

## Community Preparedness Index to Tsunami in South Halmahera Regency North Maluku, Indonesia

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### ABSTRACT

Every disaster was a widespread lack of knowledge about disaster risks and how to react appropriately to minimize loss of life, property, and livelihoods. Thus, public awareness and readiness are critical components of tsunami awareness and preparedness. The objectives of the study are to analyze the preparedness level of coastal communities in South Halmahera Regency, North Maluku. The study adopted a descriptive qualitative approach where the questionnaire used to measure the community's preparedness for the tsunami disaster was modified from the LIPI-UNESCO/ISDR 2006 standard with the parameters of Knowledge and Attitude (KA), Emergency Response Plan (EP), Disaster Warning System (WS), and Resource Mobilization Capacity (RMC). The result shows that the Community Preparedness Index result is 71.7, indicating that the community in the study site is ready category. The community's readiness is closely monitored at the research location, with a knowledge and attitude (KA) score of 92.6 percent and an emergency response plan (EP) score of 67.5. While the warning system parameter (WS) has a value of 34.0 percent and the resource mobilization parameter (RMC) has a value of 45.9 percent, the parameters have low values.

### Keywords

Community Preparedness; Tsunami; South Halmahera

### Introduction

Indonesia is a tsunami-prone state with the highest number of tsunami victims worldwide (Triatmadja 2010). Reference (Hamzah, Puspito, and Imamura 2000) stated that from 1600 to 2004, there were approximately 109 tsunamis that occurred in Eastern Indonesia including North Maluku Province. This is because the region has a very high seismic potential due to the existence of three plates: the Philippine Plate Subduction Zone in the north, the Sorong and Sula Faults in the south, and the West Maluku Thrust in the west (Løvholt et al. 2012). According to US Geological Survey (USGS) statistics, there have been 580 earthquakes in North Maluku Province between 2000 and 2020 with a magnitude of 5 Mw and a depth of 0–70 km (Brilliantina, Pratiwi, and Susanti 2021).

Generally, tsunamis have become the greatest lethal threat to people who live in tsunami-prone regions, mainly coastal areas, during the past decade (Muhari, Diposaptono, and Mamura 2007). Reference (Synolakis et al. 1995) report that tsunami occurs in southeast Java and Bali causes 200 people have died, 400 were injured, and 1000 houses were destroyed. Whereas the tsunami in Aceh in 2004 causes about 110.229 people were dead, 12.132 people declared were missing, and 703.748 people were evacuated. While in the coastal area of South Halmahera Regency North Maluku Province, it has been reported that a tsunami occurred in 1994 on Obi Island, which was triggered by a 6.8 Mw earthquake and caused tsunami run-up to reach 3 m. This tsunami has left one person dead, 52 injured, and 479 houses damaged (Geurhaneu, Budi, and Latuputty 2016). The government is concerned because the population is panicking and fleeing alone or in groups in hilly regions due to unfounded news stories. Although recently, tsunamis can be predicted in terms of time and location, triggers for tsunami events such as earthquakes, landslides at sea, or underwater volcanoes are still very difficult to predict (Triatmadja 2010) (Berman 2013). This

indicates that a tsunami may hit at any moment and from any location along with most coasts and wreaking havoc. A tsunami results in both quantifiable costs such as environmental and infrastructural damage (buildings, bridges, streets, landslides) and unquantifiable losses like fatalities, health, and psychological pressure for survivors (Asmawi and Ibrahim 2014)(Carballo, Daita, and Hernandez 2005). Even though tsunamis are relatively rare, their potential risk cannot be neglected (Jelinek et al. 2009).

Numerous studies showed that a significant underlying element in every disaster was a widespread lack of knowledge about disaster risks and how to react correctly to minimize loss of life, property, and livelihoods (Takako 2011). As a result, the community must understand the fundamentals of what a tsunami is, how it is produced, and how it may destroy them. Any system will fail if the population is ignorant of what to do in the case of a tsunami and is unprepared to take appropriate action. As a result, (Adger et al. 2005) emphasized the significance of the connections between ecosystems and human societies and shifted the idea toward a more practical perspective targeted at maintaining and improving social-ecological systems' ability to adapt to uncertainty. However, community preparation is one of the most challenging jobs, particularly in regions where tsunamis are uncommon and vulnerable populations may be unable to pass on safety practices from generation to generation.

Additionally, strategies must be developed to guarantee that a community is fortified, becoming less vulnerable to disasters and tsunami damage. It is critical for the community to understand the many types of disasters and prepare for catastrophic particularly tsunamis. Thus, public awareness and readiness are critical components of tsunami awareness and preparedness since it is the least expensive and most effective catastrophe prevention. Community disaster preparation must be measured before the occurrence of a tsunami. Therefore, the study's objectives are to analyze the preparedness level of coastal communities in South Halmahera Regency, North Maluku.

## **Literature Review**

Tsunamis are a set of very long wavelength ocean waves generated by rapid displacement of water induced by Earth's dynamic processes such as plate tectonics, earthquakes, landslides, or subsurface slumps (Dhar, Hussain, and Ansary 2008). Although low in the deep ocean, a tsunami wave can grow to almost 10 meters in height as it reaches land. Tidal waves from tsunamis can inundate low-lying coastal regions, causing widespread devastation. Tsunami inundates the coastal area depend on the typology of the coastal area. Coastal characteristics, including morphology, geology, shoreline character, vegetation cover, and land use, need to be considered in the aspect of potential disaster risk that may arise from a tsunami (Maemunah, Sulaeman, and Robiana 2011). Therefore, tsunami preparedness is just one part of a comprehensive plan covering a broad range of possible local damage, community readiness, and contingency plan (UNESCO 2008).

There are three stages in disaster management: pre-disaster, disaster, and post-disaster. The activities or efforts were undertaken before a disaster result in disaster mitigation and preparedness initiatives (Rumambi, Nabila, and Bintang 2021). Preparedness is described as a sequence of efforts to anticipate disasters (Hidayati et al. 2015). Preparedness is defined in

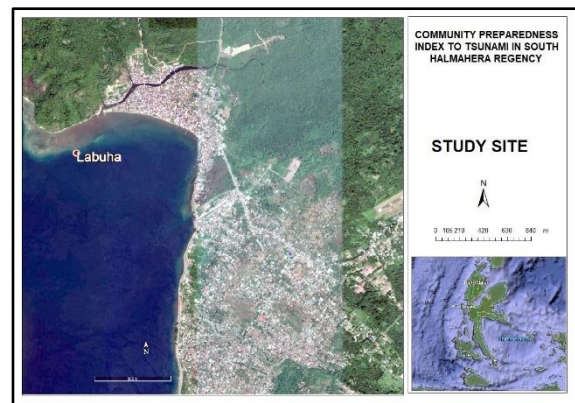
reference (UNISDR 2007) as anticipating, responding to, and recovering from anticipated hazard consequences that include planning, resource identification, warning system development, training, risk communication, public awareness and education, and exercise are all steps done to enhance the safety and efficacy of a community's reaction to a catastrophe (Said et al. 2011). Principally, preparation is the key to reducing risk before a tragedy. According to reference (LIPI-UNESCO/ISDR 2006), reduced casualties are essential for risk reduction. This can be achieved by having adequate evacuation and early warning systems. However, such facilities may be ineffective if individuals are not informed, motivated, and prepared. Low community preparedness and rising population in disaster-prone areas exacerbate disaster consequences. So, communities in tsunami-prone locations should be better prepared. Individuals and communities should be psychologically prepared for tsunamis. (Paton 2008) created a preparation model based on interactions between three variables: personal, community, and institutional. According to (Paton and Johnston 2010), a personal variable is an individual's judgment of his/her capacity to cope with calamities.

Governments and communities should work together to prepare for disasters. Community engagement is a critical component in disaster response because the local community is responsible for preparation planning and reaction (Simpson 2008). Failures of government and community functions that affect catastrophe victims. As a result, to ensure the effectiveness of all programs and initiatives dealing with tsunami danger, the community must be a primary stakeholder (Rahman 2012). For example, the National Disaster Management Authority has shifted the emphasis away from a centralized government-led strategy and toward decentralized community engagement in India. The national system might be responsible for creating planning and disaster management plans: prevention, mitigation, readiness, response, rehabilitation, or reconstruction (Husna, Alam, and Darmawati 2014). (LIPI-UNESCO/ISDR 2006) indicated that five variables impact preparedness: 1) improve emergency knowledge and attitudes in disaster preparedness, 2) regulations and procedures are implemented. 3) planning for emergency preparedness, 4) availability and reliability of disaster Early Warning Systems (EWS), 5) ability to mobilize resources: might include human resources and infrastructure that support disaster management action.

(Twigg 2015) states that disaster preparedness has two primary goals: preventing disasters and developing strategies, resources, and processes to offer appropriate aid. Twigg also considers this capability with nine catastrophe preparedness aspects. a) Vulnerability Assessment is the main point for long-term prevention and mitigation to create disaster preparedness actions. b) Commitment and guaranteed resources, it is crucial to create an agreed-upon catastrophe preparedness strategy. c) Institutional Framework, establishing a well-coordinated disaster preparedness and response system, including all stakeholders. d) Exchanging information among stakeholders. e) Resources availability including goods (food, housing, etc.) and services (search and rescue, medical, engineering, and nutrition professionals) are readily available and accessible. f) A robust communication system that is capable of successfully notifying impacted individuals. g) Respond strategies which include evacuation procedures and shelter, search and rescue teams, needs assessment teams, activation of emergency line facilities, reception centres, and shelters. h) public education and information systems spread knowledge of danger and response actions. i) Training, evaluation, and development of emergency response methods.

## Materials and Methods

The research took place in eight villages in South Halmahera Regency: Amasing Kota Barat (AKB)village, Amasing Kota Utara (AKU) village, Amasing Kota (AK) village, Labuha village, Tomori village, Mandaong village, Tembal village, and Kupal village. These places were selected for a variety of reasons. Firstly, Labuha is the capital city of South Halmahera Regency, and it is here that all human and development activities are concentrated. Secondly, such places are coastal villages that have been developed into human communities. Thirdly, the regions are earthquakes and tsunami-prone (Figure 1).



**Figure 1.** Study Site

The study adopted a descriptive survey design using a descriptive qualitative approach. Qualitative research is defined as "a method for elucidating and comprehending the meaning ascribed by people or groups to a social or human situation (Alfi et al. 2021). Interviews were conducted to obtain data and information on public and local government perceptions of disasters that occurred and to measure the disaster preparedness index. A total of 150 respondents were selected by purposive sampling to obtain accurate information from stakeholders. Respondents mainly come from community leaders, youth leaders, and housewives. The questionnaire used to measure the community's preparedness for the tsunami disaster modified based on the (LIPI-UNESCO/ISDR 2006)(Mayzarah and Batmomolin 2021) standard with the parameters of Knowledge and Attitude (KA), Emergency Response Plan (EP), Disaster Warning System (WS), and Resource Mobilization Capacity (RMC) (Table 1).

**Table 1.** Parameters and its Question

Parameter	Question
A. Knowledge and Attitude (KA)	A1. What is the meaning of natural disaster according to you? (Natural disasters are natural events that can cause damage to nature and harm humans)
	A2. In your opinion, what natural events can cause disasters around you? (Earthquake, tsunami, beach abrasion, tidal wave)
	A3. In your opinion, what caused the tsunami? (Earthquake. Landslide at Sea)
	A4. In your opinion, what are the characteristics of a tsunami? (Earthquake, Low tide, rancid smell)

	A5. What actions would you take in the event of a tsunami? (Climb to a high place, run away from the beach)
	A6. In your opinion, what kind of buildings are earthquake and tsunami resistant? (Made of lightweight material and not easily damaged)
	A7. Do you know of aftershocks after the earthquake? (Tsunamis; liquefaction, flash flood)
	A8. Do you know that your area is vulnerable to earthquakes and tsunamis?
	A9. Do you consider disaster risk in building a house?
	B1. Is there a division of tasks in rescue actions in the event of a disaster emergency?
	B2. Are maps, places, family evacuation routes and family gathering places available in the event of a tsunami?
	B3. Do any relatives/family provide temporary shelter in the event of a tsunami disaster?
	B4. Is there a first aid kit or essential medicines for first aid available?
	B5. In your opinion, what rescue actions will you take when a tsunami occurs? (Running to high places, away from the beach etc.)
	B6. Have any family members attended first aid training and/or tsunami evacuation?
B. Emergency Response Plan (EP)	B7. Is there an evacuation route in this village in case of a tsunami?
	B8. Do you know the evacuation route in this village?
	B9. How do you prepare for an emergency? (Food, drink, standby bag, lights etc.)
	B10. Are family communication devices available (HP/radio/HT)
	B11. Is there a family lighting device available in an emergency (flashlight/lamp/Genset)?
	B12. "Have you prepared your bags and disaster preparedness kits?"
	B13. Do you have significant numbers to call in an emergency (such as hospitals, police, firefighters)?"
	B14. "Is it easy for you to access these important facilities?"
	B15. "Have you ever received education and materials for tsunami preparedness?"
	B16. Have you ever participated in any public or household evacuation drills?
C. Disaster Warning System (WS)	C1. Are there traditional or local disaster warning sources available?"
	C2. Are there sources of tsunami warning information available?
	C3. Where did you get your tsunami warning information from? (TV, Radio, SMS, other sources)
	C4. Are Earthquake and Tsunami Disaster Simulations always carried out?
D. Resource Mobilization Capacity (RMC)	D1. Has any family members attended/involved in seminars/workshops/meetings/tsunami disaster preparedness training?"
	D2. Where did you find out about preparedness for a tsunami disaster

- D3. Do you have tsunami preparedness materials?"
- D4. Do your family members have skills related to disaster preparedness?"
- D5. Do you have special allocations such as funds, savings, insurance, logistics materials related to disaster preparedness?"
- D6. Are social networks (family/relatives/friends) willing to help during a tsunami emergency?"
- D7. "Has your family ever conducted an evacuation simulation or tsunami emergency response?"
- D8. Is there a family member who monitors the disaster preparedness bag?"

This evaluation used simple replies “Yes,” “No,” and “I am not sure” to determine the level of readiness, this scale measurement provided by (Bollin and Hidajat 2006). This choice was made based on feedback from respondents throughout the questionnaire's testing. Respondents who replied "Yes" are considered to be "prepared," while those who said "No" and "I ain't" are considered to be "not prepared."

Furthermore, the results of the community preparedness will be calculate using formula;  $Index = 0.45 * KA \text{ index} + 0.35 * EP \text{ index} + 0.15 * RMC \text{ index} + 0.05 * WS \text{ index}$ . Based on the index value for tsunami disaster preparedness, it is classified as very ready if the index value is  $\geq 80-100\%$ , ready category  $\geq 65-79\%$ , almost ready category  $\geq 55- 64\%$ , category less ready  $\geq 40-54\%$ , and the category not ready  $<39\%$ .(LIPI-UNESCO/ISDR 2006)(Riviwanto et al. 2021)(Mayzarah and Batmomolin 2021).

## Result and Discussion

### Respondents Characteristic

Respondents are an important key in this study. The selection of respondents was carried out purposively with the aim that this research upholds objectivity. Respondents are stakeholders in the village as well as key figures in the community. Respondent selection is differentiated by gender, age, education level, and length of stay in the village. The characteristics of respondents showed in Table 2.

**Table 2.** Characteristic of Respondents

Parameters		Frequency	%
Gender	Female	82	54.7
	Male	68	45.3
Education Level	Elementary school	5	3.3
	Yunior high school	5	3.3
	Senior high school	79	52.7
	Academy/University	61	40.7
Age	20 – 30 Years old	23	15.3
	30 – 40 Years old	49	32.7
	40 – 60 Years old	56	37.3

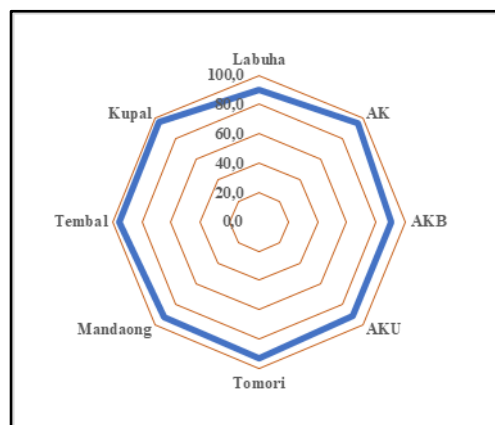
	> 60 Years old	22	14.7
Village-Length of Residence	0 -5 Years	2	1.3
	> 5 Years	148	98.7

Based on the interviewed person characteristics in table 2, most respondents are female (54.7%), and 45.3% are male. This is probably due to the fact that more women are at home as housewives than men who work a lot outside the home. Following that, those who have completed high school obtain rate 52.7%, while those who have completed college education earn of 40.7%. Most respondents are aged between 30 – 60 years old (70%), and around 15% are > 30 years old and < 60 years old. Concerning the length of residences in the village studied in the coastal area of >5 years, as 148 respondents (98.7%).

### Knowledge and Attitude Parameter (KA)

Knowledge affects their attitude and commitment to being prepared and attentive in the event of emergencies and is the primary component in individual preparation (Spahn et al. 2010) (Wegscheider et al., 2011). As a result, knowledge is a critical component and a prerequisite for preparedness (Suwaryo et al., 2021). According to the knowledge and attitude variables, most respondents in the research sites knew that both natural and human-induced destruction causes disasters. These disasters include earthquakes, tsunamis, landslides, floods, forest fires, hurricanes, and volcanic eruptions. Furthermore, respondents are aware that tsunamis can be triggered by various events, one of which is low tide. Meanwhile, many respondents indicated that they would move to higher ground in the event of a tsunami. Additionally, participants are informed that their region is prone to earthquakes and tsunamis. According to responses, recent earthquakes have happened regularly in this area, although there have been no tsunamis.

Additionally, 93.8 percent of respondents indicated that earthquake-resistant building constructions have solid foundations, are firmly buried, and are constructed of lightweight materials. As a result, the majority of respondents believed that catastrophe risk should be considered while designing a house. By and large, respondents have a working understanding of the earthquake and tsunami disasters and the appropriate steps to take as a result of television shows and social media. Respondents also gained valuable knowledge from their experiences in Aceh and Pangandaran during the disaster.



### **Figure 2. KA Index on Study Locations**

The scoring on the dimensions of disaster knowledge and attitudes at all research locations ranged from 90.0 to 96.7. This demonstrates that most responders are already aware of the earthquake and tsunami tragedy in their area. The KA index ascribed to each village is depicted in Figure 2.

The high value of the KA index is significantly affected by the respondents' education level, with more than 90% being high school and university graduates. According to (Setyaningrum and Setyorini 2020), Education at a very high level is contingent upon the preparation of the head family. The greater one's education level, the broader one's perspective becomes, making it easier to stay current on both knowledge and current events, allowing you to keep up with accessible information.

### **Emergency Response Plan (EP)**

Preparedness for disasters is any action conducted before a catastrophe that aims to build operational and practical facility response capabilities in the event of a disaster. Emergency planning is one of the critical tasks in community preparedness (Husna et al., 2014). A disaster emergency response plan is a sequence of operations carried out immediately before mitigating its impacts. These tasks include establishing an evacuation route, assembling an emergency kit, establishing communication devices, and managing the evacuation.

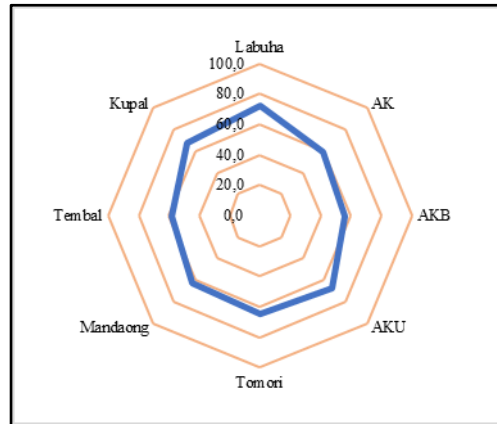
Regarding the emergency response plan, the division of tasks in the family when a disaster occurs, it turns out that around 29.2% of families have done it. The division of tasks in the family, for example, the father is responsible for carrying the necessities, and the mother is in charge of saving the children. Meanwhile, 48.5% of families answered that they already knew what to do to evacuate in the event of a tsunami but had not provided a temporary gathering place for families. Furthermore, most of the respondents (84.6%) said that their relatives or family would provide temporary shelter in the event of a disaster. This is because the sense of brotherhood and kinship between the people is very high. Furthermore, regarding the availability of evacuation route signs at the study sites, 73.1% of respondents stated that evacuation signs had been installed, but many have been damaged or removed. However, every village community in the study location already knows where to evacuate in a tsunami disaster.

Emergency preparation is still insufficient, as only 52% of respondents have vital medicines/first aid kits on hand in case of an emergency, and only 30% of respondents have first aid skills among family members. Additionally, 73% of respondents have packed a backup bag to be carried in the event of a crisis and have vital contact information on hand in an emergency. Additionally, all responders said that they have communication and illumination equipment on hand in the event of an emergency. Regrettably, just around 30% of respondents said they had attended evacuation exercises and had disaster preparedness materials in the emergency response plan.

The scoring result on the parameters of the emergency response plan at the study site got a score between 55.6 – 72.3. The highest index value was obtained in Labuha village and the lowest in



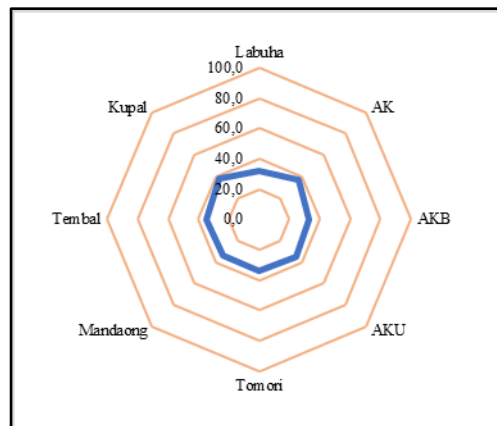
Tembal village. These results indicate that most of the community's preparedness is ready level during the emergency response (Figure 3).



**Figure 3.** EP Index on Study Locations

### Disaster Warning System (WS)

The Early Warning System is a collection of mechanisms designed to alert the public to the onset of natural catastrophes or other natural signals(Mathbor and Katrina 2006).Early warning of disasters to the public is the act of presenting information in a manner that is readily absorbed by the general population(Setyaningrum and Setyorini 2020). In general, early warning, or the dissemination of information, is expressed in crucial circumstances via sirens, gongs, etc.The public's vigilance and quick response are required due to the short amount of time from when the information is published to the moment it is acted upon.



**Figure 4.** WS Index on Study Locations

Based on the survey findings, most respondents (56%) in the research sites indicated no automated early warning system in their region. There are conventional disaster warning systems such as ringing electric poles, and others utilize technology such as speakers in places of worship.

The availability of a catastrophe warning system is also linked to tsunami warning information. Meanwhile, 49.2% of respondents stated that tsunami warning information was received through TV, radio, and social media broadcasts. However, it should be emphasized that all respondents responded that the earthquake and tsunami catastrophe simulation had been carried out but only incidentally and not regularly. The simulations carried performed did not include all individuals. The scoring of the parameters of the disaster warning system at the study site obtained a value between 31.7% - 37.5%. This shows that preparedness is still low, so that the disaster warning system needs attention (Figure 4).

### Resource Mobilization Capacity (RMC)

Resource mobilization is a critical component of preparation. According to (Setyaningrum and Setyorini 2020), effective mobilization may significantly increase readiness in the case of a disaster. Additionally, facilities and infrastructure, as well as money for support preparation, must be addressed.

In terms of the mobilization of human resources, as many as 20% of respondents have been involved in seminars, workshops, or training on disaster preparedness. However, 40.8% of respondents stated that they knew about disaster preparedness from TV broadcasts and social media, so they revealed that even though they had never been involved in disaster preparedness activities, they already knew how to save themselves in the event of a tsunami. However, only about 30% of respondents stated that they had allocated funds related to emergencies, including disasters, and 98% of respondents admitted that social networks (family/relatives/friends) were willing to help during a disaster situation. As many as 82.3% of respondents have also prepared standby bags containing essential and valuable documents to be easier to carry in the event of a disaster. The scoring result on the parameters of the disaster warning system at the study site obtained a score between 30.0% – 52.2% (Figure 5).

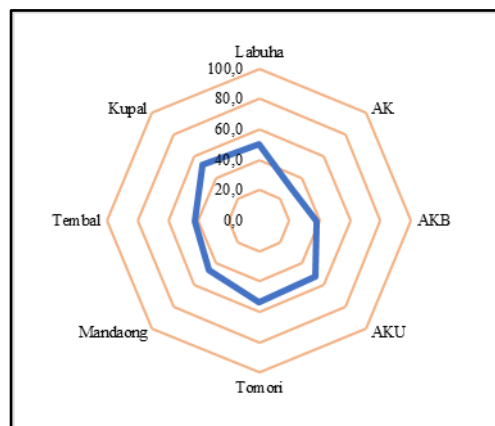
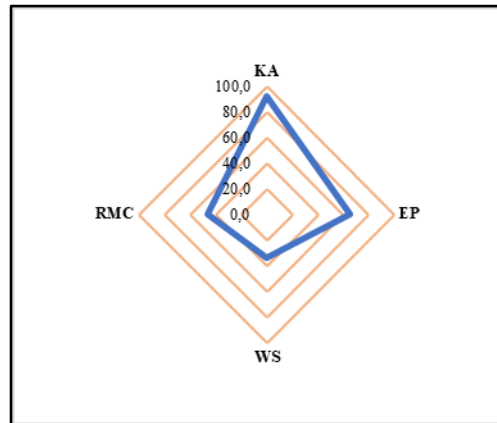


Figure 5. RMC Index on Study Locations

### Community Preparedness Index

The community preparedness index offers several advantages, both practical and research-based. It assists policymakers in planning and implementing community initiatives aimed at mitigating catastrophe risk. In the viewpoint of (Adiyoso and Kanegae 2018), the index measures social

participation, enabling crisis managers to zero in on particular areas where a community's degree of preparation might be improved. By computing the scores for all parameters, the Community Preparedness Index result is 85.2, indicating that the community in the study site is highly prepared. The community's readiness is closely monitored at the research location, with a knowledge and attitude (KA) score of 92.6 percent and an emergency response plan (EP) score of 67.5. While the warning system parameter (WS) has a value of 34.0 percent and the resource mobilization parameter (RMC) has a value of 45.9 percent, the parameters have low values (Figure 6).



**Figure 6.** Community Preparedness Index on Study Locations

According to the analysis's outcomes, the community's preparation for an earthquake and tsunami catastrophe in Labuha Village and its surroundings is the ready category. When viewed through the lens of the LIPI-UNESCO/ISDR preparedness indicators, indicators that meet the preparedness conditions in this area include community members being aware of their area's vulnerability to disasters and more than half of respondents being aware of what to do in the event of a disaster.

The community is aware that earthquakes often occur in their region, but they think the magnitude of the earthquake is not excessive, and therefore they are unsure if earthquakes that occur frequently may produce tsunamis. In light of the tsunami disaster that has never happened in this region, the community believes that the research site is not particularly susceptible to tsunami risks. According to some respondents, the beach in the Labuha Village region and its surroundings are shaped like a harbour, preventing the area from being struck by a tsunami, and there are several islands in front of the study locations. On the other hand, several items have been fully prepared by the community, including telephone numbers for critical institutions such as hospitals, fire departments, and PLN, and those who have prepared vital equipment and papers to be easily carried in the event of an emergency.

Unfortunately, there are still deficiencies that need the attention of all stakeholders, including the absence of an appropriate and conventional disaster transmission system and the lack of real-time disaster information. Additionally, disaster exercises and simulations are not planned regularly and must include all communities, and evacuation routes and signage are not visible to the public.

## Conclusion

Individual preparation in Labuha village and its surroundings for the tsunami disaster is classified as ready, with an average index score of 71.7. Several low-value categories include the emergency response plan, warning system, and resource mobilization capacity, which means that indicators for these parameters will need to be improved in the future to cope with the tsunami catastrophe. We highly suggest that local governments consider the specific conditions of each community and conduct periodic reviews of current action plans. Thus, planners will adjust the suggested overall strategy to the particular geography, special conditions, changes in the social environment, and scientific research of each town. Nonetheless, it is more people-centered, which is anticipated to mitigate the danger of a tsunami catastrophe. Additionally, it is beneficial for a community to understand its strengths and limitations when predicting tsunami risks.

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