640        | 16,61          |
| Teenagers (10-24)    | 1.444.250      | 24,42          |
| Adults (25-44)       | 1.780.800      | 30,11          |
| Seniors (45-64)      | 1.243.220      | 21,02          |
| Elderly ( 65>)       | 463.390        | 7,87           |
| Total (West Sumatra) | 5.914.300      | 100            |

These findings indicate that the core challenge does not lie in the absence of information, but in the insufficient contextualization of learning processes within local seismic characteristics. Locally grounded instructional approaches such as integrating real seismic data, historical catalogs, hazard maps, and scenario-based simulations are essential for fostering not only conceptual understanding but also adaptive behaviors and decision-making skills in disaster situations (Nathe, 2000).

Thus, the persistent seismic threat, combined with the large youth population and the observed knowledge–action gap among students, highlights the need for an adaptive and context-oriented disaster education framework. Such a framework is expected to enhance adolescent resilience and contribute to long-term disaster risk reduction efforts in West Sumatra.

## METHOD

This study adopted the Library Research Study method with a Descriptive-Qualitative approach that focused on Evidence Synthesis (Sumari et al., 2016). The qualitative approach was

chosen to analyze, categorize, and synthesize findings from various independent studies to gain a holistic understanding of the knowledge-action gap and the need for a contextual resilience model for adolescents in West Sumatra. Secondary data were collected from three main sources: (1) Scientific publications on seismotectonics, disaster mitigation, and adolescent resilience; (2) Official reports from state institutions, such as risk maps and historical earthquake data from the Meteorology, Climatology, and Geophysics Agency (BMKG, 2024), as well as reports from the Central Statistics Agency (BPS) on demographics; and (3) Documents on post-disaster urban spatial change studies (Putri et al., 2022). Data analysis was conducted through three structured stages. The first stage was Focused Thematic Analysis to group findings based on the themes of local threats (Sumatera Fault and Megathrust), gaps in youth knowledge and action, and the effectiveness of adaptive learning models. The second stage, Conceptual Gap Analysis, was used to examine the contradiction between high seismic threats (Hutchings & Mooney, 2021) and moderate levels of social preparedness (Nurdiawati et al., 2024).

The synthesis of critical evidence in the final stage aims to formulate policy implications and practical recommendations in the form of a disaster education model rooted in local seismic characteristics and oriented towards empowering youth as agents of resilience.

## RESULTS AND DISCUSSION

### Seismicity Level in West Sumatra Region

West Sumatra is one of the regions with the highest seismic activity in Indonesia, due to its position on the border of the Indo-Australian and Eurasian plates (Hutchings & Mooney, 2021), and crossed by the Great Sumatra Fault, which is divided into active land segments (Sieh & Natawidjaja, 2000). Historical evidence from BMKG (2010) confirms that significant earthquakes occur almost every decade and often cause severe damage, as was the case with the 2009 Padang Earthquake and the 2022 West Pasaman Earthquake. Studies of urban spatial changes after 2009 also show that mitigation efforts and the restructuring of evacuation infrastructure have become a top priority (Putri et al., 2022). This phenomenon indicates the existence of a vulnerability gap exacerbated by social vulnerability, where structural mitigation is not balanced with increased community adaptive capacity, making investment in social resilience, especially among the younger generation, an urgent non-structural mitigation imperative (Sumari et al., 2016)

Studies related to preparedness in the Padang region confirm the existence of a preparedness paradox among adolescents. Cognitively, the level of disaster knowledge among high school students tends to be high (more than 55% found to be in the high category) (Huriani



et al., 2021; Nurdawati et al., 2024). However, their ability to translate this theoretical knowledge into practical actions or actual preparedness remains in the moderate to low category. This phenomenon, academically known as the knowledge–action gap, is a global challenge in disaster education and a major obstacle in building community resilience (Kivi et al., 2023).

This gap is exacerbated by two main factors: first, the lack of contextualization of specific learning materials linking disaster knowledge to local geophysical hazards. General education fails to instill specific risk awareness, especially that related to local fault segments on land (such as the Sianok Fault or Sumani Fault) in the school environment or where they live, even though studies emphasize the importance of a contextualized curriculum (Ulfah et al., 2025; Loquillano et al., 2021). Second, the low level of self-confidence or self-efficacy among adolescents in dealing with emergency situations (Sarfika et al., 2022). Research identifies that practice-based training (simulations and drills) is the strongest predictor that significantly improves disaster response self-efficacy, transforming passive knowledge into active adaptive competencies (Hasan et al., 2024; Şahin & Karaca, 2025). Thus, even though adolescents know the basic theory of earthquakes, they have not yet achieved the adaptive competencies needed to implement rapid evacuation measures or fully understand early warning systems, which are crucial for shallow crustal earthquakes with minimal warning time.

### **Transformative Learning Based on Local Seismicity for Adaptive Competence**

Efforts to bridge the knowledge–action gap require the adoption of a transformative learning approach that explicitly integrates local geophysical hazard data (Yulianto et al., 2023). This model demands a fundamental shift from a passive knowledge transmission paradigm to an educational process centered on real threat scenarios in the region. Effective implementation includes the use of primary data, such as the National Earthquake Map (PuSGen, 2024), which is then processed through an analysis of the risks surrounding schools to trigger community-based risk mapping initiatives by students.

This approach is crucial because transformative disaster learning has been proven effective in promoting deep behavioral change and developing adaptive competencies (Sharpe, 2021). Therefore, the curriculum must consistently prioritize methods that focus on psychomotor training and the development of practical self-confidence in crisis situations (Sarfika et al., 2022). Active involvement in scenario-based simulations and participatory exercises not only increases cognitive preparedness but also fosters responsive adaptive behavior and rapid decision-making autonomy (Yuniarti & Junaldi, 2023; Keating & Hanger-





Kopp, 2020). Thus, the goal of disaster education goes beyond simply conveying information; rather, it is oriented toward building cognitive capacity, practical skills, and a fundamental foundation of psychosocial resilience.

## Utilizing the Demographic Potential of Youth as Agents of Disaster Transformation

Adolescents in West Sumatra (aged 10–24 years) are a very significant demographic group, comprising more than 1.4 million people or around 25.73% of the total population (BPS, 2022). This proportion makes them a strategic group and agents of change with crucial potential in disaster mitigation and management (Ronan & Johnston, 2001). The role of adolescents is twofold: they not only serve as recipients of knowledge but also as information ambassadors capable of disseminating preparedness to vulnerable groups within families and wider communities.

Optimizing this potential must be at the core of strategies to increase non-structural resilience. The active involvement of adolescents in training programs, simulations, and advocacy activities (Lestari et al., 2022) has been shown to not only increase individual preparedness but also contribute to the development of collective psychosocial resilience and reduce the impact of post-disaster trauma (Gable, 2022). Therefore, empowerment strategies should be directed toward the formal integration of disaster training into extracurricular activities and school organizations (e.g., through youth-led disaster risk reduction programs). Harnessing this demographic potential through transformative education will ensure the creation of a generation that is not only responsive but also proactive and adaptive to future earthquake risks.

## CONCLUSION

Indonesia has a high level of seismicity, with West Sumatra facing a double threat from the Sunda Subduction Zone and the Great Sumatra Fault. A history of destructive earthquakes and high structural vulnerability shows that structural mitigation efforts must be balanced with strengthening social adaptive capacity. This synthesis identifies a preparedness paradox among West Sumatran youth, where high theoretical knowledge is not matched by practical preparedness (knowledge-action gap). This weakness is exacerbated by a lack of contextualization of learning with local seismicity data and low self-confidence among youth in emergency situations.

With adolescents comprising more than a quarter of the total population aged 10-24 years, they are a strategic group for building social resilience. Therefore, this study concludes



that improving adolescent resilience must be done through transformative disaster education that integrates local seismic data and simulations based on real threat scenarios. This model will foster not only knowledge but also adaptive competencies and a sense of social responsibility, making adolescents the main agents of change in disaster risk reduction efforts in West Sumatra.

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