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ANALYSIS OF THE LEVEL OF COMMUNITY PREPAREDNESS FOR THE TSUNAMI DISASTER IN BENGKULU CITY

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ABSTRACT

Geographically, Bengkulu City is located in a coastal area and is highly vulnerable to tsunamis. Since the earthquake and tsunami that hit the Indian Ocean in 2004, the attention of the Bengkulu City government to this phenomenon has increased significantly. However, to support government efforts in anticipating the risks and impacts of a tsunami, community preparedness is essential in addressing this threat. This study explores the level of community preparedness in facing the threat of tsunamis. A survey was conducted among a sample of 400 respondents from the coastal communities of Bengkulu City, spanning nine sub-districts, using a structured questionnaire. The questionnaire evaluated five parameters: knowledge and attitudes, family policies, emergency response plans, early warning systems, and resource mobilization. The level of community preparedness is determined using index analysis. The results show that the level of tsunami preparedness among the Bengkulu City community was at a moderate to ready level. The two sub-districts classified as being at the ready level are Gading Cempaka and Sungai Serut. In comparison, the seven sub-districts at the moderate level are Selebar, Teluk Segara, Muara Bangkahulu, Kampung Melayu, Ratu Agung, Ratu Samban, and Singaran Pati. Based on the results of this study, it is hoped that the government and the community can increase their preparedness for tsunami disasters to reduce the negative impacts that may occur.

Keywords: *community; disaster; preparedness; tsunami*

INTRODUCTION

Earthquakes and tsunamis are natural disasters that have the potential to cause significant impacts on affected communities. Bengkulu City is one of the cities most vulnerable to earthquakes and tsunamis (BNPB, 2016; Fathiyah et al., 2024). This vulnerability is caused by the convergence of two very active tectonic plates: the Indo-Australian Tectonic Plate and the Eurasian Tectonic Plate (Lestari & Susiloningtyas, 2022) along the west coast of Sumatra. This

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region is part of the Sumatra megathrust zone, which is characterized by frequent seismic activity and repeated large earthquakes, highlighting the urgent need for continuous disaster preparedness efforts in Bengkulu City. The potential for future tsunamis in Indonesia has also been emphasized through probabilistic hazard assessments, which indicate significant tsunami risks along the Sumatra subduction zone (Horspool et al, 2014). In addition, studies on tsunami generation mechanisms highlight the importance of understanding earthquake fault dynamics in assessing tsunami hazards (Wang & Liu, 2006).

Although the 2004 Indian Ocean earthquake and tsunami had a devastating global impact, its direct effects on Bengkulu were less significant compared to severely affected regions such as Aceh. The impact of the 2004 Indian Ocean tsunami has been widely studied, not only in terms of physical damage but also socio-economic consequences, including disruptions to tourism and coastal economies (Birkland et al., 2006; Sharpley, 2005). Environmental features such as coastal vegetation and geomorphology have also been shown to play a role in reducing tsunami impacts (Chatenoux & Peduzzi, 2007). Therefore, using this event alone does not fully represent the disaster context of Bengkulu City. Instead, Bengkulu has experienced its own history of major seismic events, including the 2000 Bengkulu earthquake (Mw 7.9) and the 2007 (Mw 8.4), both of which caused substantial damage to infrastructure and highlighted the region's high seismic vulnerability. These events are closely related to the activity of the Mentawai segment of the Sumatra megathrust, which is recognized as one of the most seismically active and potentially hazardous zones capable of generating large earthquakes and tsunamis. The seismic gap identified along this segment indicates the potential for future megathrust earthquakes, posing a serious threat to coastal areas, including Bengkulu Cty. This local seismic history and potential for future large-scale events underline the urgent need to strengthen community preparedness in Bengkulu. Unlike regions that have experienced catastrophic tsunamis, the relatively limited direct tsunami impact in Bengkulu may lead to lower risk perception among communities, which can hinder preparedness efforts.

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Therefore, understanding and improving preparedness levels in this context becomes critically important for reducing future disaster risks.

Preparedness is an effort that is carried out to anticipate the possibility of a disaster to avoid casualties, property losses, and changes in the way of life of the community in the future (Hargono et al. 2023; Langshiang, 2023; Ryan et al. 2020). Community engagement has been identified as a critical component in strengthening disaster preparedness, particularly through participatory approaches and risk communication strategies (Ryan et al, 2020). Furthermore, evacuation behaviour and response effectiveness are strongly influenced by human behavior and prior disaster experience (Makinoshima et al, 2020). Preparedness efforts must be carried out when a disaster is identified as occurring. One step in the disaster management strategy is preparation. Increasing preparedness is one of the key components of proactive disaster risk reduction efforts, according to the current idea of disaster management, before a disaster occurs.

In the current concept of disaster management, increasing preparedness is one of the important elements of proactive disaster risk reduction activities, before a disaster occurs (Sagay & Pangemanan, 2023). A community's preparedness for disasters is significantly influenced by its awareness of disaster anticipation, particularly for people who reside in areas susceptible to natural disasters (Doondori et al. 2023; Hoffmann & Muttarak, 2017). A high level of community preparedness can minimize the negative impacts caused by disasters that occur (Rangarirai et al. 2023; Suwaryo et al. 2021). A well-prepared society can reduce the risk of disasters (Asih et al. 2023; Bogdan et al. 2021; Bronfman et al. 2019).

Previous studies have extensively examined community preparedness for tsunami and earthquake hazards in various regions. For instance, Hoffmann & Muttarak (2017) emphasized the role of education and risk awareness in enhancing household preparedness, while Bronfman et al. (2019) highlighted the importance of risk perception and trust in authorities as key determinants of preparedness behavior. Similarly, Suwaryo et al (2021) found that community participation and local knowledge significantly influence disaster preparedness in coastal areas.

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Other studies, such as Rangarirai et al. (2023), demonstrated that socio-economic factors and access to information play a crucial role in shaping preparedness levels.

However, most previous studies have focused on general determinants of preparedness or have been conducted in different geographical and socio-cultural contexts, which may not fully represent the specific conditions of coastal communities in Bengkulu City. In addition, limited studies integrated local vulnerability characteristics with preparedness assessments in tsunami-prone areas along the Sumatra megathrust zone. Therefore, this study seeks to fill gaps by specifically assessing the level of coastal community preparedness in Bengkulu City, taking into account its unique hazard exposure and local context. Understanding the factors that can motivate and increase community preparedness for tsunami disasters is one effort to minimize the impact of tsunami disasters. Therefore, this study aims to assess the level of coastal community preparedness in Bengkulu City in facing a tsunami disaster. In addition, this research can serve as a basis for building local capacity, encouraging community participation in disaster planning, and improving communities' socio-economic resilience to disasters.

MATERIALS AND METHODS

This research was conducted in Bengkulu City, Indonesia. The selection of research locations was carried out using the purposive sampling method, where samples were chosen based on their geographic location in areas prone to tsunami disasters. The research location can be seen in **Figure 1**.

This study employs a quantitative method. The data used were obtained from questionnaires, with the number of respondents calculated using the Slovin formula (Equation 1) and an error tolerance of 5%.

$$n = \frac{N}{1 + N.e^2} \quad (1)$$

Information:

n: Number of samples

N: Population size

e: Error tolerance

The population of Bengkulu City is 390,060 people (BPS, 2024), divided into 9 sub-districts. The questionnaires were distributed to respondents using a stratified random sampling technique in 9 sub-districts in Bengkulu City.

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The selection of parameters in this study is based on the preparedness framework developed by LIPI-UNESCO/ISDR (2006) and the Regulation of the Head of BNPB No. 2 of 2012, which has been widely used as a standard for assessing community preparedness in disaster-prone areas. This framework conceptualizes preparedness as a multidimensional construct. Five key parameters were adopted in this study, namely knowledge and attitudes (KA), family policies (FP), emergency response plans (ERP), early warning systems (EWS), and resource mobilization (RM).

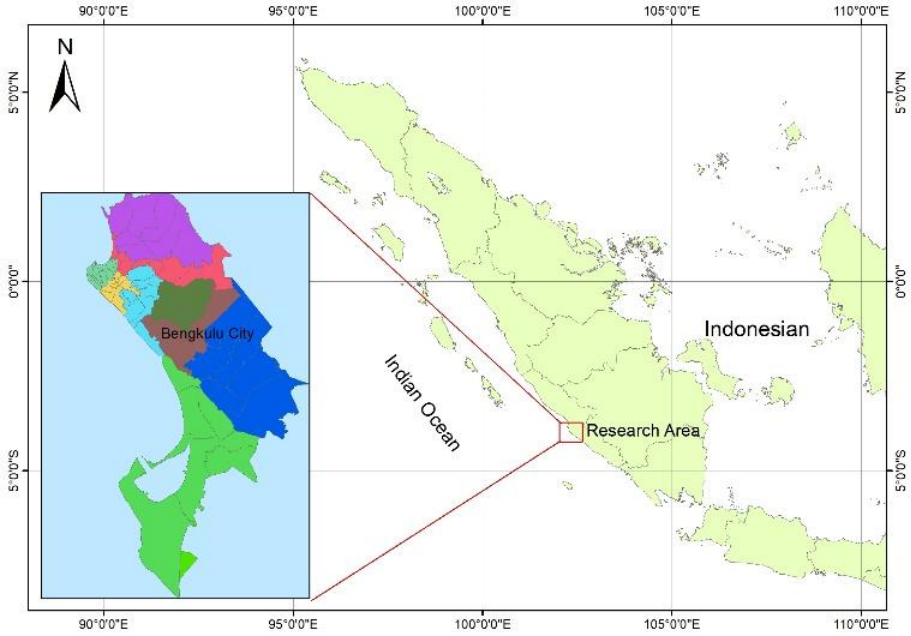


Figure 1. Research Area

Sources: ArcGIS Software Processing Results, 2025

The rationale for selecting these parameters lies in their ability to represent both cognitive and practical aspects of preparedness. KA reflects the community's understanding of tsunami hazards and appropriate responses, while FP indicates the existence of internal household-level regulation and agreements related to disaster preparedness. ER plans capture the extent to which individuals and households have prepared specific actions to be taken during a tsunami event. EWS represents the community's capacity to receive, interpret, and respond to warning information effectively. Meanwhile, RM reflects the availability and utilization of human,

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material, and logistical resources necessary for disaster response.

Operationally, each parameter is measured using a set of questionnaire items adapted from LIPI–UNESCO/ISDR (2006) guidelines. The KA parameter includes indicators related to understanding tsunami characteristics, causes, and response actions. FP is assessed through the presence of household-level preparedness agreement and planning. ER plans are evaluated based on the existence of evacuation plans and preparedness actions. EWS are measured through the ability to access and respond to warning information, while RM includes indicators related to the availability of emergency supplies, community coordination, and logistical preparedness. These operational definitions ensure that each parameter is measured consistently and reflects the actual preparedness conditions of the community. The data analysis technique used is index analysis. Index assessment is carried out in several stages.

1. Calculate the index of each parameter in each sub-district

The index is computed using the answers to the questionnaires. The responses to the questionnaire are assessed using the Guttman scale, where a 'yes/done' answer is assigned a score of 1, and a 'no/not done' answer is assigned a score of 0. For each sub-district, the total real score is obtained by adding up all respondents' answers, while the maximum parameter score is obtained by adding up all question scores if all are correct. The index is calculated for each parameter and each sub-district using Equation (2).

$$Index = \frac{Total\ real\ score\ parameter}{Maximum\ score\ \ parameter} \times 100 \quad (2)$$

2. Determine the weight of each parameter

The weight of each parameter is calculated using Equation (3) (Hidayati, et al. 2011).

$$Bp_i = \frac{JPp_i}{JS} \quad (3)$$

Information:

Bp_i : Parameter weight *i*

JPp_i : Number of parameter questions *i*

JS : Total number of questions

3. Calculate the total index of parameters for each sub-district

The total index score is calculated using Equation (4) (Apriyatno et al. 2020; As'ari, 2017) with modifications.

$$Total\ Index = KA\ weight * KA\ Index +$$

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$$FP\ weight * FP\ Index + ERP\ weight * ERP\ Index + EWS\ weight * EWS\ Index + RM\ weight * RM\ Index \quad (4)$$

4. Determine the level of preparedness

The total index value for each sub-district will be classified into three intervals (not ready, moderate, ready) to determine the level of community preparedness in facing a tsunami disaster. The preparedness level intervals are determined based on **Table 1**.

Table 1. Index of Community Preparedness Level

No	Index Score	Category
1	70,000 – 100,000	Ready
2	45,000 – 69,999	Moderate
3	< 45,000	Not Ready

Source: LIPI-UNESCO/ISDR, 2006, with modifications

RESULTS AND DISCUSSION

Bengkulu City is located on the west coast of Sumatra Island, bordering the Indian Ocean. Bengkulu City is one of the cities prone to earthquakes and tsunamis. Administratively, Bengkulu City consists of 9 sub-districts. A total of 400 respondents was determined as the required sample using the Slovin formula (Equation 1). The number of population and samples taken for each sub-district can be seen in **Table 2**.

Table 2. The Number of Population and Samples

No	Sub-district	Total Population (People)	Number of Samples (People)
1	Selebar	86.103	88
2	Gading Cempaka	38.571	40
3	Teluk Segara	22.193	23
4	Muara Bangkahulu	53.675	55
5	Kampung Melayu	48.897	50
6	Ratu Agung	51.953	53
7	Ratu Samban	21.975	23
8	Sungai Serut	25.719	26
9	Singaran Pati	40.974	42
	Total	390.060	400

Source: Research Analysis, 2025

Community preparedness in dealing with tsunamis was measured using five parameters based on the Regulation of the Head of BNPB No. 2 of 2012 concerning General Guidelines for Disaster Risk Assessment. The parameters are knowledge and attitudes (KA), family policies (FP), emergency response plans (ERP), early warning systems (EWS), and resource

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mobilization (RM). The level of community preparedness was calculated based on the results of a questionnaire distributed proportionally to 9 sub-districts in Bengkulu City, with the number of questions for each parameter as in **Table 3**, but after a validity test was carried out, three questions were removed from the questionnaire because they were invalid.

Table 3. Number of Questions for Each Parameter

Number of Questions for Each Parameter									
Before Validity Test					After the Validity Test				
KA	**FP**	**ERP**	**EWS**	**RM**	**KA**	**FP**	**ERP**	**EWS**	**RM**
7	5	13	4	5	6	5	11	4	5

Source: Research Analysis, 2025

Based on 31 question items in the questionnaire given, the calculation results show that the index for each parameter in each sub-district calculated using Equation 1 can be seen in **Table 4**, and the weight of each parameter calculated using Equation 2 can be seen in **Table 5**.

Based on **Table 5**, the emergency response plans (ERP) parameter has the highest weight (0.355), indicating that it plays a dominant role in determining the overall preparedness level. Sub-districts, such as Sungai Serut, Kampung Melayu, and Singaran Pati, which fall into the "ready" category for ERP, tend to have higher overall preparedness indices. These findings suggest that the existence of structured evacuation plans, clear procedures, and community training significantly enhances disaster preparedness. In contrast, the resource mobilization (RM) parameter shows relatively low index values in several sub-districts, particularly in Selebar and Ratu Agung, which are categorized as "not ready". This indicates that limitations in accessing and managing resources such as emergency logistics, trained personnel, and disaster-relevant infrastructure remain a major constraint in improving preparedness levels. Therefore, RM can be identified as a critical limiting factor in overall community preparedness in Bengkulu. The category for each parameter and each sub-district can be seen in Table 6 obtained from the index for each parameter and each sub-district in **Table 4** and the weight of each parameter in **Table 5**. Based on **Table 6**, Sungai Serut demonstrates the highest preparedness level due to consistently high scores across almost all parameters, especially ERP, EWS, and RM. Meanwhile, sub-districts categorized as moderate

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generally show imbalances between parameters, particularly KA, but weak implementation aspects, such as FP and RM. This imbalance indicates that knowledge alone is sufficient without being supported by practical preparedness measures.

Table 4. Index for Each Parameter Each Sub-District

No	Sub-district	Index of Parameter				
		KA	FP	ERP	EWS	RM
1	Selebar	87,689	51,136	62,500	58,523	41,818
2	Gading Cempaka	94,167	64,500	74,091	61,875	56,000
3	Teluk Segara	79,710	50,435	67,194	65,217	50,435
4	Muara Bangkahulu	86,061	61,091	66,116	64,091	49,818
5	Kampung Melayu	86,667	50,800	72,545	74,000	54,400
6	Ratu Agung	85,849	52,830	65,695	53,302	36,226
7	Ratu Samban	79,710	56,522	69,565	76,087	59,130
8	Sungai Serut	92,949	65,385	78,322	76,923	78,462
9	Singaran Pati	84,524	60,952	70,996	73,214	49,524

Source: Research Analysis, 2025

Table 5. Weight for Each Parameter

Weight of Parameter				
KA	FP	ERP	EWS	RM
0,194	0,161	0,355	0,129	0,161

Source: Research Analysis, 2025

These findings are consistent with previous studies; for example, Hoffmann & Muntarak (2017) emphasized that knowledge and experience alone do not guarantee preparedness unless supported by institutional and household-level actions. Similarly, Bronfman et al (2019) found that preparedness is strongly influenced by the ability of communities to translate risk awareness into concrete actions such as planning and resource allocation. Furthermore, the importance of emergency planning and community participation identified in this study aligns with the findings of Suwaryo et al (2021), which highlight that preparedness in coastal communities is significantly improved when communities actively engage in disaster simulations and planning activities. Likewise, Rangarirai et al (2023) demonstrated that access to resources and community-based approaches are key determinants of disaster preparedness.

However, compared to previous studies, this research provides a more localized analysis by integrating parameter-based index assessment at the sub-district level in Bengkulu City. This allows for a more specific identification of priority areas for intervention. While earlier studies

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tend to generalize preparedness determinants, this study highlights that in Bengkulu City, the main challenge lies not in knowledge (which is already high), but in the implementation aspects, particularly resource mobilization and family-level preparedness.

Table 6. Category for Each Parameter Each Sub-District

No	Sub-district	Category of Parameter				
		KA	FP	ERP	EWS	RM
1	Selebar	Ready	Moderate	Moderate	Moderate	Not Ready
2	Gading Cempaka	Ready	Moderate	Moderate	Moderate	Moderate
3	Teluk Segara	Ready	Moderate	Moderate	Moderate	Moderate
4	Muara Bangkahulu	Ready	Moderate	Moderate	Moderate	Moderate
5	Kampung Melayu	Ready	Moderate	Ready	Ready	Moderate
6	Ratu Agung	Ready	Moderate	Moderate	Moderate	Not Ready
7	Ratu Samban	Ready	Moderate	Moderate	Ready	Moderate
8	Sungai Serut	Ready	Moderate	Ready	Ready	Ready
9	Singaran Pati	Ready	Moderate	Ready	Ready	Moderate

Source: Research Analysis, 2025

Therefore, strengthening preparedness efforts in Bengkulu City should prioritize improving emergency response planning and enhancing resource mobilization capacity, especially in sub-districts that are still categorized as moderate. This includes increasing community training, improving access to early warning systems, and ensuring the availability of adequate disaster response resources. The total index for each sub-district can be determined using Equation 3, which can be seen in **Table 7**. The level of community preparedness for a tsunami disaster in Bengkulu City is shown in **Figure 2**.

Table 7. Total Index and Category for Each Sub-District

No	Sub-district	Total Index	Category
1	Selebar	61,694	Moderate
2	Gading Cempaka	71,935	Ready
3	Teluk Segara	63,955	Moderate
4	Muara Bangkahulu	66,276	Moderate
5	Kampung Melayu	69,032	Moderate
6	Ratu Agung	61,169	Moderate
7	Ratu Samban	68,583	Moderate
8	Sungai Serut	78,908	Ready
9	Singaran Pati	68,817	Moderate

Source: Research Analysis, 2025

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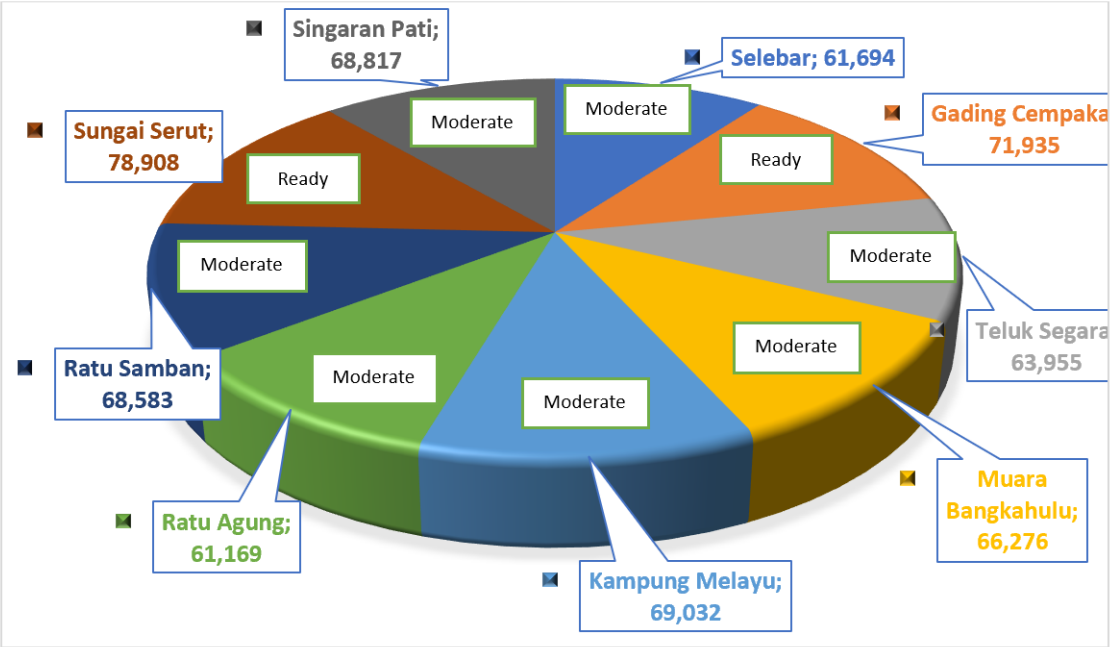


Figure 2. The Level of Community Preparedness for Tsunami Disaster in Bengkulu City

Source: Research Analysis, 2025

A more comprehensive analysis of the five preparedness parameters reveals a clear pattern of variation in their contribution to overall preparedness. Among all parameters, KA consistently shows the highest index values across all sub-districts, indicating that the majority of the population already has a good understanding of tsunami hazards. In contrast, RM emerges as the weakest parameter, with several sub-districts such as Selebar and Ratu Agung categorized as not ready. This indicates significant limitations in the availability and accessibility of emergency resources, logistics, and community-level support systems. Meanwhile, ERP represents the most influential parameter due to having the highest weight (0.355), meaning that variations in ERP significantly affect the overall preparedness index. Therefore, ERP can be considered the most critical parameter in determining preparedness levels, while RM acts as the main limiting factor. This pattern suggests that although cognitive preparedness (knowledge) is already strong, practical and operational preparedness remains insufficient. From a spatial perspective, the distribution of preparedness levels across Bengkulu City shows a distinct

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geographic pattern. Sub-districts categorized as ready, such as Sungai Serut and Gading Cempaka, tend to have better access to infrastructure, information, and community organization, which support higher preparedness levels. In contrast, several coastal and densely populated sub-districts, such as Selebar and Kampung Melayu, exhibit moderate preparedness despite their higher exposure to tsunami hazards. This indicates a mismatch between hazard exposure and preparedness capacity. Furthermore, sub-districts with relatively lower resource mobilization capacity are spatially clustered in areas with limited access to emergency facilities and infrastructure. This suggests that geographic factors, including accessibility and urban development, play an important role in shaping preparedness levels. These spatial disparities highlight the need for location-specific disaster risk reduction strategies, particularly in high-risk coastal zones with limited preparedness capacity.

An important finding of this study is the presence of areas with relatively high tsunami risk but only moderate preparedness levels. For example, coastal sub-districts such as Kampung Melayu and Muara Bangkahulu are directly exposed to tsunami hazards but have not yet reached the ready category. This condition indicates a preparedness gap, where communities living in high-risk areas are not fully equipped with adequate response capacity. Such gaps can significantly increase potential disaster impacts, including higher vulnerability to casualties and damage. Therefore, priority interventions should be directed toward these high-risk but moderately prepared areas.

Socio-economic factors also appear to influence preparedness levels. Sub-districts wth better preparedness tend to have stronger community organization, better access to information, and more resources to support disaster response. Conversely, areas with lower preparedness are likely constrained by limited economic capacity, reduced access to information, and weaker institutional support. This finding supports previous studies, which emphasize that disaster preparedness is not only determined by knowledge but also by socio-economic conditions and access to resources.

However, these findings should be interpreted with caution due to several limitations. The assessment relies on a

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limited set of preparedness parameters, which may not fully capture the complexity of community resilience, particularly socio-institutional and cultural aspects. Furthermore, the study is geographically limited to coastal areas in Bengkulu, which may restrict the generalizability of the findings to other regions.

CONCLUSIONS

The results of this study indicate that the overall level of community preparedness for tsunami disasters in Bengkulu City is predominantly at a moderate level, with only two sub-districts classified as ready. A key pattern emerging from the findings is that while the community demonstrates a strong level of knowledge and attitudes regarding tsunami hazards, other critical components, such as family policies, emergency response planning, early warning systems, and resource mobilization, remain insufficiently developed. This imbalance suggests that cognitive awareness has not been fully translated into practical preparedness actions at both household and community levels.

These findings can be generalized to other coastal urban areas with similar socio-economic and hazard characteristics, where awareness of disaster risks does not necessarily correspond to comprehensive preparedness. Therefore, effective disaster risk reduction strategies should emphasize not only knowledge dissemination but also the strengthening of institutional and practical preparedness capacities.

This study contributes to disaster science by providing an empirical assessment of community preparedness using a multi-parameter index approach based on national disaster risk assessment guidelines. The integration of five key parameters offers a more comprehensive understanding of preparedness conditions and highlights specific gaps between knowledge and implementation, which are often overlooked in conventional assessments.

Based on these findings, several recommendations can be proposed. First, local governments should prioritize strengthening family-based preparedness programs to ensure that disaster response plans are clearly defined at the household level. Second, improvements in early warning systems and community response mechanisms are needed to enhance the effectiveness of evacuation

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processes. Third, capacity building in resource mobilization should be intensified, particularly in sub-districts categorized as not ready, to ensure the availability and efficient use of human, material, and logistical resources. Finally, continuous community-based training and simulation programs should be implemented to transform knowledge into practical skills and improve overall disaster resilience.

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