

## Spatial Mapping of Community Earthquake Preparedness in West Sumatra

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### ABSTRACT

Preparedness is the readiness of the community or individuals in the face of a disaster including earthquakes, preparedness is very necessary for every community because disasters cannot be predicted when they occur. West Sumatra is among the most earthquake-prone regions because it is between the meeting of the large continental plate (Eurasian plate and Indo-Australian plate) and the Semangko fault. Around the plate meeting there is a Mentawai fault. The purpose of this research is to know the preparedness of the people of West Sumatra in the face of earthquakes. This type of research is a descriptive method research, this research sample is the entire community that exists in the Regency / City of West Sumatra. The results showed that 52.63% of people's preparedness in the preparedness category was low. The authors suggest preparedness in the face of earthquake disasters needs to be improved again.



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## INTRODUCTION

Indonesia is a country located along the global *Ring of Fire*, making it highly prone to earthquakes and tsunamis. The movement of the Indo-Australian Plate in western Indonesia reaches approximately 7 mm/year, while the Pacific Plate in eastern Indonesia moves at about 12 mm/year [1]. These movements indicate active tectonic activity, resulting in approximately 1,200 earthquakes annually with magnitudes greater than 4 on the Richter scale [2]. Figure 1 shows that more than 60,000 earthquakes with magnitudes greater than Mw 4 occurred in Indonesia between 1779 and 2020. Most earthquakes in Indonesia are shallow earthquakes, which have the potential to produce significant ground acceleration at the surface.

West Sumatra is one of the provinces located in the western part of Indonesia. Geographically, this province has three major earthquake sources that have the potential to generate large-scale earthquakes [3–4]. If an earthquake occurs in the subduction zone approximately 200 km offshore, it can trigger a tsunami [5–7]. The land area of West Sumatra lies along an active fault line extending from Singkarak, Padang Panjang, Padang, to Painan, covering a length of about 500 km. Earthquake records from 1779 to 2019 indicate that many events were of large magnitude due to their shallow depth, such as those in 1928 (Mw 8.4), 1933 (Mw 9.3), 1981 (Mw 8.1), and 2007 (Mw 8.4) [3]. The extensive building damage and casualties during the 2009 earthquake demonstrate that earthquake disaster preparedness must be improved.

These tectonic movements are driven by oceanic forces [4]. The effect of these shifts is vibration, known as an earthquake, which occurs due to the displacement of mass within the Earth's crust. According to the Indonesian Agency for Meteorology, Climatology, and Geophysics (BMKG), between 1991 and 2009 there were 13 earthquakes that triggered tsunamis. An earthquake is defined as a ground-shaking event caused by tectonic plate collisions, fault activity, volcanic activity, or rock collapse [2]. Such events are unpredictable and occur suddenly without prior warning.

West Sumatra is also one of the most earthquake-prone regions because it lies at the convergence of major tectonic plates (the Eurasian Plate and the Indo-Australian Plate) and along the

Semangko fault system. Near this plate boundary lies the Mentawai fault zone. One of the major earthquakes occurred on September 30, 2009, with a magnitude of 7.9. According to BMKG, the earthquake was located approximately 57 km southwest of Pariaman at a depth of 71 km. This earthquake caused severe damage and significant losses across several regions of West Sumatra, including Padang Pariaman Regency, Padang City, Bukittinggi City, Padang Panjang City, Pesisir Selatan Regency, and West Pasaman Regency. Seismological records indicate that West Sumatra experiences a major earthquake cycle approximately every 200 years, and the early 21st century marks the recurrence phase of this cycle [5].

The earthquake disaster that struck West Sumatra on September 30, 2009, left deep sorrow and trauma for the affected communities. The earthquake, with a magnitude of 7.9 at 17:16 WIB, devastated the region and resulted in 1,195 fatalities. In addition to the loss of life, the earthquake caused extensive damage to office buildings, residential houses, healthcare facilities, educational facilities, places of worship, roads, bridges, and markets. A total of 249,833 housing units were damaged, consisting of 67,838 lightly damaged units, 67,198 moderately damaged units, and 114,797 severely damaged units [6].

Communities must remain vigilant, considering that natural disasters cannot be predicted. The best effort that can be made is to minimize potential damage. Disaster preparedness can help avoid disaster impacts or at least reduce casualties and material losses. Preparedness is defined as a series of activities carried out to anticipate disasters through proper organization and effective measures [7]. Building preparedness among communities living in earthquake-prone areas does not mean teaching them to resist or prevent disasters, but rather enhancing their capacity to respond effectively when disasters occur. Individual preparedness in facing earthquake disasters is closely related to adequate knowledge about disaster preparedness. Based on the background described above, the author is interested in conducting research entitled “*Mapping Individual Preparedness for Earthquake Disasters in West Sumatra*”.

## RESEARCH METHODS

This study was conducted throughout West Sumatra. The research indicators include knowledge of earthquake disasters, building conditions, and community preparedness for earthquake disasters. The sample used in this study consisted of 359 respondents from the West Sumatra community [8]. The stages of the research methodology can be seen in the research flow, as follows:

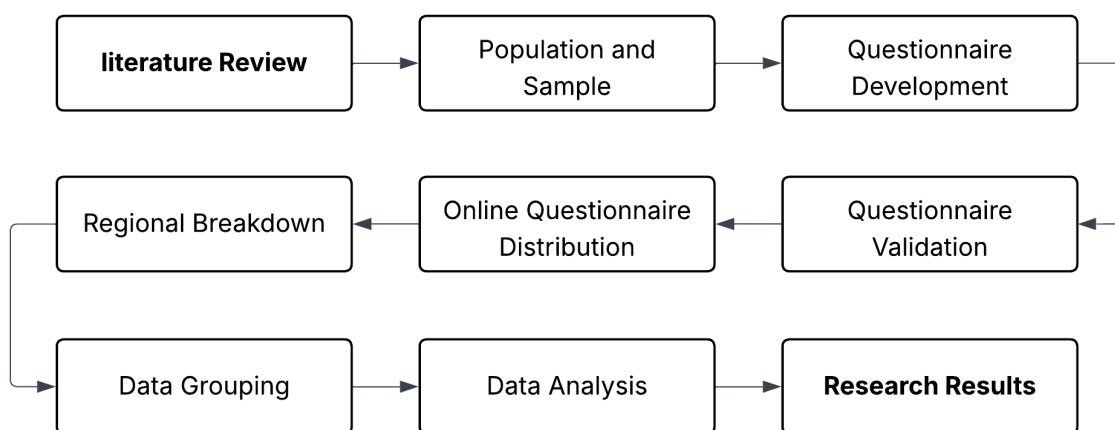


Figure 1. Research Flow Diagram

### 1. Research Location

The study was conducted across regencies and cities in West Sumatra Province, including Agam Regency, Dharmasraya Regency, Mentawai Islands Regency, Lima Puluh Kota Regency, Padang Pariaman Regency, Pasaman Regency, West Pasaman Regency, Pesisir Selatan Regency, Sijunjung Regency, Solok Regency, South Solok Regency, Tanah Datar Regency, Bukittinggi City, Padang City, Padang Panjang City, Pariaman City, Payakumbuh City, Sawahlunto City, and Solok City.

### 2. Population and Sample

Prior to designing the questionnaire, the researcher first determined the population and sample of the study.

a. Population

The population refers to the entire group of individuals or communities within a specific area. In this study, the population consisted of all residents in the regencies and cities of West Sumatra.

b. Sample

The sample used in this study comprised 359 respondents from the West Sumatra community.

3. **Questionnaire Development**

The questionnaire was used as a data collection instrument by distributing a set of written questions to respondents. The questionnaire consisted of respondent biodata and core questions regarding community preparedness for earthquake disasters. These questions were structured into four indicators: respondent general characteristics, knowledge of earthquakes, building conditions, and preparedness for earthquake disasters. This study employed a closed-ended questionnaire, in which both questions and answer options were provided to respondents [9].

4. **Questionnaire Validation**

The validation test aimed to determine whether the questionnaire used to measure the research variables was valid. The questionnaire was validated by two Civil Engineering lecturers. The researcher obtained expert feedback, and the suggestions provided were used to revise and improve the questionnaire.

5. **Online Distribution of Questionnaire**

This study on mapping community preparedness for earthquake disasters was conducted by distributing the questionnaire online via Google Forms. The link was shared through social media platforms such as WhatsApp, Facebook, Instagram, and others. The questionnaire served as a tool for collecting data by providing written questions for respondents to answer.

6. **Regional Data Classification**

After distributing the questionnaire online, responses were collected and grouped according to the respondents' respective regions. The study covered all regencies and cities in West Sumatra, including Tanah Datar, Lima Puluh Kota, Solok, Agam, South Solok, Padang Pariaman, West Pasaman, Pasaman, Pesisir Selatan, Mentawai Islands, Sijunjung, Dharmasraya, Bukittinggi, Sawahlunto, Payakumbuh, Padang Panjang, Solok, Pariaman, and Padang. The number of respondents from each region is presented in Table 1.

7. **Data Classification**

This study consists of four main indicators: respondent biodata, knowledge of earthquakes, building conditions, and community preparedness for earthquake disasters [10]. Data analysis was grouped based on these four indicators, as follows:

a. General Respondent Indicator

This indicator includes respondent biodata such as gender, age, occupation, and monthly income.

b. Knowledge of Earthquakes

Earthquakes are unpredictable disasters that can occur suddenly; therefore, public knowledge must be improved. This indicator includes:

- 1) Whether respondents have participated in earthquake evacuation training and simulations
- 2) Respondents perceptions of earthquake preparedness
- 3) Sources of earthquake-related information
- 4) Frequency of seeking earthquake information
- 5) Awareness of earthquake events and their impacts
- 6) Participation in earthquake evacuation training and simulations

c. Building Conditions

Building conditions are an important factor during earthquakes. This indicator includes :

- 1) Whether the respondent residence is constructed according to earthquake-resistant building standards
- 2) Number of floors in the house
- 3) Type of residential building
- 4) Ownership of insurance
- 5) Availability of nearby evacuation sites

- 6) Distance to the nearest evacuation site
- d. Community preparedness for earthquakes  
 Preparedness refers to the readiness of individuals or communities in facing earthquakes. This includes the availability of food, water, first air kits/medications, flashlights, radios, and appropriate responses during an earthquake. This indicator includes:
- 1) Availability of safety measures at home
  - 2) Preparedness of food supplies
  - 3) Preparedness of water supplies
  - 4) Availability of first aid kits/medications
  - 5) Ownership and use of a functional radio for information
  - 6) Availability of flashlights for evacuation
  - 7) Access to earthquake information and related applications (e.g., BMKG or other sources)
  - 8) Respondent actions during a sudden earthquake

## RESULTS AND DISCUSSION

The results of the study on community preparedness for earthquake disasters in West Sumatra can be explained as follows:

### 1. Data Processing Results

**Table 1. Number of Respondents by Regency/City in West Sumatra**

Regency/City	Quantity	Unit
Tanah Datar Regency	19	org
Lima Puluh Kota Regency	24	org
Solok Regency	11	org
Agam Regency	28	org
Solok Selatan Regency	7	org
Padang Pariaman Regency	17	org
Pasaman Barat Regency	18	org
Pasaman Regency	15	org
Pesisir Selatan Regency	33	org
Mentawai Islands Regency	6	org
Sijunjung Regency	3	org
Dharmasraya Regency	5	org
Bukittinggi City	13	org
Sawah Lunto City	2	org
Payakumbuh City	8	org
Padang Panjang City	4	org
Solok City	7	org
Pariaman City	11	org
Padang City	128	org

Based on the data in table 1, it can be seen that the total number of respondents in the regencies/cities of West Sumatra is 359 people.

#### 1) General Characteristics of Respondents

**Table 2. Respondents' Gender**

Gender	Quantity	Percentage (%)
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Male	128	35.65%
Female	231	64.34%

Based on the data in Table 2, it can be seen that the majority of respondents in this study are female, totaling 231 respondents (64,34%).

**Table 3. Respondent's Age**

Age	Quantity	Percentage (%)
11-19 Years	54	15.04%
20-60 Years	304	84.68%
>60 Years	1	0.28%

Based on the data in Table 3, it can be seen that respondents aged 11-19 years total 54 people (15,04%), those aged 20-60 years total 304 people (84,68%), and only 1 respondent is over 60 years old (0,28%). The data indicate that the majority of respondents are aged 20-60 years.

**Table 4. Respondent's Type of Work**

Type of Work	Quantity	Percentage (%)
Students	240	66.85%
Servants	57	15.88%
Private Employee	24	6.69%
BUMN/BUMD Employee	5	1.38%
Entrepreneur	10	2.79%
Traders	4	1.11%
Farmers	2	0.56%
Breeder	0	0%
Fisherman	0	0%
unemployee	17	4.74%

Based on the data in Table 4, it can be seen that the majority of respondents in this study are students, totaling 240 respondents (66,85%).

**Table 5. Respondent's Monthly Income**

Income	Quantity	Percentage (%)
< Rp.500.000,00	120	33.43%
Rp.500.000,00- Rp. 1.500.000,00	46	12.81%
Rp. 1.500.000,00- Rp. 2.500.000,00	29	8.08%
Rp.2.500.000,00- Rp. 3.500.000,00	16	4.46%
<>Rp.3.500.000,00	76	21.17%
0	72	20.05%

Based on the data in Table 5, it can be seen that the majority of respondents have an income of less than Rp 500.000 totaling 120 respondents (33,43%) from all regencies/cities in West Sumatra.

## 2. Knowledge of Earthquake

Table 6. Knowledge of Earthquake

Regency/City	Value	Category
Tanah Datar Regency	75	Moderate
Lima Puluh Kota Regency	70.14	Moderate
Solok Regency	68.94	Moderate
Agam Regency	70.54	Moderate
Solok Selatan Regency	73.81	Moderate
Padang Pariaman Regency	77.45	Moderate
Pasaman Barat Regency	74.07	Moderate
Pasaman Regency	67.22	Moderate
Pesisir Selatan Regency	74.49	Moderate
Mentawai Islands Regency	84.72	High
Sijunjung Regency	63.89	Moderate
Dharmasraya Regency	70	Moderate
Bukittinggi City	71.79	Moderate
Sawah Lunto City	70.83	Moderate
Payakumbuh City	71.88	Moderate
Padang Panjang City	62.5	Moderate
Solok City	78.57	Moderate
Pariaman City	74.24	Moderate
Padang City	73.24	Moderate

The data presented in Table 6 indicate that the level of earthquake knowledge among the community in West Sumatra is categorized as moderate.

Table 7. Earthquake Information Media

Earthquake Media	Quantity	Percentage(%)
Newspaper	0	0%
Radio	2	0.56%
Internet	325	90.53%
Television	32	8.91%

Based on the data in Table 7, it can be observed that the majority of respondents obtain information about earthquakes through the internet, with a total of 325 respondents.

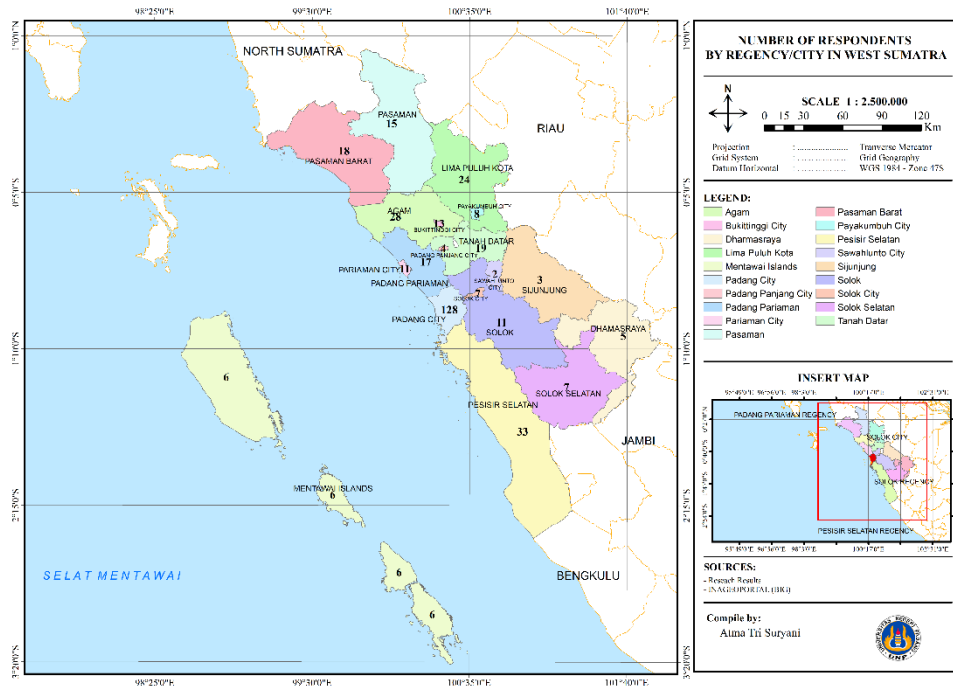


Figure 2. Number of Respondent by Regency/City in West Sumatra

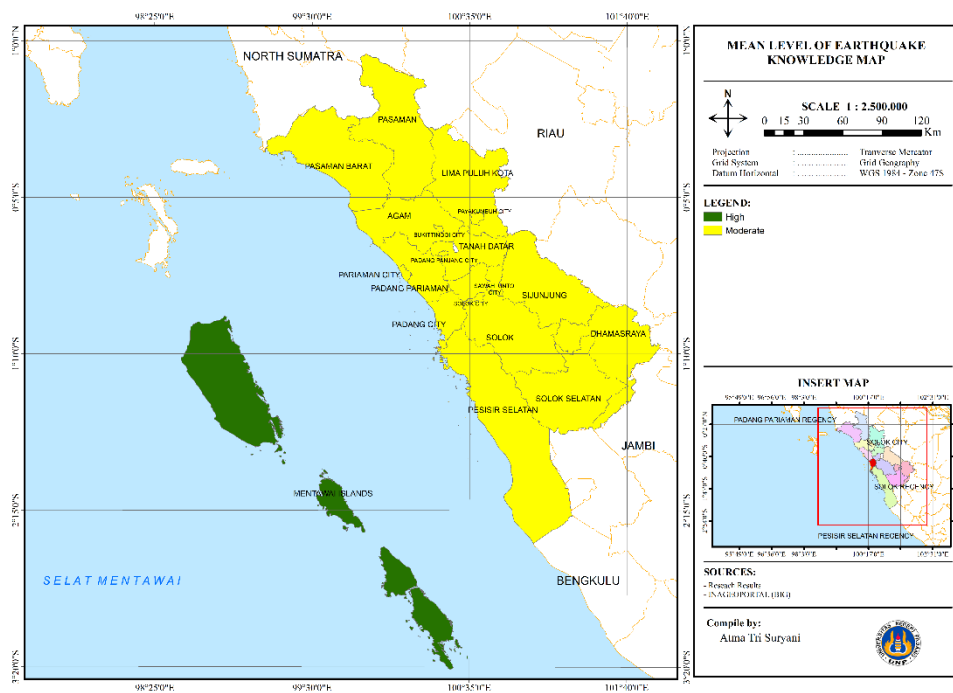


Figure 3. Mean Level of Earthquake Knowledge Map

Table 8. Earthquake Knowledge and Impact

Earthquake Knowledge and Impacts	Quantity	Percentage(%)
Yes, Very Know	169	47.08%
Yes, Little Know	183	50.97%
Not Know	7	1.95%

The data in Table 8 show that most respondents answered “yes” and “somewhat knowledgeable,” while the lowest proportion of responses was “do not know.”

### 3. Building Conditions

Table 9. Earthquake Resistant Building

Earthquake-Resistant Building	Quantity	Percentages(%)
Yes	180	50.14%
Nok	179	49.86%

Based on the information presented in Table 9, it can be observed that 180 respondents (50.14%) answered “yes,” while 179 respondents (49.86%) answered “no.” This indicates that slightly more respondents selected “yes.”

Table 10. Building Floor of Respondents

Building Floors	Quantity	Percentage(%)
1 Floor	250	69.64%
2 Floor	94	26.18%
3 Floor	12	3.34%
>3 Floor	3	0.84%

Based on the data in Table 10, the majority of respondents live in single-story houses, totaling 250 respondents (69.64%). Furthermore, the data indicate that most residential buildings in West Sumatra are permanent (concrete) structures, accounting for 77.16%.

Table 11. Type of Building Residents

Type of Building Residents	Quantity	Percentage(%)
Permanent (Concrete)	277	77.16%
Semi Permanents	74	20.61%
Wooden	8	2.23%

Based on the data presented in Table 10, the majority of respondents’ houses in West Sumatra are permanent (concrete) structures, accounting for 77.16%.

Table 12. Insurance Owned

Insurance Owned	Quantity	Percentage(%)
Life Insurance	101	28.13%
Building Insurance	15	4.18%
Vehicle Insurance	19	5.29%
Do Not Have	224	62.4%

According to Table 12, 101 respondents (28.13%) have life insurance, 15 respondents (4.18%) have building insurance, and 19 respondents (5.29%) have vehicle insurance, while 224 respondents (62.4%) do not have any form of insurance. This shows that the majority of respondents do not possess insurance.

Table 13. Evacuation Site Availability

Evacuation Site Availability	Jumlah	Persentasi (%)
Availability	208	57.94%
Not Availability	49	13.65%
Not Know	102	28.41%

Based on the data in Table 13, it can be concluded that most respondents answered “yes,” accounting for 57.94%.

Table 14. Evacuation Distance

Evacuation Distance	Quantity	Percentage(%)
< 1 km	92	25.63%
1-2 Km	59	16.43%
> 2 km	50	13.93%
Not Know	158	44.01%

According to Table 14, the majority of respondents do not know the distance between their residence and the nearest evacuation site. A total of 158 respondents (44.01%) reported that they were unaware of this information.

Table 15. Response to Sudden Earthquakes

Response to Sudden Earthquakes	Quantity	Percentage(%)
Remain Calm	272	75.77%
Evacuate by Vehicle	64	17.83%
While Carrying Essential Supplies		
Panic and Evacuate to an Undertermined Location	13	3.62%
Stay inside the House	10	2.79%

Table 15 indicates that most respondents remain calm when an earthquake occurs suddenly, with a percentage of 75.77%.

Table 16. Preparedness of Earthquake

Regency/City	Value	Category
Tanah Datar Regency	64	Moderate
Lima Puluh Kota Regency	62.35	Moderate
Solok Regency	60.71	Moderate
Agam Regency	62.37	Moderate
Solok Selatan Regency	50	Low
Padang Pariaman Regency	59.24	Low
Pasaman Barat Regency	62.89	Moderate
Pasaman Regency	52.62	Low
Pesisir Selatan Regency	62.66	Moderate
Mentawai Islands Regency	76.19	Moderate
Sijunjung Regency	50	Low
Dharmasraya Regency	59.29	Low
Bukittinggi City	73.35	Moderate
Sawah Lunto City	57.14	Low
Payakumbuh City	46.43	Low
Padang Panjang City	37.14	Low

Solok City	55.92	Low
Pariaman City	51.17	Low
Padang City	62.67	Moderate

Based on the data in Table 16, the level of community preparedness in West Sumatra in facing earthquake disasters is categorized as low.

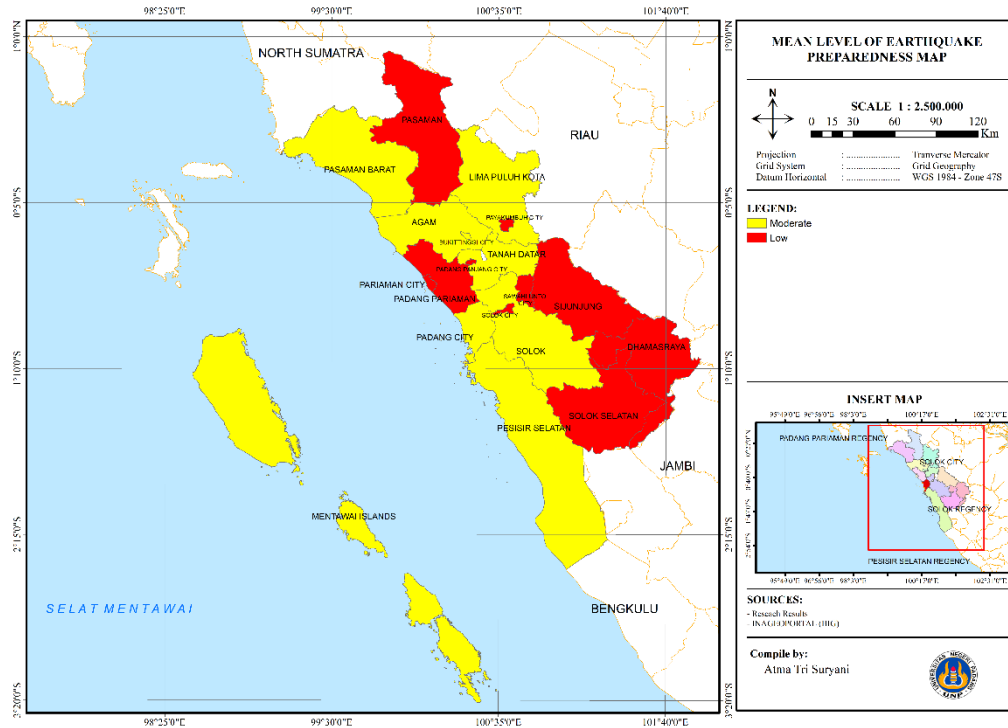


Figure 4. Mean Level of Earthquake Preparedness Map

#### 4. Discussion

##### a. Knowledge of Earthquakes

Based on the data presented in Table 6, the average level of respondents' knowledge regarding earthquakes in West Sumatra is categorized as moderate. The majority of respondents obtain information about earthquakes from the internet, with a total of 325 respondents (90.53%).

Regarding knowledge of earthquake occurrences and their impacts, most respondents selected "yes, somewhat knowledgeable," accounting for 183 respondents (50.97%). This indicates that respondents' understanding of earthquake events and their impacts is still not fully comprehensive. Knowledge is a fundamental aspect that must be possessed by every individual in order to sustain life. Therefore, knowledge about earthquakes should be thoroughly understood, especially by individuals living in earthquake-prone areas.

##### b. Building Conditions

During a large-scale earthquake, buildings may experience cracks or even collapse. Therefore, the implementation of earthquake-resistant building standards is essential, particularly in earthquake-prone areas. Structural damage can be minimized if buildings comply with these safety standards.

Based on the data in Table 9, it can be observed that 50.14% of respondents' houses comply with earthquake-resistant standards, while 49.86% do not. This indicates that earthquake-resistant construction remains a critical requirement, especially in regions such as West Sumatra.

The number of floors in residential buildings also influences vulnerability during earthquakes. Based on Table 10, the majority of respondents live in single-story houses, accounting for 69.64%.

In terms of structural characteristics, the physical condition of buildings in West Sumatra is relatively good. Permanent (concrete) structures account for 77.16%, semi-permanent buildings (wood and concrete) account for 20.61%, and only 2.23% are wooden structures.

According to Table 12, 101 respondents (28.13%) have life insurance, 15 respondents (4.18%) have building insurance, and 19 respondents (5.29%) have vehicle insurance, while 224 respondents (62.40%) do not have any form of insurance. This indicates that the majority of respondents are not covered by insurance.

Based on Table 13, 208 respondents (57.94%) answered “yes” regarding the availability of evacuation facilities, 49 respondents (13.65%) answered “no,” and 102 respondents (28.41%) answered “do not know.” This suggests that most respondents have access to evacuation facilities.

However, based on Table 14, most respondents are unaware of the distance between their residence and the nearest evacuation site, with 158 respondents (44.01%) selecting “do not know.”

#### c. Community Preparedness in Facing Earthquake Disasters

Preparedness refers to the readiness of communities in facing various disasters such as floods, landslides, forest fires, tornadoes, tsunamis, volcanic eruptions, and earthquakes. West Sumatra is a highly earthquake-prone region due to its location at the convergence of major tectonic plates, namely the Eurasian Plate and the Indo-Australian Plate, as well as the presence of the Semangko Fault.

The 2009 earthquake, with a magnitude of 7.9, caused significant damage and loss of life in West Sumatra, leaving long-lasting trauma among affected communities. Therefore, enhancing earthquake preparedness in West Sumatra is essential, given the region’s high seismic risk. Preparedness is defined as a series of activities undertaken to anticipate disasters through organized and effective measures [7].

Based on the data in Figure 3, the overall level of community preparedness in districts/cities across West Sumatra is categorized as low. A total of nine districts/cities fall into the moderate preparedness category, namely Tanah Datar, Lima Puluh Kota, Solok, Agam, West Pasaman, Pesisir Selatan, Mentawai Islands, Bukittinggi, and Padang. Meanwhile, ten districts/cities are categorized as having low preparedness levels, including Solok Selatan, Padang Pariaman, Pasaman, Sijunjung, Dharmasraya, Sawahlunto, Payakumbuh, Padang Panjang, Solok, and Pariaman.

## CONCLUSION

The conclusions drawn from this study are as follows:

1. Based on the questionnaire responses, the level of knowledge regarding earthquake disasters in West Sumatra is categorized as moderate.
2. A total of 180 respondents have constructed their residential buildings in accordance with earthquake-resistant standards, while 179 respondents’ houses do not comply with such standards.
3. The level of community preparedness in West Sumatra in facing earthquake disasters is categorized as low.
4. The study results indicate certain inconsistencies, which may be attributed to the limited number of respondents, as the questionnaire was distributed online.

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