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Message Distortion Potential of Tsunami Early Warning System in Southern Java

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Abstract - **Many tsunami events that have occurred in Indonesia have been published and also indicate the need for more adequate disaster mitigation efforts. One appropriate disaster mitigation measure is the use of an early warning system. Several studies have found that early warning systems do not work when tsunamis occur. This study aims to identify problems in the implementation of the tsunami early warning system in Indonesia from the perspective of the concept of distortion in communication messages. The research uses qualitative approaches supported by previous studies, various government regulations and supporting data from interviews with residents and tsunami early warning system managers. The research found that the potential for message distortion in communication in early warning systems is grouped into three categories. First, message distortion potential can arise from the operation of tsunami early warning system equipment. Second, message distortion may occur due to coordination in the management of the early warning system. Thirdly, message distortion may arise due to the perception of residents regarding their knowledge of the early warning system. This research recommends eliminating potential message distortion in tsunami early warning system communication by simplifying the flow of the early warning system to shorten coordination among system managers.**

Keywords: Distortion, Early Warning System, Message, Tsunami.

INTRODUCTION

The last decade has seen several devastating tsunami disasters in Indonesia, which have become crucial records for the country. The Aceh tsunami in December 2004, the Pangandaran tsunami in July 2006, the Palu, Sigi, and Donggala tsunamis followed by liquefaction in September 2017, and the Pandeglang tsunami in December 2018 have all provided important lessons for coastal residents and other stakeholders. Even today, experts are still studying various tsunami events from the past. In recent years, many studies by experts have also been published on the potential for tsunamis in southern Java. In 2013, a National Tsunami Hazard Assessment for Indonesia was conducted jointly by experts from Indonesia and Australia. The assessment mapped 273 districts in Indonesia that are at risk of tsunamis. The mapping considered factors such as the height of the tsunami, the speed of seawater to land, and the recurrence period of the tsunami.

Based on an assessment of the earthquake and tsunami potential due to the megathrust in the southern part of western Java, it was found that this zone holds a potential source of future earthquakes up to M 8.9, which could trigger more than the height of the 2004 Aceh tsunami. The arrival time of tsunami waves ranges from 15-166 minutes. The maximum tsunami wave height occurred in the Lumajang area, up to 4.5 m with a reach of up to 20 km from the coast. The predicted height of tsunami inundation with a travel time of ten minutes and the fastest travel time is estimated to occur in residential areas in Cianjur Jawa Barat, reaching 26 kilometers.

While in the Sukabumi region, it is estimated to reach 5.8 kilometers from the coast. Tsunamis in areas south of the equator tend to occur 50.5% faster than in northern areas due to an active subduction zone resulting from the meeting of the Indo-Australian and Eurasian tectonic plates in the southern region. Tsunami vulnerability in Pangandaran has also resulted in the mapping of areas whose geography can anticipate the risk of tsunami recurrence [1–7]. A Paleotsunami study of tsunami traces between the Pangandaran and Cilacap regions even identified several tsunami events that occurred hundreds of years ago and may be repeated [8].

Java is currently the most densely populated island with a high risk of tsunami disasters. Some coastal areas in Java are tourist and industrial areas. Tsunami disaster events will not only cause casualties for residents around the coast but can also paralyze industries that support the economy of the community. Therefore, with the publication of the tsunami potential in southern Java, it is necessary to study preparedness efforts, one of which is the use of tsunami early warning systems.

The Presidential Regulation 93 of 2019 concerning the Strengthening and Development of Earthquake Information Systems and Tsunami Early Warnings includes the following (a) the earthquake information system and tsunami early warning have a strategic and urgent role to anticipate and mitigate, therefore, efforts to strengthen and develop the system continuously are necessary to increase the safety of life and property of the Indonesian people from earthquakes and tsunamis. (b) to realize the nation's independence and reliability in managing and utilizing earthquake information systems and tsunami early warnings, arrangements are needed to create synergy between institutions. Local governments are required to build an adequate early warning system for the community and prepare measures to help rescue victims in situations where disaster is not avoidable [9].

Early warning as part of disaster risk reduction is certainly not only about technically accurate warnings, but it is also a tool to build a good understanding of the disaster risks, and also improve the capability of authorities and communities to react properly to early warnings. If one of these components is not fulfilled, the early warning system will not be successful as a whole [10]. Several studies on tsunami preparedness in Indonesia have found that the Indonesia-Tsunami Early Warning System (Ina-TEWS) has not been able to meet the desired expectations in minimizing the number of victims and losses caused by tsunamis.

Community preparedness for earthquakes and tsunamis is also still very low [11]. On the other hand, the rapid response carried out by InaTEWS during the Banten earthquake successfully provided tsunami early warning information to stakeholders and the community [12]. Meanwhile, in the Carita area, it was found that community awareness increased significantly after experiencing the tsunami in 2018 compared to before the tsunami in Pandeglang, West Java [13]. An article on the 2018 Palu tsunami recommended the development of disaster information technology and the revisiting of the buoy component in the tsunami early warning system [14]. However, officially the buoy system installed in Indonesian waters, including those in the Sunda Strait, has been declared missing or non-functional since 2012 [15].

The early warning system built by the government is the mainstay of citizens. Not all areas on the south coast of the island of Java have local wisdom such as the "smong" which saved many people during the 2004 tsunami [11,16]. Or if there has been a previous tsunami event in an area, residents may not know about it because the event has passed through several generations.

Tsunami Early Warning System

Indonesia has employed a tsunami early warning system (Ina-TEWS) developed by the German-Indonesian Cooperation for Tsunami Early Warning (GITEWS) project that focuses on developing procedures and mechanisms to ensure that residents in tsunami risk areas receive timely warnings and can carry out rescue efforts quickly and appropriately. Evaluations of the system have shown that Ina-TEWS has not been able to meet the desired expectations in minimizing tsunami casualties and losses [11]. One of the studies on the aftermath of the 2018 tsunami in Pandeglang found that the early warning system, which has also been equipped with sirens and tide stations since 2012, was designed to detect tsunamis caused by earthquakes. However, the system was unable to detect tsunamis that occurred caused by the 2018 eruption and avalanche of Mount Anak Krakatau [17].

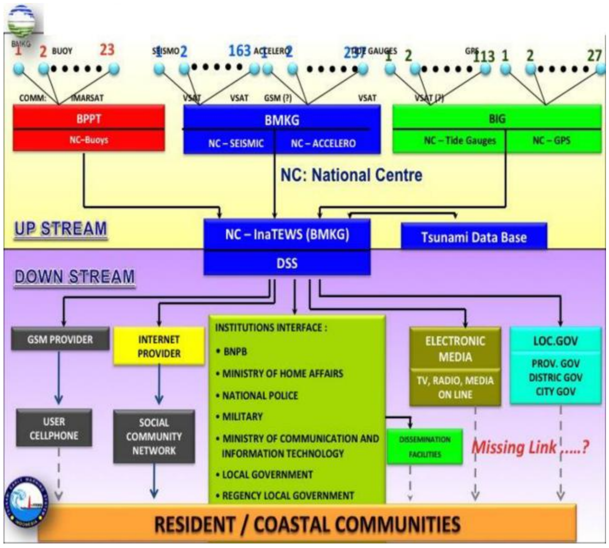
At the same time, communication systems that support disaster relief through the development of emergency mobile communication systems and rapid assessment applications to support the implementation of rapid reaction team tasks in disaster situations have also been found. The existence of innovations can also get inspiration to develop innovations [18].

Existing studies find that the high-tech of TEWS will certainly not work effectively during a tsunami if it is not fully supported by several other important aspects such as adequate communication system infrastructure, good coordination between authorized government institutions, education on the importance of tsunami early warning systems, and evacuation during a tsunami disaster [19]. On the other hand, the role of government in disaster coordination as regulatory states as stabilizers is very important. However, sometimes, the regulatory states themselves become resistors because of the bureaucratic chain and the complexity of administrative procedures that must be taken first before taking disaster management actions [20]. As stated in the Tsunami Early Warning Service Guide Book for Ina Tews issued by the Meteorology and Geophysics Agency in 2012, a tsunami can reach the coast in less than thirty minutes after an earthquake. Given the short travel time of a local tsunami and the limited time to respond, information about tsunamis should be considered as a basis for decision-making and guidance to react in sufficient time.

The communication system for early warning of forest and land fires in Riau is implemented from the level of policymakers, corporations, and civil society organizations to the community from the level of interpersonal communication and group communication [21].

In addition to the disaster early warning system built by the government, disaster preparedness technology is also needed in the form of applications that can be used by the community. For example, the Plewangan application for disaster information, apparently cannot be used optimally through Android smartphones for the people of Yogyakarta. To optimize the use of the application, it is also necessary to have supporting institutions ready to convey various information so that the application can be optimized [22].

The following chart illustrates how the Indonesia Tsunami Early Warning System (INATEWS) involves so many elements in its operation.



Source: Tsunami Early Warning Service Guide book for Ina Tews, Badan Meteorologi dan Geofisika 2012 [10]

Picture 1. End to End INA TEWS.

The system was officially institutionalized in November 2008. INA-TEWS already has a way of providing reliable data and issuing tsunami warnings.

INA-TEWS is an end-to-end early warning system. This means that the system can only work if all its components are functional. The various components of the system are 1) earthquake observation data from seismographs; 2) ocean (and land, GPS) observation data from tsunami detection technology; 3) generation of tsunami warnings and related messages/information 4) dissemination of tsunami warnings and information to communities, intermediary agencies, and local governments; 5) community preparedness that enables appropriate reactions by communities at risk to the warnings issued.

It is essential to note that, due to the short travel time of a localized tsunami and the limited time to respond, information on tsunami potential should be utilized to produce decisions and provide guidance and direction for reaction.

Based on the above configuration, the researcher attempts to criticize the following points. Local tsunami preparedness plans must take into account the restricted time for responding. As a result, such tactics should make extensive use of the most current information available. Earth tremors (if felt) are the first warning to the community. The BMKG will issue the second warning, which will include data on the earthquake and if it has the potential to generate a tsunami. This notification from the BMKG does not always provide confidence about whether or not a tsunami is approaching. However, this first notification is likely to be the final timely information that local authorities can have about the potential tsunami hazard. It is not possible to confirm warnings using natural warning indicators such as retreating seawater. The time required to initiate an evacuation is frequently insufficient, as a confirmation message can arrive up to 30 minutes after an earthquake. A two-tiered method to deciding on evacuation presents issues for community preparedness. However, it also provides a chance to lessen the frequency and severity of large-scale evacuations.

Given the short travel time of localized tsunamis and limited response time, information on tsunami potential should guide decision-making and reaction. In this study, a system has various characteristics, according to Littlejohn's system theory in Human Communication. First, the system must be open (which they are). Second, because the system's application involves an adaptation process, the system must be homeostatic or balanced. Third, the system can self-regulate or manage interactions with its surroundings. Fourth, the system must undergo feedback or reviews to ensure its functionality. Fifth, the system should be goal-oriented, and sixth, the system should be structured clearly [23].

Research on disaster early warning systems from a communication standpoint is becoming increasingly important as a good early warning system plays a critical role for the community as the party is directly confronted with the possibility of disaster. Disaster early warning systems must be researched from a communication distortion perspective because, in multiple tsunami events, the early warning system failed to save lives.

Distortion of Communication

Certain communication models contain only the bare minimum of components, that is, the sender, the recipient, and the message itself. The process of communication involves a wide range of components, some of which overlap and all of which are interrelated. This is relevant to a study on communication distortion conducted by Lemaru in the context of mass media. Lemnaru [24] identifies communication distortion as one of the aspects that influence how we perceive an event through mass media. The language employed by the media can influence how people comprehend and respond to the information they receive.

According to the research conducted by Hoken and Strik, people tend to rely on social media to learn about new scientific and technological advancements, rather than acquiring information from direct sources. As a result, there are often gaps in knowledge that lead to incorrect perceptions of technology. This highlights the importance of being cautious about the information obtained through social media and verifying it from reliable sources [25].

A research on communication distortion in interpersonal communication was carried out in the Karo culture of North Sumatra. The study focused on issues that are considered taboo in this society and discovered that communication distortions occur in scenarios such as using distance while talking, indirect communication (mediated communication), and avoiding eye contact during interactions. The community refers to these communication aberrations as "Rebu" [26].

Distortion during the message-sending process can also be analyzed in depth using specific calculations to identify the level of distortion between the transmitter and receiver. Distortions can develop and impact message recipients throughout the receiving process due to factors such as backdrop or previously acquired information. Distortion can be measured as low, medium, or high. To reduce distortion, Xiao et al. [27] proposed an encoding technique.

Shannon and Weaver developed one of the communication models that supports the studies mentioned above, which includes information, transmitter, message, destination, source, and noise. The difficulty of conveying communications might be understood in terms of accuracy. This model implies that information sources provide messages that are plausible. In addition, this model straightens out the communication process from the source to the receiver. During a conversation, the source of information is a person's brain, which transmits the message through sound produced by the speaker's mechanism, then transmitted through the air as a channel and received by the listener's brain. It's important to consider noise, which refers to any additional unwanted stimuli that can interfere with the accuracy of the message conveyed [28].

The analogy of this research can be linked to the study of COVID-19 disasters related to policy communication from the government to the community. Mal-information, misinformation, and disinformation carried out by the government in every policy aimed at citizens will only lead to uncertainty, panic, and confusion, ultimately triggering decision-making in the form of wrong attitudes and actions in the community [29]. Feedback, which illustrates how the message can be understood by the recipient, is one of the most crucial components of the communication paradigm. When it comes to early warning systems for disasters, feedback refers to how the public responds in terms of attitudes toward information in the form of knowledge and actions toward mitigation measures in the form of property and life preservation. If the noise issue is resolved, the anticipated feedback will materialize.

This circumstance is consistent with the research conducted by Perera et al. [30], which looked at issues including community reaction capacities and warning communication. Cross-cutting issues such as inadequate preparedness and response levels of FEWS, inadequate translation of disaster risk reduction (DRR) policies into action at the community level, lack of DRR knowledge and practices among key stakeholders, insufficient gender and social inclusion in all stages of FEWS, gaps in institutional communication and collaboration, and, finally, technical and financial constraints were identified with the aid of a literature review, results from a global online survey, and experiential knowledge.
Based on the above description, this study aims to identify potential distortions to communication messages in the tsunami early warning communication system. With various problems regarding tsunami early warning devices during disasters, this study is expected to provide an overview of how the disaster early warning system works so that its messages can be translated by the community to save themselves before a disaster occurs. This study aims to be an initial idea to calculate the level of distortion and offer a solution model to minimize the level of distortion in the tsunami early warning system.

RESEARCH METHOD

This research employed a descriptive analysis approach to examine the tsunami early warning system, with a specific focus on the possibility of message distortion and was conducted in 2023.Three criteria were used to identify potential distortions. Early warning systems for tsunamis might be prone to the first type of message distortion due to equipment failure. Secondly, there is a chance that the coordination of early warning system management might affect the clarity of the messages. Third, there could be a message distortion depending on how the local population perceives the early warning system.

The study strategy in this research uses descriptive qualitative methods for two main reasons. Firstly, this approach allows for more comprehensive, in-depth, and reliable data collection, including a broader understanding of social context, such as beliefs, habits, mental attitudes, and cultural practices adopted by the community or group being studied. Secondly, this approach helps to identify early warning signals by analyzing the relationships between different elements of the system, providing insight into the meaning of the object being researched [31].

Two categories of data were collected for the study. First, a review of previous studies related to the operation of tsunami early warning systems and a review of tsunami early warning system regulations issued by the government. Secondly, data was obtained from interviews with several officers who run the operation of the disaster early warning system in the field. The interviews were also a confirmation of the results of the review on the operation of the disaster early warning system, including obtaining an overview of potential communication distortions in the operation of tsunami early warning devices, both technologically and in terms of the human element (operational system managers, local government and community members in the affected areas).

RESULTS AND DISCUSSIONS

The study discovered probable distortions of communication messages in the early warning system, which were classified into three groups. First, consider probable message distortions caused by the operation of tsunami early warning system equipment. Second, there is the possibility of message distortion as a result of the coordination method used to run the early warning system. Third, the attitudes of local citizens about the early warning system may affect communication messages. The following are the findings from the analysis of these three categories.

Potential message distortion in the operation of tsunami early warning system tools.

Tsunami early warning systems should ideally be established in all coastal waters, with technological considerations such as dependability and safety. However, due to Indonesia's vast tsunami potential (around the west coast of Sumatra, the south of Java, Nusa Tenggara, and Sulawesi), installing early warning systems is a difficult undertaking. The following studies demonstrate the potential message distortions that can result from the employment of early warning system equipment in regions where tsunamis have occurred and caused casualties.

In 2018, a tsunami hit Palu, and according to local media reports, Ina-TEWS was able to detect the tsunami. However, the telephone network was paralyzed due to the previous earthquake, making it difficult to disseminate the warning effectively. In West Nusa Tenggara, early tsunami warning sirens are considered the most effective method, but their number is still limited. Additionally, Cogan Radio Communication can be triggered in the event of a disruption in the telephone signal, as described by [14].

Solihudin emphasized in his publication that the use of tsunami early warning system technology in Indonesia must consider at least two important aspects: low costs (installation and maintenance) and vandalism prevention, in addition to technical aspects such as measuring accuracy and early warning delivery speed. The National Disaster Management Agency (BNPB) has also planned to include the Indonesian National Army (TNI) in defending early warning system facilities [32]. Problems with the use of disaster early warning system tools in the Palu tsunami highlighted the lack of buoys, the limitations of early warning, and the consequences for the community, so it was suggested to develop disaster information technology and review the use of buoys [33]. Meanwhile, the Pandeglang Banten tsunami advised modifications to ensure that early warning information is disseminated using various tools. Furthermore, the use of sirens in early warning systems can be expanded to include local communities, allowing them to participate [34].

The early warning system for disasters has several components that provide information about earthquakes. These earthquakes can potentially result in tsunamis. However, this information takes time to reach the community as several phases must be passed before dissemination. Time is crucial in any crisis scenario, and adequate time is necessary for community members to evacuate following the identification of a hazardous earthquake.

A tsunami early warning system consists of numerous components, both at sea and on land. The vast area of potential tsunamis, coupled with a lack of public awareness, may lead to disruptions or disturbances in technical equipment.

The tsunami early warning system in Labuan (Teluk TPI pier) has been in place since 2012, using a sea level measurement system with a siren that continued to sound till 2017. However, when the tsunami disaster struck in 2018, this method did not work at all. In February 2019, the sensor was no longer functioning and was not connected to the siren system. BPPT also installed an offshore tsunami buoy (Inabouy) in 2006. However, BPPT labeled this tool defunct or missing due to vandalism and a lack of maintenance [32].

An interview with one of the experts (AS) who designed a buoy system at sea to monitor seismic disturbances with the potential for tsunamis revealed the following:

> *Buoys are no longer functional because many have been destroyed or lost, thus fiber optics are being used instead. Indeed, this early warning system must be regularly upgraded with cutting-edge technology that is becoming more trustworthy. The most important thing to remember is that technology has many flaws, so it is up to individuals to be aware of evacuation procedures.*

Interviews with HS residents also noted the risks of employing telecommunications equipment to support early warning systems in the case of a disaster.

> *These tools also rely on power. During a disaster, the signal may suddenly cease because telecommunications equipment is disconnected, and we typically rely on walkie-talkies*.

This opinion is consistent with a study on early warning systems in numerous tsunami-prone sites on Sibesi Island and Maina Jambu in the Sunda Strait. The remote sites made it challenging to obtain signals. Some data gaps span several hours or days. These conditions are typically caused by equipment conditioning issues that require manual reset after interference and delays from charging internet quotas to IDSL, rebooting systems, interference from server errors, interference from ongoing equipment repairs, and other communication disruptions that cause early warning communication to be severely delayed [35].

When the Palu tsunami hit, some local populations and authorities did not receive early warning signals. In almost all instances, the tsunami waves had already arrived before the early warning sirens sounded. Furthermore, the sole early warning siren that was available did not function, and communication routes were disrupted, which meant that mobile texts did not reach their intended recipients [14].

Based on the examination of publication data and interviews in this section, the author attempts to compile a list of results about the potential for communication message distortion caused by technological elements of catastrophe early warning system tools. This possibility can occur as a result of tool placement, tool quality selection, tool installation, tool maintenance, tool operation, and data reading.

By observing the elements of the early warning system, researchers obtained input from several parties to adopt the weaknesses of several tools due to signal interference due to earthquake vibrations that interfere with electrical and signal functions by using drones as support.

In addition, it can be controlled without being disrupted by telecommunications equipment or power outages during a crisis. Its movable nature will be extremely useful in locations that are difficult to access by land.

According to one of the required attributes of the system is the element of adaptation to the surrounding environment, the communication of the early warning system can certainly be different in one region from another in its operation. For example, in the Pandeglang Banten tsunami incident, the tsunami was generated by a landslip on the Krakatau volcano that was not preceded by an earthquake. Because the present equipment was incapable of detecting various circumstances, the community did not receive an early warning message.

The following discussion examines the potential message distortions that can arise from shortcomings in coordinating the management of disaster early warning systems. This is because managing tsunami early warning system equipment placed at sea, on land, and in the air necessitates some level of cooperation among diverse parties.

Potential Distortion of Communication Messages in Early Warning System Management Coordination

The operational management process for the catastrophe early warning system is lengthy, and numerous parties are responsible for running the system. The decision on whether or not there is a tsunami threat marks the end of the functioning early warning system, as does the battle against time. For coastal communities, communication and information about the tsunami alert status will continue in the next phase, which is evacuation with all of its complexity.

The next potential message distortion to be evaluated from the tsunami early warning system is related to the coordination of all authorized parties in the operation of the equipment, as well as the decision to evacuate the community when an earthquake with tsunami-causing potential happens. The early warning system must be coordinated from policymakers, corporations, and civil society organizations to the community. This flow occurs at all levels of communication, from interpersonal to public communication.

A tsunami early warning system is implemented and operated by entities at both the national and local levels. A tsunami early warning system can mitigate the negative effects of a disaster if it is based on a working analysis and communication chain in which people and agencies can successfully transform warnings into action. The community's reaction to the warning will demonstrate the success of early warning. This is consistent with Perera's findings that in the communication component, warnings, even when provided and disseminated with adequate lead time, do not always reach all those at risk. When warnings reach communities, too many people ignore them [30].

A study on natural disaster early warning system procedures shows that the Disaster Management Operations Control Center (Pusdalops PB) has the task of analyzing information and disseminating information. Its authority is to activate the InaTEWS, provide evacuation directions, direct all potential institutions and communities, and organize and supervise policy implementation. The

Meteorology, Climatology, and Geophysics Agency (BMKG) provides information to inform the decision-making process for evacuation directives issued to the general population. The decision must subsequently be communicated to the Governor and/or the Regional Leadership Conference [36].

From the results of an interview with an informant from the Regional Disaster Management Agency in Kebumen, Central Java, who monitors the potential for earthquake activity along the south coast, the explanation is as follows:

> *".... From all the information on the monitor that we see, if there is an earthquake, we must first coordinate with the Regent. Then we wait for direction from the BMKG. If it turns out that there is the potential for a tsunami then we just turn on the sirens on the beach for residents to evacuate."*

Based on the interviews, numerous phases and types of information are required to determine evacuation in the case of a tsunami. To prepare for the evacuation of citizens, many government agencies must work together. Government Regulation No. 21/2008 on the Implementation of Disaster Management clarifies the BMKG's jurisdiction. According to Article 19, paragraph (1), the BMKG is the agency authorized to present analysis results to the BNPB and BPBD for further decision-making. Following that, the Regional Disaster Management Agency (BPBD) is in charge of coordinating community rescue efforts.

Furthermore, a study conducted by the Regional Disaster Management Agency (BPBD) on the disaster early warning system in the city of Palu, which experienced three types of disasters, namely earthquakes, tsunamis, and **liquefaction**, revealed that the planning element was not optimal, as there were still programs or activities that had not reached their target. Members of the directing element have not properly comprehended the chain of command, and there are still sectoral egos, resulting in a lengthy crisis management process [37]. In line with this, it is vital to anticipate the impediment to government operations as a result of disasters. One approach is to improve local government readiness as an effective reaction to risks [38]. In line with this, Wicaksono et al. discovered that citizens' testimonies during the 2018 tsunami in Pandeglang Banten emphasized the presence of unsynchronized and delayed matters in the disaster management bureaucracy. As a result, improvements in decision-making and early warning distribution were suggested [34]. Thus, the tsunami early warning system can become more precise, rapid, and efficient.

In the next section, the discussion related to the system that can cause potential message distortion is on the community element. Since the users of the early warning system are the people directly affected by the disaster, it is necessary to identify how the community perceives the early warning system.

Potential Distortion of Communication Messages in Public Perceptions of Early Warning Systems

In efforts to ensure the safety of citizens in disaster-prone areas, the early warning system is far more than only technological equipment and the responsibility of the government. However, residents must be self-prepared and aware of the disaster risk in their area.

According to interviews with local locals, a lot of residents on the south coast in the Petanahan and Mrecong areas were aware of disaster early warning systems such as sirens, evacuation routes, and coastal signage. This is because they frequently participate in socialization programs organized by the BPBD of Kebumen District. Tourists who visited the area, however, claimed that they were unaware of the tsunami threat looming off Java's south coast.

On the other hand, a slightly different situation was found according to the results of one interview with the BPBD in Central Java, which actively socializes with residents about the potential for tsunami disasters. Although residents often receive socialization, it is necessary to repeat the definition of disaster risk, including the elements of threat and capacity. In addition, there is a problem found in the field that there are community leaders who try to influence residents not to participate in the socialization carried out by the local government.

> SG: ... *Yes, we have had opposition from some residents. We routinely conduct socialization in several areas on the South Coast. Some people encourage people not to participate in socialization. They believe that the tsunami will not come because they have been regularly performing sea alms.*

This condition can be conceptually described as follows. Beliefs about the tsunami early warning system are related to the level of understanding of the community at a certain level or related to their beliefs. Aksa [39] noted the possibility of message distortion in her book about disaster risk reduction, which includes fatalism. This perspective holds that everything that happens is God's will, even natural disasters and that people cannot modify God's provisions. This view grew stronger following the Aceh tsunami, which revealed that several mosques had survived. During the 2016 earthquake in Pidi Jaya Aceh, about 200 mosques were damaged or destroyed. This belief increased during the Aceh tsunami. Whereas in the 2016 earthquake in Pidi Jaya Aceh, almost two hundred mosques were damaged and lost [39].

To reduce confusion, it would be helpful if multi-hazard early warning systems used the same number of alarm levels for each hazard. Although the alert levels can have different thresholds in each country, the core message would remain unchanged. International organizations such as the United Nations could play a vital role in promoting such an approach in line with the Sendai Framework's multi-hazard early warning strategy [40].

Interpreting disaster early warning systems can sometimes be problematic for local communities using modern approaches, as stated in Rafliana's article. The lack of knowledge among local communities about the natural indicators of a tsunami, coupled with insufficient mitigation efforts, can increase the risk exposure and lead to loss of life during future disasters. Some societies rely on traditional environmental knowledge, which is based on social memory, passed down from generation to generation, and influenced by religious beliefs. Others rely on modern sources of knowledge, such as media and educational programs offered by schools. Warning messages and signs must be customized to meet the unique needs of the people facing the hazard. Additionally, these messages must be geographically specific to ensure that they are intended for those who are at risk. It is necessary to conduct regular studies to understand how people obtain and comprehend warning messages [41].

Based on the facts presented above, the researchers have come up with conclusions in the form of a chart on the potential distortion of communication messages in the tsunami early warning system. The horizontal part of the table depicts the division or grouping of probable message distortions into categories, while the vertical column displays the findings of which parts are detected in each category.

Tabel 1. Group of Potential Distortion

Potential Message Distortion	Tsunami Early Warning System Equipment	Operational Management of Tsunami Early Warning System.	Public Perceptions of the Tsunami Early Warning System.
Potential Distortion Elements	Quality selection, placement, installation, maintenance, and operation of early warning systems peringatan dini	The early warning system is structured with various layers of command and coordination before it reaches the community.	Community capacity to understand the early warning system.
	Inadequate toolkit resulting in inaccurate data (depth of vibration and epicenter of tsunami-potential earthquakes)	The capacity of personnel to interpret information correctly based on accurate data generated by tools in the system.	Belief in traditional information that is considered to be in conflict with modern technology.

CONCLUSIONS

A successful tsunami early warning system is one that can save lives and property during a disaster, as time is the most valuable resource during such events. To achieve this, the system needs to optimize its performance by taking a range of measures, one of which is investigating potential message distortion.

An analysis of the tsunami early warning system revealed three types of possible message distortion. Firstly, the equipment used for transmitting messages may be insufficient, of poor quality, damaged, or malfunctioning due to the earthquake that preceded the tsunami, leading to inaccurate data and issues with personnel availability. Secondly, the coordination procedures involved in determining responses to potential tsunami threats can be complex, leading to confusing messages and delays, which is problematic as time is of the essence during disasters. Finally, inadequate community understanding of the messages in the early warning system can also be a source of distortion. This may be due to local beliefs that oppose modern early warning systems or a lack of sufficient socialization. To eliminate potential message distortion in the tsunami early warning system, the study recommends several actions. Firstly, it suggests increasing the capacity of early warning equipment, both in terms of quantity and quality, and ensuring backup equipment is available. Secondly, it recommends shortening the communication coordination flow between various levels of government to speed up the delivery of messages to the community regarding evacuation actions. Thirdly, it suggests increasing community capacity for early warning systems by integrating modern technology, social and traditional aspects, and local wisdom. This will enable communities to build self-reliance and readiness to face potential disasters, making them better prepared to deal with such events.

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REFERENCES

[1] Findayani A, Utama NJ, Anwar K. Kearifan lokal dan mitigasi bencana masyarakat pantai selatan Kabupaten Cilacap. J Indones Hist 2020; 9:28–37.

[2] Horspool N, Pranantyo IR, Griffin J, Latief H, Natawidjaja D, Kongko W, Cipta A, Bustamam, Anugrah SD, Thio HK. A National tsunami hazard assessment for Indonesia. Australia Indonesia Facility for Disaster reduction; 2013.

[3] Latifah A, Supriyadi, Masykuri AF. Pemodelan tsunami pada zona megathrust pantai selatan Jawa menggunakan Community Model Interface for Tsunami (ComMIT). Unnes Phys Educ J. 2022; 11:78–87.

[4] Nainitania R, Darmawan D. Analisis zona genangan tsunami akibat gempa bumi megathrust di selatan pulau Jawa. J Ilmu Fis Dan Ter 2021;8.

[5] Riyanto AM, Muslim D, Yulianto E, Krisnabudhi A, Firmansyah F. Discerning geomorphological aspects of tsunami risk in Pangandaran, West Java, Indonesia. Ris Geol Dan Pertamb. 2023; 33:49–60. https://doi.org/http://dx.doi.org/10.55981/risetgeotam.2023.1247.

[6] Savitri AR, Julius AM, Sandi AW, Hakim FA, Widyaningrum N, Sakti SK, Widana IDKK. Pelajaran pada manajemen bencana di Jepang untuk tujuan pembangunan berkelanjutan di Indonesia. Nusantara. 2021; 8:142–57. https://doi.org/10.31604/JIPS.V8I1.2021.142-157.

[7] Widiyantoro S, Gunawan E, Muhari A, Rawlinson N, Mori J, Hanifa NR, Susilo S, Supendi P, Shiddiqi HA, Nugraha AD, Putra HE. Implications for megathrust earthquakes and tsunamis from seismic gaps south of Java Indonesia. Sci Rep. 2020; 10:15274. https://doi.org/10.1038/s41598-020-72142-z.

[8] Riyadi M, Triyono R, editors. Jejak tsunami masa lalu di antara Pangandaran dan Cilacap (Hasil riset paleotsunami). Jakarta: BMKG; 2018.

[9] Indonesia. Peraturan Presiden Republik Indonesia nomor 93 tahun 2019 tentang penguatan dan pengembangan sistem informasi gempa bumi dan peringatan dini tsunami. 2019.

[10] BMKG. Tsunami early warning service guidebook for InaTEWS. 2nd ed. Jakarta: BMKG; 2012.

[11] Kurniasih A, Marin J, Setyawan R. Belajar dari Simeulue: Memahami sistem peringatan dini tsunami di Indonesia. J Geosains Dan Teknol 2020; 3:21–30. https://doi.org/10.14710/JGT.3.1.2020.21-30.

[12] Kurniawan AA, Iskandar J, Wijaya GB. Studi simulasi numerik waktu tempuh tsunami pantai selatan Jawa Timur. Dimens Pratama Tek Sipil. 2020; 9:11–8.

[13] Sari MM, Triana D. Tingkat awareness masyarakat terhadap bencana tsunami di Kecamatan Carita, Kabupaten Pandeglang Banten. J Environ Sci 2022; 5:15–25.

[14] Sidik J, Wardana IMS, Zuhdi M, Ayub S, Syamsuddin S. Efektivitas sistem informasi Indonesia Tsunami Early Warning System (InaTEWS). GeoScienceEd. 2023; 4:26–31. https://doi.org/doi.org/10.29303/goescienceed.v4i1.219.

[15] CNN Indonesia. Antisipasi Pencurian, Buoy Dibuat Pakai Kabel di Bawah Laut. CNN Indones 2018. https://www.cnnindonesia.com/nasional/20181

225131335-20-356214/antisipasi-pencurian-buoy-dibuat-pakai-kabel-di-bawah-laut.
[16] Sari RH, Husin T, Syamsidik. Kearifan lokal Smong masyarakat Simeulue dalam kesiapsiagaan bencana 12 tahun pasca tsunami. J Ilmu Kebencanaan 2016; 3:27–32.
[17] Prasetya G, Husrin S, Kongko W, Istiyanto D, Hidayat R, Asvaliantina V, Kodijat A, Fitriyana F. The 22nd December 2018 Anak Krakatau Tsunami in Sunda Straits, Indonesia. Geophys. Res. Abstr., vol. 21, Vienna: 2019.
[18] Juhana T, Widagdo J, Widyani RN. Pengembangan sistem komunikasi seluler darurat serta aplikasi kaji cepat untuk mendukung pelaksanaan tugas Tim Reaksi Cepat pada situasi bencana. Dialog Penanggulangan Bencana 2012; 3:79–90.
[19] Dian AD. Evaluasi kinerja sistem peringatan dini tsunami di Indonesia. Indept 2014;4.
[20] Jati WR. Analisis penanggulangan bencana berbasis perspektif cultural theory. J Dialog Penanggulangan Bencana 2013; 4:1–12.
[21] Badri M, Lubis DP, Susanto D, Suharjito D. Sistem komunikasi peringatan dini pencegahan kebakaran hutan di Provinsi Riau. J Pikom 2018; 19:1–16. https://doi.org/10.31346/jpikom.v19i1.1266.
[22] Barata GK, Lestari P, Hendariningrum R. Model komunikasi untuk penanggulangan bencana gunung merapi melalui aplikasi Plewengan. J Commun Spectr 2017; 4:183–98.
[23] Littlejohn SW, Foss KA, Oetzel JG. Theories of human communication. 12th ed. Long Grove: Waveland Press; 2021.
[24] Lemnaru AC. Communication distortions and linguistic features in the journalistic style. Procedia - Soc Behav Sci 2013; 70:963–8. https://doi.org/10.1016/j.sbspro.2013.01.146.
[25] Hoeken H, Strick M. What people tell other people about new technologies: The Impact of attitudes toward the technology and trust toward the source on information distortion. vol. 15. 2021.
[26] Sebayang FAA. Communication distortion in concept of Rebu in Karonese society. J Duta Bhs 2023; 1:40–4.
[27] Xiao Y, Zhang X, Li Y, Shi G, Basar T. Rate-distortion theory for strategic semantic communication. IEEE Inf. Theory Work., Mumbai: 2022.
[28] Shannon CE, Weaver W. The Theory of mathematical communication. Urbana: The University of Illinois Press; 1964.
[29] Ridho A. Kritik dan distorsi komunikasi Pemerintah di masa Pandemi Covid-19, bagaimana seharusnya? Orasi J Dakwah Dan Komun 2022; 13:134–46.
[30] Perera D, Agnihotri J, Seidou O, Djalante R. Identifying societal challenges in flood early warning systems. Int J Disaster Risk Reduct 2020; 51:1–9. https://doi.org/10.1016/j.ijdrr.2020.101794
[31] Creswell J. Research design: qualitative, quantitative & mixed methods approaches. 2018.
[32] Solihuddin T, Salim HL, Husrin S, Daulat A, Purbani D. Dampak tsunami selat sunda desember 2018 di Provinsi Banten dan upaya mitigasinya. J Segara 2020; 16:15–28. https://doi.org/10.15578/segara.v16i1.8611.
[33] Siska, Hidayat NRW. Analisis dampak ketidakadaan buoy terhadap Badan Meterologi Klimatologi dan Geosfisika (BMKG) studi kasus tsunami Palu. Sensistek 2023; 6:266–72.
[34] Wicaksono W, Sopaheluwakan J, Desportes I. Optimizing subnational warning mechanisms: Community and practitioner perspectives on the 2018 Anak Krakatau- induced tsunami in Pandeglang, Indonesia. Int J Disaster Manag 2023; 6:209–26.
[35] Husrin S, Novianto D, Bramawanto R, Setiawan A, Nugroho D, Permana SM, Sufyan A, Sarnanda S, Sianturi DSA, Mulyadi U, Daniel D, Suhelmi IR, Purnama MSB. Analisa kinerja IDSL/PUMMA untuk peringatan dini tsunami di Pangandaran. J Kelaut Nas 2021; 16:87–98.
[36] Sanjaya SPA, Budiana IN. Implementasi kebijakan sistem peringatan dini tsunami di Provinsi Bali. Sorot 2020; 15:1–11. https://doi.org/10.31258/sorot.15.1.1-11.
[37] Ramadani AE, Lolo CS, Fitriani R, Alghifari MM, Payung A, Kurniawan AAP. Mitigasi bencana kawasan pesisir Kota Palu. Sensistek 2022; 5:61–4.
[38] Nurhabibi P, Dharmastuti A, Arida V. Kapabilitas pemerintah daerah dalam membangun kesiapsiagaan sebagai upaya pengurangan risiko bencana tsunami (Studi kasus pada wilayah pesisir Kulonprogo). J Dialog Penanggulangan Bencana 2016; 7:71–81.
[39] Aksa FI. Islamic perspectives in disaster: An alternative to changing fatalistic attitudes. Jamba J Disaster Risk Stud 2020; 12:1–4. https://doi.org/10.4102/JAMBA.V12I1.942.
[40] Neußner O. Early warning alerts for extreme natural hazard events: A review of worldwide practices. Int J Disaster Risk Reduct 2021;60. https://doi.org/10.1016/j.ijdrr.2021.102295

[41] Oktari RS, Munadi K, Ridha M. Effectiveness of dissemination and communication element of tsunami early warning system in Aceh. Procedia Econ Financ 2014; 18:136–42. https://doi.org/10.1016/s2212-5671(14)00923-x.