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RECEIVED 21 May 2025

ACCEPTED 02 October 2025

PUBLISHED 20 October 2025

CITATION

Rizal E, Winoto Y, Sugito T, Nugroho C and Septian FI (2025) Disaster communication in the digital age: a community-based case study of media, education, and local knowledge in Pangandaran, Indonesia. *Front. Commun.* 10:1632436. doi: 10.3389/fcomm.2025.1632436

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Disaster communication in the digital age: a community-based case study of media, education, and local knowledge in Pangandaran, Indonesia

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In disaster-prone regions such as Pangandaran Regency, Indonesia, effective communication is essential for mitigating risk and enhancing community preparedness. This study examines how digital media, disaster education, and localized communication strategies contribute to developing disaster mitigation information literacy and resilient community behaviors. Using a qualitative case study approach, researchers collected data through 10 semi-structured interviews and a focus group discussion involving key stakeholders, including disaster response officers, educators, community leaders, and local volunteers. Thematic analysis explored perceptions, barriers, and practices related to disaster communication and preparedness. Supplementary field observations and document reviews supported triangulation. Findings reveal that digital platforms like WhatsApp and Facebook have become central channels for risk information dissemination. However, they also present challenges due to misinformation, connectivity gaps, and limited institutional presence online. Traditional warning systems, such as sirens and signage, are deteriorating due to maintenance issues, further complicating message delivery. In contrast, informal networks, local knowledge, and school-based disaster education initiatives have significantly shaped public understanding and response behavior. The study highlights a disconnect between formal communication infrastructures and community-based practices, revealing a need to integrate digital media with culturally rooted communication models. This research offers a novel contribution by bridging modern digital tools, formal education efforts, and indigenous knowledge in one framework—an integrative approach largely absent in previous disaster communication studies. Trust-building, media literacy, and familiar community intermediaries emerge as critical for improving disaster communication efficacy. Communication strategies must embrace a multi-channel, participatory, and culturally adaptive approach to strengthen coastal communities' disaster mitigation literacy and preparedness. Bridging digital and traditional knowledge systems is key to fostering community resilience in the face of increasingly complex disaster risks.

KEYWORDS

community resilience, disaster communication, disaster literacy, local knowledge, mitigation preparedness

Introduction

Disasters are events that are very close to the people of Indonesia. These events threaten and disrupt lives, the environment, and cultural heritage that usually function within a balanced socio-ecological system. The phenomenon is attributed to a combination of natural and anthropogenic forces, leading to the detrimental consequences of fatalities and property damage. Thus far, the government's disaster management endeavors to mitigate risk have not been completely executed, as communities often remain underprepared due to limited access to preparedness training and risk communication (Kitagawa, 2015; Septikasari and Ayriza, 2018). This phenomenon shows that Indonesia, located along the Pacific Ring of Fire—a major tectonic subduction zone, still has several problems, such as low performance in disaster management and attention to disaster risk reduction (Cazabat et al., 2023). The Indonesian government and society face a formidable task in establishing a secure living environment for individuals in disaster-prone regions. By enhancing disaster management programs, particularly for volcanic and seismic hazards, effective monitoring and preparedness programs can reduce disaster risk through improved communication systems and community preparedness plans (Andreastuti et al., 2019; Suparji et al., 2022).

Geographically, Pangandaran Regency consists of sea, mountains, and forests. Based on these geographical characteristics, the potential for natural disasters in this region are tsunamis, earthquakes, land shifts, landslides, floods, and typhoons. According to the Regional Disaster Management Agency (BPBD) of Pangandaran Regency, this region is ranked 11th in the West Java region in the risk of natural disasters. Data in 2021 recorded 105 natural disasters. Based on data from the Regional Disaster Management Agency (BPBD) of Pangandaran Regency in 2021, there are 10 sub-districts that have the highest disaster risk. The 10 sub-districts are Cijulang, Cimerak, Parigi, Cigugur, Langkap lancar, Sidamulih, Pangandaran, Kalipucang, Padoherang, Mangunjaya (BPBD Pangandaran, 2022).

Based on historical records owned by the Regional Disaster Management Agency (BPBD), tsunami disasters that have occurred in Pangandaran Regency are (a) March 28, 1871 (b) July 17, 2006, with a magnitude of 6.8 on the Richter scale (c) December 15, 2017, with a magnitude of 6.5 on the Richter scale, and (d) September 11, 2021 with a magnitude of 7.5 on the Richter scale (BPBD Pangandaran, 2022). In addition, Pangandaran Regency has a high potential for hurricanes. Based on data from BPBD Pangandaran Regency from 2017 to 2019, typhoons occurred 131 times in 2017, 166 times in 2018, and 29 times in 2019 until mid-July 2019. The most vulnerable areas for hurricanes are Prigi, Cigugur, and Kalipucang sub-districts.

Based on data in 2018 from 10 sub-districts affected by disasters, facilities and infrastructure that were damaged either severely, moderately or lightly reached 220 buildings consisting of houses, offices, schools, and others. From this damage, it can be estimated that the loss reached Rp. 6,157,300,000. The biggest loss was the human casualties of 632 people. This data illustrates that natural disasters can cause enormous losses, both in property and lives. Mass disasters such as hurricanes and tsunamis, landslides, land shifts, floods, as well as local disasters such as fires, must be a common concern in prevention and mitigation.

According to established definitions of disaster (Andreastuti et al., 2023; McFarlane and Norris, 2006; Rahiem and Widiastuti, 2020) disasters involve occurrences that can result in harm and even fatality.

Volcanic eruptions are widely regarded as the most perilous natural calamities of all. Volcanic eruptions generate cascading hazards (e.g., earthquakes, tsunamis, and ashfall) with immediate and long-term social and environmental impacts. Due to heightened levels of aerosols in the Earth's atmosphere, volcanic eruptions can also give rise to further calamities, such as volcanic earthquakes, tsunamis, and alterations in weather and climate (Kozák and Čermák, 2010; Malawani et al., 2021). Meanwhile, according to Indonesian Law No. 24 of 2007 disaster management refers to dealing with events or a sequence of events that pose a threat and cause disruption to people's lives and livelihoods (Law of the Republic of Indonesia Number 24 of 2007 Concerning Disaster Management, 2007). These events can be caused by natural, non-natural, or human factors, resulting in casualties, environmental damage, property loss, and psychological impact. Disasters are either caused by natural phenomena or by humans and will become disasters if they negatively affect the form of losses to the surrounding community (Maryani, 2021; Suarmika et al., 2022).

Several stakeholders must address the frequent calamities in West Java, including earthquakes, tsunamis, and landslides, to mitigate the detrimental effects and minimize the resulting losses. One way to enhance community preparation is to augment disaster information literacy (Kılınç İşleyen et al., 2025; Sultan et al., 2024). Disaster literacy, also known as community awareness initiatives in response to a disaster, is crucial for the community and alleviating a catastrophe. The disaster information literacy factor is categorized into four components: identifying the origin of disaster information, assessing the credibility of disaster information, arranging disaster information, and effectively utilizing and communicating disaster information (Ayuningtyas et al., 2021; Hansson et al., 2020; Spiekermann et al., 2015). As for disaster mitigation literacy, it is an understanding of the precautions and preparations to reduce the risks and impacts of natural or human disasters. Disaster mitigation literacy involves understanding the types of disasters, the factors that cause disasters, and ways to minimize the effects on humans and the environment (Logayah et al., 2024; Ramli et al., 2025).

By strengthening disaster literacy, the community is hoped to be more prepared and responsive to disaster threats. In addition, this model can also enhance social awareness and solidarity among communities when facing the threat of disasters. By strengthening disaster mitigation literacy, the community will have sufficient knowledge and skills to deal with natural disasters and reduce the risks and impacts of these disasters (Kınık and Çalışkan, 2024; Torani et al., 2019). Strengthening disaster mitigation literacy is a process that improves people's knowledge and skills in dealing with disasters, which is essential considering that natural disasters can occur anytime and anywhere and can significantly impact the community's life and sustainability.

The importance of strengthening disaster mitigation information literacy in communities in Indonesia, given that Indonesia is a country surrounded by the meeting of the world's three (3) main tectonic plates, namely the Eurasian plate, the Indo-Australian plate and the Pacific Plate (Kasman and Triokmen, 2021; Katili, 1973; Sultan et al., 2021). This condition causes several areas directly facing the zone to be very vulnerable to earthquake and tsunami disasters, including the southern areas in West Java Province such as Pangandaran Regency, southern Tasikmalaya Regency and southern Garut Regency (Horspool et al., 2014;

Minarno et al., 2025; Syamsidik et al., 2020) Therefore, in fostering disaster mitigation information literacy in surrounding communities, especially those prone to natural disasters, it is always necessary to strengthen disaster mitigation information literacy.

The coastal area of Garut Regency has never experienced a natural disaster in the form of an earthquake followed by a tsunami (Rianawati et al., 2017), but the potential for a tsunami event to occur in this region is quite large considering that other areas facing the Indo-Australian megathrust have experienced several earthquakes followed by tsunamis (Jumadi et al., 2025; Widiyantoro et al., 2020). From 1992 to 2006, there were several earthquakes followed by tsunamis triggered by this Megathrust, including the Flores tsunami, East Nusa Tenggara in 1992, the Banyuwangi tsunami, East Java, in 1994 (M 7.2), and the Pangandaran tsunami (M 7.7), West Java in 2006 (Purnama et al., 2025). The Pangandaran Regency area, on July 17, 2006, experienced a severe earthquake disaster with a scale of around 7.7. Richter scale has devastated almost the entire coastal area of Pangandaran, including the southern region of Tasikmalaya, such as Cipatujah Beach, and several other coastal areas along the southern coastal area of Tasikmalaya Regency (Kumoro, 2023; Mardiatno et al., 2020).

To deal with various potential natural disasters such as earthquakes and tsunamis that will always occur at any time, the communities in the coastal areas of Pangandaran Regency, the southern region of Tasikmalaya Regency, and the south region of Garut Regency need disaster preparedness so that in turn they will be able to create disaster resilient communities. One of the efforts to develop this preparedness must be done by strengthening disaster mitigation information literacy, including education and the use of social media (Seneviratne et al., 2024). Disaster education and social media use are complementary activities in efforts to strengthen disaster mitigation information literacy (Maulana et al., 2025). Disaster education provides the knowledge and skills needed to deal with disasters, while social media provides a platform for rapid and widespread dissemination of information and education (Batu et al., 2024; Nasliati et al., 2025).

The earthquake and tsunami that struck Pangandaran Regency on July 17, 2006, resulted in significant devastation and highlighted the urgent need for effective disaster communication and community preparedness strategies. Multiple international studies have examined this event as a critical case in understanding localized disaster response and community resilience. Bisri (2011), using the US-IOTWSP framework, assessed Pangandaran Village's resilience levels across various indicators such as governance, risk knowledge, and early warning systems, aligning with the argument that resilience-building must extend beyond structural interventions and incorporate socio-cultural and educational components (Bisri, 2011). Damayani et al. (2022) demonstrated the essential role of local wisdom in disaster mitigation literacy among indigenous Pangandaran communities. Their study emphasized that cultural knowledge, such as traditional signs of impending tsunamis, enhances public understanding when integrated into formal education and simulation drills (Damayani et al., 2022). Complementing this, Rusmana et al. (2024) examined the challenges of community-based disaster mitigation in Pangandaran. They found that although institutional collaboration exists, sustainability issues—such as lack of funding, maintenance, and stakeholder commitment—hinder long-term impact.

These findings underline that enhancing disaster information literacy and fostering resilient communities in coastal regions like Pangandaran requires a synergy between traditional knowledge systems, communication infrastructure, and participatory governance (Rusmana et al., 2024). However, despite many studies focusing on community resilience and indigenous knowledge, few have explicitly analyzed the strategic role of disaster communication and media—particularly the combined use of digital platforms, formal disaster education, and local wisdom—in strengthening disaster mitigation literacy. This study addresses that gap by examining communication strategies as a critical bridge between awareness, preparedness, and community resilience. By integrating digital communication tools, school-based disaster education activities, and indigenous knowledge into one analytical framework, our study provides a novel perspective on disaster preparedness. This is one of Indonesia's first qualitative case studies to explicitly connect these three elements, highlighting how modern and traditional systems can complement each other in building disaster-resilient communities (Figure 1).

This study addresses that gap by examining communication strategies as a critical bridge between awareness, preparedness, and community resilience. In the study, the communication strategy of strengthening disaster mitigation information literacy is limited to disaster education activities and communication media. This strategy is expected to increase community preparedness for disasters, which can create a resilient disaster community. The definition of disaster preparedness is an approach that aims to improve the ability and resilience of communities in facing disasters. Meanwhile, a disaster-resilient community is the ability of a community or society to respond to, manage, and recover from various natural and artificial disasters. This study aims to determine the strategy for strengthening disaster mitigation information literacy through disaster education activities and the use of media in creating disaster-resilient communities. It was conducted in Pangandaran Regency, West Java.

Literature review

Disaster communication

Effective disaster communication reduces vulnerability and enhances societal resilience before, during, and after hazardous events. Empirical studies confirm this; for example, Houston et al. (2015) show that multi-channel risk communication improved evacuation compliance during U.S. flood events. Communication in disaster contexts serves not only to inform but also to influence behavior, shape public perception, and facilitate coordinated action (Erokhin and Komendantova, 2024; Nazli, 2024). Houston et al. (2015) emphasize that crisis communication must operate through a multi-channel framework, combining traditional mass media (e.g., radio, television), digital platforms (e.g., WhatsApp, Facebook, Twitter), and localized interpersonal networks to ensure that critical information reaches segmented and diverse audiences (Houston et al., 2015). This model reflects a broader systems-based view of communication, where redundancy across channels mitigates the risk of information loss due to infrastructure failure or audience exclusion.

Crisis and risk communication theory deepens this understanding by outlining communication across five stages: pre-crisis, initial event, maintenance, resolution, and evaluation (Herovic et al., 2020). In the

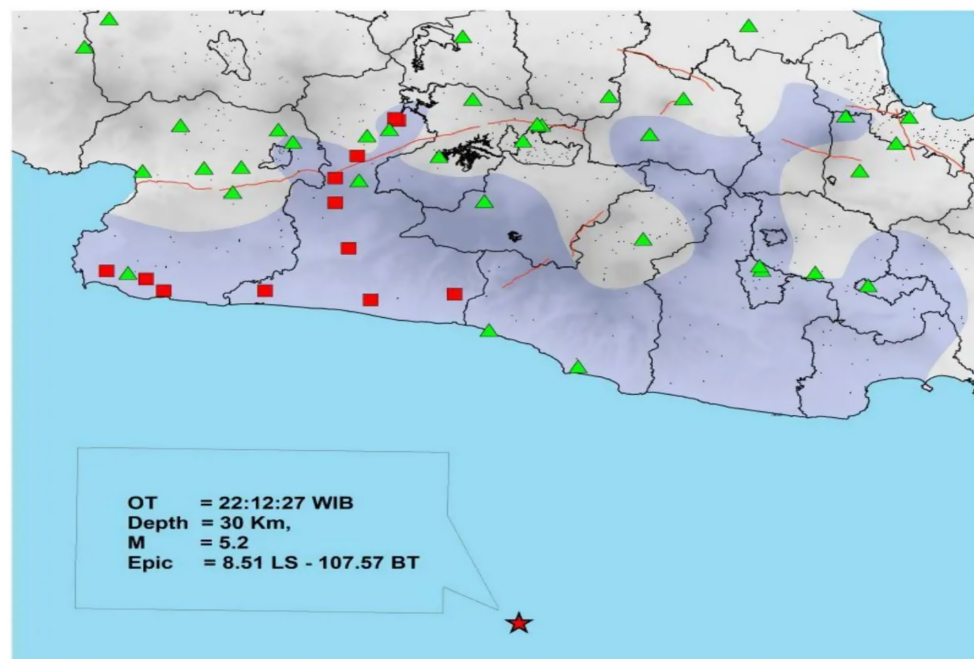


FIGURE 1
Isoseismic map of the Pangandaran Earthquake—1 March 2022. Source: BMKG. (Meteorology, Climatology and Geophysics Agency) (2022).

pre-crisis stage, building public trust, cultivating institutional credibility, and educating citizens is central to achieving risk-aware communities (Salley et al., 2025; Sellnow and Seeger, 2020). These stages are not merely chronological but cyclical, requiring continuous engagement and adaptation. In disaster-prone areas like coastal Indonesia, this trust-building is particularly critical, as rapid-onset events such as tsunamis demand instantaneous response, leaving no margin for interpretive delay or confusion. Contemporary disaster research further highlights the superiority of two-way communication models over traditional top-down paradigms. See Kapucu (2008), Palttala et al. (2025), and Miller et al. (2025), all of which show that participatory, two-way communication models increase trust and preparedness.

The inter-organizational communication networks—comprising governmental agencies, NGOs, media institutions, and local community organizations—enable more responsive and adaptive crisis management by fostering collaborative decision-making and real-time information exchange (Kapucu, 2008; Miller et al., 2025). This cooperative structure supports horizontal diffusion of knowledge, reducing the bottlenecks often associated with centralized command-and-control models. Similarly, caution against overly technical language, one-way alerts, and unclear messages, which may hinder public comprehension and fail to incite protective behaviors (Palttala et al., 2025). This challenge is especially pronounced in coastal settings vulnerable to tsunamis, where even seconds of confusion or misinterpretation can lead to devastating consequences (Fearnley, 2020).

The digital transformation of society has further reshaped the disaster communication landscape. Mobile-based applications and social media platforms now serve as primary information sources and participatory spaces (Nugroho, 2020). Studies show that platforms like Twitter and Facebook enable decentralized communication where users co-create, validate, and disseminate disaster information,

accelerating the viral spread of warnings, survivor updates, and coordination appeals (Alexander, 2014; Marx and Cheong, 2023). These platforms also foster “backchannel communication,” where unofficial narratives may compete with, contradict, or complement formal communications (Peters and Wong, 2014; Vieweg et al., 2010). However, this democratization of communication is not without its risks. As Takahashi et al. (2015) illustrate during the Great East Japan Earthquake, misinformation, disinformation, and rumor propagation can emerge rapidly, complicating the information environment and exacerbating public anxiety, which presents a paradox: while digital media empowers rapid community engagement, it simultaneously requires robust mechanisms for content verification, authoritative presence, and rumor management (Takahashi et al., 2015).

In summary, disaster communication is most effective when it adopts a holistic, adaptive, and inclusive approach—anchored in trust, clarity, accessibility, and interactivity. The shift from linear, top-down messaging to dynamic, participatory communication reflects a broader theoretical evolution in disaster risk reduction (Chirwa, 2023). Effective strategies must consider the message, medium, and socio-cultural and technological context in which communication occurs. In areas like Pangandaran, where historical trauma from past disasters persists and digital adoption is uneven, integrating disaster communication theory into practice means tailoring strategies that bridge formal systems with grassroots knowledge and technological channels with human relationships.

Disaster literacy and resilient community

Disaster literacy refers to an individual’s ability to access, understand, evaluate, and apply disaster information to make sensible decisions during disaster mitigation, preparation, response, and

recovery (Genc et al., 2022; Zhang et al., 2024). Enhancing disaster literacy involves cognitive understanding and practical readiness, such as knowing evacuation routes or assembling emergency kits (Yates and Partridge, 2014). Education systems, community outreach, and cultural practices shape literacy, which has significantly impacted long-term preparedness. School-based disaster education in Japan and Nepal has been shown to not only improve student knowledge but also influence family preparedness behaviors, thereby extending risk awareness beyond the classroom (Shaw et al., 2004).

Studies in Indonesia support this approach. Study from Triyanto and Syamsi (2021) reveals that optimizing the School Literacy Movement (GLS) toward disaster literacy can significantly enhance public understanding, preparedness, and risk reduction through a structured approach involving habituation, development, and learning activities. It also emphasizes that family engagement and the use of digital technology are critical in strengthening disaster literacy by contextualizing knowledge and enabling fast, accurate access to disaster-related information (Triyanto and Syamsi, 2021). Oktari et al. (2018) highlights the highlights that strengthening school-community collaborative networks significantly contributes to enhancing community resilience by positioning schools as key actors in disaster preparedness and risk reduction in tsunami-prone areas (Oktari et al., 2018). Desilia et al. (2023) underscores that integrating disaster education into school curricula is crucial for fostering student resilience and preparedness in Indonesia, yet its implementation remains inconsistent and heavily reliant on individual school initiative, highlighting the need for systemic policy support (Desilia et al., 2023).

Meanwhile, da Silva et al. (2023) criticize the lack of integration between local knowledge and formal education systems, arguing that community risk awareness is often dismissed or underutilized (da Silva et al., 2023). More recent studies caution that without continuous reinforcement, much of this knowledge may fade over time, creating what (Zhuo et al., 2024) describe as a 'retention gap'. A disaster-resilient community encompasses not only preparedness and adaptive capacity but also the ability to recover and transform in adversity. According to Liu et al. (2022), resilience is a function of social capital, infrastructure, governance, and communication. There are four adaptive capacities of resilience: economic development, social capital, information and communication, and community competence (Pasca et al., 2023; Kusumasari, 2015). These capacities are enhanced through local institutions, participatory governance, and inclusive planning. In the case of Pangandaran, for example, FKDM groups and religious gatherings have been used as platforms for disaster communication and organizing drills (Damayani et al., 2022).

The literature reviewed above demonstrates the importance of disaster communication, literacy, and community resilience in disaster-prone regions. Studies highlight the role of disaster education (Oktari et al., 2018; Desilia et al., 2023), the influence of social media in crisis communication (Alexander, 2014; Erokhin and Komendantova, 2024), and the enduring value of local knowledge systems in shaping preparedness behaviors (Damayani et al., 2022; da Silva et al., 2023). However, existing research tends to examine these elements separately. Few studies explicitly analyze how digital media, formal disaster education, and indigenous/local wisdom can be integrated into a coherent communication strategy for building disaster mitigation literacy. This gap is particularly relevant in the case of Pangandaran, where communities face recurrent multi-hazard

risks but possess rich local knowledge and ongoing exposure to education and digital tools. To address this gap, our study is guided by the following research questions: (1) How do digital media, disaster education, and local knowledge influence disaster mitigation literacy in Pangandaran? (2) What communication strategies and stakeholder roles most effectively foster community preparedness and resilience?

Study area: Pangandaran Regency, geographic, and demographic features

Pangandaran Regency is located on the southern coast of West Java Province, Indonesia, bordering the Indian Ocean. Geographically, the regency covers 1,010.92 km² and comprises 10 sub-districts with a population of approximately 430,000 residents (BPS Pangandaran, 2023). The economy is strongly oriented toward tourism, fisheries, and agriculture, making livelihoods and infrastructure highly vulnerable to natural hazards. The regency combines low-lying coastal zones with upland areas of hills and forests. Its coastline stretches over 91 kilometers, including popular tourist beaches such as Pangandaran Beach, Batu Karas, and Madasari. Settlements are concentrated along the coastal plain, often within a few hundred meters of the shoreline. This geographic concentration of people and assets near the ocean increases vulnerability to tsunamis and storm surges.

Pangandaran is among the most hazard-prone districts in West Java: (1) Earthquakes and Tsunamis: Pangandaran has a high seismic risk and is located along the Indo-Australian subduction zone. Historical records note major tsunamis in 1871 and 1921, most notably on 17 July 2006, when an earthquake with a magnitude 7.7 undersea triggered waves up to 8 meters high. The 2006 tsunami caused over 600 fatalities, destroyed 1,973 houses, and displaced more than 23,000 people (BNPB, 2007). On 1 February 2022, another earthquake occurred in the Pangandaran region with a magnitude of M 5.2 with isoseismic distribution as shown in Figure 1. (2) Tropical Storms and Hurricanes: The region frequently experiences strong winds and coastal storms. BPBD records show 131 storm events in 2017, 166 in 2018, and dozens more annually, damaging hundreds of homes. (3) Landslides and Flooding: Upland areas face recurrent landslides during the rainy season. Flooding also occurs along lowland rivers, compounding risks for inland communities. (4) Multi-Hazard Environment: This combination of seismic, hydrometeorological, and geological hazards creates a multi-hazard landscape where residents must prepare for diverse threats.

Research methods

This research adopts a qualitative approach with a case study design to explore the communication strategy for strengthening disaster mitigation information literacy in Pangandaran Regency. The case study approach is particularly appropriate for in-depth exploration of complex social phenomena within their real-life context (Creswell, 2015; Yin, 2006). Case study is appropriate when investigating contemporary phenomena within real-life contexts where the researcher has little control over events (Denzin and Lincoln, 2009; Nugroho et al., 2024). This method enables the researcher to gain a nuanced understanding of the interplay between

disaster communication, institutional engagement, and community responses in a region with a historical vulnerability to tsunamis and earthquakes.

Primary data were collected through semi-structured interviews and a focus group discussion (FGD). This research's primary unit of analysis is the community-based disaster communication system in Pangandaran Regency, West Java. The study examines how disaster mitigation information literacy is constructed, conveyed, and internalized at the grassroots level through formal institutional efforts and informal community engagement. Conducted from May 2023 to early 2024, the fieldwork captures a dynamic picture of seasonal preparedness activities and institutional communication patterns. The FGD was conducted in Masawah Village, Pangandaran, on June 14, 2023, and provided rich insights into community experiences, perceptions, and suggestions related to disaster education and communication.

The interviews were conducted using an open-ended guide, allowing participants to freely express their experiences, perspectives, and knowledge (Agwenda and Yesicha, 2024). Thematic saturation was achieved after conducting 10 in-depth interviews. All sessions were audio recorded (with consent), transcribed verbatim, and analyzed thematically to identify recurring patterns, insights, and divergences. Key participants include 10 individuals selected through purposive sampling, each holding strategic roles in disaster preparedness efforts. As described in Table 1, research participants are FKDM representatives with firsthand experience in tsunami evacuation simulations (INF1, INF2), a village head who oversees community mitigation protocols (INF3), and BPBD infrastructure technicians responsible for early warning systems (INF4, INF10). Also included are a school-based disaster educator (INF5), youth leaders and religious figures supporting public awareness (INF7, INF8), and a coastal tourism operator who balances safety messaging with economic concerns (INF9).

All informants were selected using purposive sampling based on their roles and experiences with disaster preparedness, communication, and community outreach. Ethical clearance for the study was obtained from the institutional research ethics committee. Participation was voluntary, and all informants provided informed consent. These diverse perspectives—gathered through semi-structured interviews and a focus group discussion in Masawah Village—form a comprehensive narrative of how communication

systems operate and adapt within the sociocultural and institutional landscape of Pangandaran. The unit of analysis thus enables a contextual exploration of disaster literacy as both a communication process and a resilience outcome.

This study was approved and acknowledged by the Faculty of Communication Science, Universitas Padjadjaran, as indicated in the official Letter of Acknowledgement No. 5253/UN6.K.1/PT.00/2025, signed by the Vice Dean for Learning, Student Affairs and Research. The research was conducted by institutional ethical standards and involved adult participants in public, non-clinical settings, with no collection of sensitive personal data. Verbal informed consent was obtained from all participants before their involvement in interviews and focus group discussions. Participants were informed about the purpose of the study, the voluntary nature of participation, and their right to withdraw at any time. As no specific consent procedure was mandated for this type of research, the Letter of Acknowledgement serves as formal institutional approval. Both the original and English translations of the document have been provided to the journal's editorial office for reference.

Data analysis was carried out using thematic analysis. This involved familiarization with the transcripts, coding of key themes, and synthesis into broader analytical categories aligned with the study objectives. Coding was performed manually to ensure a contextual understanding of each quote. This methodological design ensures a grounded understanding of how communication and education practices influence disaster mitigation literacy and preparedness in a real-world setting vulnerable to seismic hazards.

Results and discussion

Community knowledge and role of government program in disaster risk

Residents of Pangandaran demonstrated a high level of awareness regarding coastal hazards, particularly tsunamis, a risk rooted in recent traumatic experiences. Community informants frequently invoked local indicators and shared traditional knowledge to describe tsunami warning signs. For example, an Community Early Awareness Forum (FKDM) volunteer explained that a respected local observer known as “Pak Wahid” could predict a tsunami by subtle clues: “He

TABLE 1 Research participants.

No	Informant code	Description	Affiliation/role
1	INF1	Community leader and tsunami survivor	Local FKDM representative
2	INF2	Disaster preparedness volunteer	Member of FKDM Pangandaran
3	INF3	Head of village-based mitigation group	Grassroots community leader
4	INF4	Infrastructure staff in disaster response	Technical advisor, BPBD
5	INF5	School disaster education trainer	Local elementary school teacher
6	INF6	Tsunami evacuation route coordinator	District safety and evacuation task force
7	INF7	Youth leader in disaster awareness	Community youth representative
8	INF8	Representative from local religious group	Leader of religious-based outreach
9	INF9	Tourism sector representative	Hotel manager, Pangandaran coastal area
10	INF10	Early warning system technician	BPBD technical support staff

Source: Authors' field data, 2023.

knows the signs of a coming tsunami...he already sensed that 'there will be water arriving'...the salty 'anyir' smell, and animals acting noisy" (INF1). Such vernacular observations – falling water levels, odd animal behavior, unusual smells – mirror scientific early-warning cues and suggest that Indigenous wisdom has been integrated into collective understanding. Informants also pointed to widely taught rules of thumb.

One official described the well-known "20-s, 20-min, 20-meter" guideline: "If an earthquake lasts 20 s, automatically within 20 min everyone must climb 20 meters up" (INF1). This articulation of the "20–20–20" rule indicates that many residents have internalized formal evacuation protocols through drills and outreach. Nonetheless, awareness did not equate to calm confidence. During drills and real quakes, the panic was still evident. A community leader noted that despite repeated training, "when an alarm sounds, everyone panics and runs... Although they have been trained, trauma remains; when an earthquake happens, everyone's motorcycles are already facing the road, ready to flee" (INF3). In other words, even well-informed villagers can revert to flight in a crisis. Informants confirmed that traumatic memories of past events (especially the 2006 tsunami) continue to influence behavior. One FKDM member remarked that community members who directly experienced the tsunami are better able to suppress panic, whereas others "still often panic during an earthquake" (INF3).

This finding aligns with disaster psychology literature: lived experience increases perceived susceptibility and emotional stress when a warning is given. Outside of tsunami risk, other hazards were acknowledged but received less community attention. Officials noted landslides and flooding in higher elevations, but public discussion was rare. An emergency manager described measures to counter hillside slides by diverting stormwater, "we control it so that the cracked soil does not get soaked and collapse" (INF2). However, this technical strategy was not echoed by community members in the FGD, suggesting landslide risk is less salient for the general public. A focus-group participant briefly noted that drought and flooding are also concerns, emphasizing a multi-hazard context: "Disasters here include drought and floods... those need to be considered too" (INF1). In sum, while tsunami awareness is widespread and reinforced through formal drills and oral tradition, knowledge of non-coastal hazards is emerging but weaker. This uneven risk perception indicates the need for broadened education beyond the high-profile tsunami threat.

These findings are consistent with prior studies in the region. For example, Damayani et al. (2022) observed that local wisdom in Pangandaran significantly shapes community disaster literacy. Likewise, FKDM and government programs were found to improve preparedness. Our data corroborate that awareness campaigns (signage, simulations) and indigenous knowledge underpin a relatively high local hazard literacy. However, psychological aftereffects of past disasters also temper the community's confidence and response behaviors.

Government agencies and community institutions play a central role in Pangandaran's disaster mitigation strategy. The regional disaster agency (BPBD) and the FKDM (community preparedness forum) jointly deliver most formal interventions. Officials reported a variety of government-initiated programs to build infrastructure and capacity. For instance, BPBD and partners have erected physical mitigation features in critical areas: "We have built a big tsunami hazard sign near the Madasari park with evacuation steps. Some other

places wanted to remove the sign saying it would frighten tourists, but Alhamdulillah Madasari accepted it for our collective safety" (INF1). In this way, BPBD has installed warning signposts and evacuation-route markers in hazard zones. Planned projects also include hill-top refuges (TES/TEA) of at least 20 meters height, and road improvements to ensure access. One official noted the impact of improved infrastructure: "Originally from Batu Karas to Madasari took 1½ hours; now, thanks to the new road, it is only 10–15 min" (INF1).

These engineered measures reflect an active, ongoing program of mitigation investments. BPBD has also taken initial steps to deploy early-warning technology. As of this study, only five permanent sirens existed across the regency—four sited in Pangandaran village and one in Ujung Salawe—through a memorandum of understanding with local agencies. Pangandaran itself has been designated a "Tsunami Ready" village by UNESCO in 2021–2022 after meeting certain preparedness criteria. However, the informants stressed that physical systems are fragile: the sirens installed have no dedicated towers and rely on local institutions for maintenance, and in practice most have become inoperable. A village informant bluntly stated, "There used to be a siren; now it is not there anymore, it's broken" (INF3). Another official confirmed that after installation, the sirens were tested only a few times and have largely been neglected (INF2). Thus, despite some capital investment, the technical early-warning system (EWS) suffers from lack of upkeep, echoing prior analyses that cite incomplete EWS coverage as a critical gap.

Beyond infrastructure, the government conducts training and public education. Numerous simulations, socializations, and trainings have been run, especially in the immediate post-tsunami period. One FKDM leader recalled that foreign aid funded the construction of evacuation routes and supported large-scale drills: "When the tsunami happened, there was a program from REMKOMPAK... they built five evacuation structures. Then they held simulation training paid by REMKOMPAK. For example, one neighborhood would escape to this point and another to that point... and families made agreements: 'Where will father, mother, and child meet if there is a tsunami?'" (INF1). Thanks to these efforts, "after an earthquake, all the villagers were already on the hill" following the routes (INF1). An FKDM member confirmed that virtually the entire local population participated in those drills (INF1). In addition, FKDM itself receives periodic training: in earlier years, members from each of the 21 at-risk villages were invited to district-level workshops two or three times a year. One FKDM official noted, "It used to be routine, but there have been no sessions for 3 years because of the pandemic. Now we rarely have training due to lack of funds" (INF2). A youth leader remarked that an annual review would be ideal, as some people "forget" the procedures over time and need reminders (INF1).

Despite these programs, the discussion revealed mixed perceptions of effectiveness. Community participants generally acknowledged that education and drills made evacuation plans clearer, but complained of insufficient follow-up and resources. They reported that financial support (e.g., from the national APBN) had paid for housing reconstruction and evacuation facilities, but had not covered maintenance or ongoing engagement. One village head lamented that even though evacuation towers were planned, the project stalled due to shifting responsibility between provincial and local budgets (INF2–INF1). Another source pointed out that key safety features—such as school posters with evacuation instructions—have vanished during

the pandemic and not been replaced (INF1). An FKDM volunteer also reported fragmented coverage: only some schools were trained and supplied with hazard markers, and even existing signboards often deteriorated. This suggests that while the presence of programs is recognized, their sustainability and reach are uneven.

The importance of institutions in bridging these gaps was highlighted repeatedly. BPBD officials often act through FKDM volunteers to deliver messages and maintain readiness kits (tas siaga) at the village level. As one responder noted, *“FKDM are our active arms... in Masawah and Madasari, tourism is [run by the] village, but for disaster [education] we back them up. Every year we do two sessions of simulations, outreach, and education”* (INF1). He also confirmed that BPBD provides guidelines and materials, but that communities must often organize themselves to make use of them (INF2, INF1).

BPBD teams even verify rumors and hoaxes in the field. In the words of a BPBD informant: *“When hoaxes spread, we go on-site to explain the confirmed facts... By phone does not connect, so we come directly to clarify... we have done verification and confirmation of hoax information”* (INF4). Thus, the BPBD-FKDM partnership appears robust in planning, but resource constraints (budget, maintenance) and coordination issues (e.g., multi-stakeholder roles for roads or sirens) impede full effectiveness. These findings are broadly in line with past research on Pangandaran. Prior work has documented active community-based mitigation, yet noted ongoing challenges: early warning devices are limited and sometimes broken, and private sector actors (hotels, restaurants) are not fully engaged.

Communication strategy for strengthening disaster mitigation literacy

The success of any mitigation strategy depends on effective communication, and the Pangandaran case reveals both opportunities and obstacles in this regard. On the technology side, numerous tools have been deployed, but their utility is often compromised. As noted, alarm sirens are one pillar of the early-warning system, yet local residents report that these are no longer functional. *“There used to be a siren in the village,”* reported one resident. *“Now it’s gone, it’s broken”* (INF3). Even when working, sirens reach only limited areas. A BPBD official explained that the only sirens are installed through agreements with coastal tourism agencies (lifeguard posts, telecom tower sites), and without dedicated towers their sound cannot carry far inland. Beyond sirens, other mass-communication devices have fared poorly. Rambu-rambu (evacuation signs and billboards) are common but often corroded by the salty environment. One participant observed that the metal posts had *“rusted and broken... we need a stronger material that will not corrode”* (INF4). Another noted that damaged signs are typically left unrepaired: *“We just leave them; there is no maintenance budget... who is going to pay out of pocket?”* (INF2). Thus, the physical signage network is patchy.

Community members pointed out that printed materials like posters and flyers have virtually disappeared. One informant explained, *“During the pandemic, most posters got lost... if we train some schools, we give them signs, but nothing else”* (INF1). The lack of updated visual aids in classrooms or public spaces means that traditional print media is not reliably reaching people. In practice, most villagers now rely on electronic media for information—but that brings its own barriers. Few households use radio or TV for disaster

news. As one participant said, *“Almost nobody has a radio anymore... most of us use social media and just read things online”* (INF3). Smartphones and messaging apps are indeed major channels: some official updates are sent via district WhatsApp groups. However, mobile connectivity is uneven along the rugged coast.

A focus-group member pointed out that cell signal is not always available and people cannot be expected to watch their phones constantly. He questioned what methods could reach everyone *“without relying on signal... maybe a siren or an FM transmitter?”* (INF2). This echoes concerns in disaster communication literature about network reliability in crisis. Social media also has a dark side. Participants reported that communities frequently encounter false information about impending earthquakes or tsunami waves. One informant lamented that villagers often *“read news from outside sources, and they trust it. If they see a headline claiming a 5-meter wave is coming, they immediately believe it... no one checks with BPBD”* (INF3). Likewise, repeated automated alerts from the national meteorology agency (BMKG) about earthquakes—some quite minor—have left people anxious and prone to panic whenever a seismic event occurs (INF3).

In Pangandaran, disaster-related communication via digital platforms reflects a dual structure of official and unofficial information streams. On the official side, the Meteorology, Climatology, and Geophysics Agency (BMKG) issues automated earthquake alerts. BPBD officials disseminate updates and evacuation instructions through WhatsApp groups that connect village leaders, FKDM members, and other local actors. These messages travel quickly within connected groups and can reach hundreds of people in seconds. On the unofficial side, however, disaster information circulates widely on Facebook community pages, personal chats, and informal WhatsApp networks. The content in these unofficial channels ranges from practical safety tips to unfounded rumors and sensational predictions. A striking example from our data was a viral Facebook post warning of a “5-meter tsunami wave,” which many residents immediately believed and acted upon, even though no such warning was issued officially, which shows that ordinary citizens often give more weight to dramatic peer-shared content than to impersonal official messages.

The actors shaping these information flows, therefore, include government representatives (who generally post one-way announcements), community volunteers and FKDM members (who try to clarify or forward accurate messages), and residents themselves (who amplify both helpful advice and misleading rumors). The effectiveness of these digital channels is therefore mixed: WhatsApp enables fast, direct dissemination, but its reach is limited to group members and subject to connectivity issues, while Facebook achieves wider spread but frequently hosts misinformation. BPBD staff reported that in cases of hoaxes, they often had to go to villages to debunk rumors in person, since correcting them online was too slow or ineffective. This pattern underscores that while digital platforms are indispensable tools for disaster communication, without active engagement and verification mechanisms, they can just as efficiently fuel confusion and panic as they can enhance preparedness.

The communication landscape in Pangandaran combines modern and traditional channels, but none is fully reliable as described in Table 2. Sirens and signs are conceptually good tools but suffer from disrepair. Radios and posters are nearly obsolete. Social media and phones dominate, yet misinformation and coverage gaps undermine

TABLE 2 Communication channels in Pangandaran.

Channels	Main uses	Strengths	Challenges
Sirens and loudspeakers	Early warning alerts in villages (tsunami, etc.)	Immediate, audible to many if functional	Very limited range; many units broken or not maintained
Static signage (evacuation signs, posters)	Display evacuation routes and safety information in public spaces	Visible constant reminders of risks and procedures	Often weathered or removed; not updated; may be ignored (e.g., by tourists)
Radio and TV broadcasts	Official disaster news and alerts via broadcast media	Can reach mass audiences if people tune in	Few locals use radio/TV for warnings now; one-way, not interactive; requires power/reception
Mobile messaging (WhatsApp)	Quick alerts and situation updates via group chats (community and official groups)	Rapid dissemination; direct reach to individuals' phones	Dependent on cellular signal; group membership is limited (not everyone included); can propagate rumors quickly
Social media (Facebook, etc.)	Broad sharing of information, warnings, and discussions in the community	Very wide reach; allows peer-to-peer sharing and discussion	High potential for misinformation/hoaxes; lacks official moderation; authorities mostly post one-way announcements without dialogue
Informal networks (word-of-mouth, local watch)	Personal communication through neighbors, family, local watch volunteers	Trusted sources due to personal relationships; utilizes local knowledge (e.g., elders' advice)	Limited scope (does not travel far beyond immediate community); slower spread than digital media; info may not reach outsiders or all groups

Source: Researchers' field interviews, FGD, and observations, 2023.

their benefit. These findings suggest the need for a multi-pronged strategy: reinforcing low-tech alerts (e.g., sirens, public address systems) while improving digital messaging and community networks. The literature on disaster risk communication underscores similar lessons: redundancy is key, and trusting relationships between authorities and communities are essential for information to be heeded.

At the core of Pangandaran's communication issues is a systemic failure not only of tools but of relational trust, which disaster communication theory identifies as foundational. While communication infrastructures like sirens and signage are widely regarded as crucial for early warning, their dysfunction in Pangandaran does more than reduce reach—it symbolically erodes public confidence in institutional capacity. The literature (Erokhin and Komendantova, 2024; Sellnow and Seeger, 2020) stresses that communication is as much about building credibility as it is about delivering facts. In Pangandaran, every rusted signpost and defunct siren becomes a visible reminder of neglect, which feeds into collective skepticism. This aligns with Salley et al. (2025), who argue that in pre-crisis contexts, visible preparedness infrastructure acts as a proxy for institutional legitimacy. The lack of visible upkeep fosters what Nazli (2024) calls “anticipatory distrust,” where communities preemptively discount official messaging in a crisis due to past failures in non-crisis contexts.

Moreover, the dichotomy between official digital communications and informal rumor networks reflects a deeper structural weakness: the absence of a functioning two-way communication ecology. While social media platforms are now dominant in Pangandaran, they function in isolation from official command structures. The CERC model's ideal of continuous and interactive communication is subverted when formal institutions treat social media as an announcement platform rather than a space for engagement and dialogic risk interpretation (Marx and Cheong, 2023). As a result, misinformation fills the interpretive vacuum, not because residents are “misinformed,” but because alternative narratives are more immediate, trusted, and emotionally resonant. The situation exemplifies what Takahashi et al. (2015) warn against: when

authorities relinquish narrative control, “backchannel communication” dominates, reducing the power of structured alerts. Therefore, Pangandaran's communication challenge is not only about failing infrastructure or weak signals—it is about a crisis of relational infrastructure, where the messenger is no longer credible, and the message loses potency regardless of its accuracy.

Disaster literacy as situated knowledge: cultural practice or systemic gap?

Disaster education is essential in building disaster-resilient communities in Indonesia. In addition, disaster education can increase people's understanding and skills in dealing with disasters and minimize the negative impacts that may arise due to disasters. Disaster education is a deliberate approach to identifying prospective disasters and their associated hazards to all learners, aiming to develop knowledgeable individuals about natural disasters. Disaster risk education, also known as risk education on natural disasters, is a systematic approach to increasing awareness by imparting knowledge, fostering understanding, and promoting proactive measures for preparedness, prevention, and recovery. In this context, risk education entails the acquisition of knowledge regarding the environment, comprehension of natural phenomena, and their associated hazards. This knowledge enables individuals to make informed decisions and adopt appropriate behaviors during emergencies (Kitagawa, 2015; Kılınç İşleyen et al., 2025),

Several previous studies emphasize the importance of disaster education for communities with disaster potential. Disaster education has an important role in reducing disaster risk which improves cognitive aspects and skills in evaluating disaster risk (Muttarak and Lutz, 2014; Oktari et al., 2018). These studies show that disaster education is a strategic means of introducing potential disasters and their risks to the community. Still, disaster education (Tahmidaten & Krismanto, 2020), also known as disaster risk education, is a process aimed at raising awareness by imparting knowledge, promoting understanding, and fostering activities that

promote prevention and preparedness for recovery. Humans should strive to coexist with nature rather than attempt to dominate it when facing natural conditions, both as individuals and as a community, which means that efforts to reduce the impact of natural disasters should not solely rely on technological methods but should also involve modifying human behavior in response to these hazards.

Knowledge of the dangers that can be caused when a disaster occurs must be understood by all levels of society, especially people living in disaster-prone areas such as the Pangandaran area, ranging from coastal and urban areas to hilly areas. Areas prone to natural disasters often have a high potential for natural disasters. Protection of natural disaster-prone areas is carried out to protect people and their activities from disasters caused by nature. This community understanding is crucial so that the disaster risk becomes smaller, which is in line with the opinion of natural disaster mitigation experts, who state that knowledge about the dangers posed by natural disasters is not enough to be given only to people who are adults. However, it is important to be given to all people of various ages, especially those who live in areas that are very at risk of disaster.

Disaster education is important in shaping people's intention to take preparedness actions in disaster mitigation. According to planned behavior theory, attitudes, subjective norms, and behavioral control learned through education influence a person's intention to take specific actions (Ajzen, 1991; Nie et al., 2020; Tzeng et al., 2022; Wang et al., 2025). Effective disaster education can increase community knowledge and awareness, shaping the intention to prepare for disasters. In addition, from a library science perspective, disaster education can strengthen information literacy, which helps people understand the importance of preparedness (Gülsoy et al., 2025; Triyanto and Syamsi, 2021), encourages them to take appropriate action, and increases people's intention in disaster preparedness in Pangandaran Regency.

Then, based on the facts and data of disasters that occurred, the Pangandaran Regency government, through the Regional Disaster Management Agency (BPBD), implemented various programs to assist the community in disaster management, both in the form of direct assistance during disasters and community awareness programs in disaster management/disaster mitigation. Seven programs have been implemented to educate the community since 2017. Several

education and training programs related to disaster mitigation are conducted in the Pangandaran Regency area.

Table 3 illustrates partial coverage; while programs have targeted children, women, and hotels, outreach remains uneven across segments of society. Thus, it is necessary to develop a program with the involvement of various sectors. Through the disaster mitigation education process, it is expected that people living in disaster-prone areas can improve aspects of their knowledge and skills in evaluating disaster risk, so as to reduce vulnerability to natural disasters. Disaster mitigation is a series of efforts to reduce disaster risk, both through physical development and awareness and improvement of the ability to face the threat of disaster. Continuous efforts must be made to cultivate disaster literacy in communities residing in areas prone to disasters. The government and the community must work together in synergy to develop community literacy on disaster mitigation. The government via affiliated institutions and the community through community leaders. Government agencies enhance disaster literacy in vulnerable populations by implementing local legislation and collaborating with community leaders to disseminate moral, social, and spiritual messages.

When it comes to education and training activities on disaster mitigation literacy, direct experience of disasters increases teachers' knowledge and awareness of disaster risk reduction (Wiwik Astuti et al., 2021). In the context of Masawah Village, the results of our research show that disaster education provided through disaster training and simulation has succeeded in significantly improving community preparedness. In addition, the research Suarmika et al. (2022) also showed that local knowledge in disaster mitigation plays an important role in improving preparedness. This can be seen from the active involvement of the community in disaster education programs based on local wisdom. This is also in line with research conducted by Anwar and Rizal (2018) who said that disaster mitigation socialization through education in schools is very effective in increasing children's disaster preparedness.

The findings from Pangandaran reveal a compelling paradox: the community demonstrates high disaster literacy through informal channels, but this literacy exists in tension with, rather than in synergy with, institutional education systems. Disaster literacy in Pangandaran functions as situated knowledge—embodied in daily rituals, family-level evacuation planning, and oral traditions. According to Triyanto

TABLE 3 Disaster mitigation training program in Pangandaran Regency area.

No.	Program name	Program objectives	Target achievement
1	Kindergarten child mitigation (ATM)	This disaster mitigation awareness program is aimed at young children	One school, 52 students
2	Disaster education tourism goes to school	This program is for elementary school children	Eighty-one schools, 5,073 students
3	empathetic gathering to share disaster education	This program is for junior and senior high school students	Five schools 285 students
4	Mother learns mitigation	This program is needed by women empowering family welfare (PKK)	247 cadres
5	Community early preparedness forum	This program is for the community, leaders, organizations, and village officials	Eighteen villages 720 people
6	Fire education ride	This program is focused on kindergarten and early childhood education students	Nine schools 183 schools
7	Disaster resilient hotel	This program is focused on all hotels in Pangndaran Regency	Two hotels

Source: BPBD Pangandaran (2023).

and Syamsi (2021) and da Silva et al. (2023), such grassroots knowledge systems provide crucial, culturally embedded frameworks for resilience. However, these systems are largely undervalued by formal institutions, revealing what da Silva calls “epistemic marginalization”—the sidelining of non-institutional knowledge forms in disaster governance.

This epistemic gap has tangible consequences. For instance, while families have evacuation plans, and elders reference natural cues (e.g., water recession, ant migrations), these are rarely reinforced or validated in formal school curricula. Oktari et al. (2018) suggest that school-community partnerships are critical in bridging this divide, yet in Pangandaran, disaster education remains optional, unsystematic, and vulnerable to leadership turnover. This reveals not a lack of knowledge in the community, but a failure of institutional synthesis—a missed opportunity to formalize and scale locally effective practices. The continued reliance on informal strategies reflects resilience, but also abandonment: the community adapts not because it is empowered, but because formal systems have left a vacuum.

Furthermore, the sporadic nature of drills and knowledge reinforcement contradicts what Zhuo et al. (2024) describe as the “retention gap”: the decline in preparedness knowledge over time without periodic simulation. Pangandaran’s pattern of disaster education reflects episodic engagement, where awareness surges post-disaster but lacks continuity. This reveals a structural flaw in how disaster literacy is framed: as a project-based intervention rather than a permanent civic capacity. Without integrating disaster education into core pedagogical frameworks and governance routines, even culturally strong communities risk erosion of knowledge across generations. The result is not just missed opportunity, but delayed vulnerability.

The findings from Pangandaran reveal several important implications for disaster risk reduction (DRR) policy and practice. Stronger policy frameworks are needed to integrate disaster education and local knowledge into official programs systematically. At present, disaster education in Pangandaran schools is often *ad hoc* and dependent on motivated teachers or NGO projects. National or regional education authorities could institutionalize disaster literacy by embedding it into school curricula, ensuring that knowledge of hazard risks, evacuation drills, and local wisdom (such as natural signs of impending disasters) is consistently transmitted. Clearer policy frameworks are also needed to establish responsibility for maintaining warning infrastructure such as sirens, signage, and evacuation routes—preventing deterioration due to unclear bureaucratic ownership.

Our field data show that several preparedness projects stalled because of budget handovers between provincial and local governments, leaving communities uncertain about responsibility for key infrastructure like evacuation towers. Multi-level governance mechanisms could clarify each agency’s roles and financial obligations, supported by regular joint drills and integrated communication protocols across BMKG, BPBD, and FKDM. Prior research confirms that collaborative governance fosters greater preparedness (Kapucu, 2008), and our case study demonstrates the urgent need for such coordination to sustain community trust. The private sector must be more actively engaged in disaster preparedness. Despite Pangandaran’s reliance on tourism, few businesses are involved in DRR. Only two hotels participated in the “Disaster Resilient Hotel” program, and some businesses initially opposed evacuation signage

for fear of discouraging visitors. However, the private sector has both resources and incentives to contribute. Hotels, restaurants, and tour operators should be encouraged—or required—to train staff, share evacuation information with guests, and participate in community drills.

Conclusion

This study has highlighted the critical role of communication strategies—particularly disaster education efforts and media usage—in enhancing disaster mitigation information literacy and promoting community preparedness in Pangandaran Regency, Indonesia. Drawing from qualitative insights (interviews and focus group discussions) and supporting quantitative data, it is evident that localized disaster communication must operate through a multi-layered, participatory, and culturally sensitive framework. Community members in Pangandaran have developed strong grassroots-based disaster literacy rooted in lived experience, local wisdom, and social networks. However, these assets are often under-recognized and insufficiently integrated into formal disaster risk reduction (DRR) systems.

The findings confirm that programs such as evacuation simulations, educational signage, and school trainings have increased awareness and preparedness. At the same time, significant obstacles remain—particularly in the sustainability of early warning systems, the fragmentation of educational outreach, and a deficit of trust in institutional communications. Challenges like technological decay (e.g., broken sirens), funding limitations, and lack of consistent follow-up hinder the continuity and effectiveness of mitigation efforts. The study affirms that harmonizing formal disaster education with local knowledge and building relational trust through two-way communication are essential for effective risk communication.

Based on these findings, stakeholders are recommended several actionable steps. First, strengthen multi-channel communication systems by modernizing digital outreach and rehabilitating critical traditional tools (for example, repair and maintain sirens and public address systems) while leveraging social media groups for rapid alerts. Second, invest in community media literacy and public education campaigns that not only disseminate information but actively counter misinformation and build trust in official sources—for instance, by having authorities regularly engage with community social media and using local opinion leaders as info brokers. Third, coordination across institutions should be improved through clear protocols and joint initiatives: local governments, BPBD, national agencies like BMKG, and community organizations should conduct integrated drills and develop unified messaging so that people receive consistent advice and know that all agencies are working together. Fourth, formally engage private sector stakeholders in preparedness planning. Hotels, tourism operators, and local businesses should be encouraged or required to partake in early warning dissemination and training; this could include establishing MOUs where businesses provide resources (like venue space for training or funding for equipment maintenance) in exchange for disaster-ready certifications that could even be a marketing advantage. Finally, long-term program sustainability can be secured by allocating dedicated resources and institutional support for DRR activities, including maintenance budgets for warning infrastructure in annual plans, scheduling regular refresher trainings in schools and

villages, and integrating local indigenous knowledge into official disaster management guidelines and school textbooks. Implementing these measures would help transform disaster preparedness from a sporadic project-based endeavor into a continuous culture of resilience.

This study has several limitations. First, its geographic scope is limited to Pangandaran Regency, which may constrain the generalizability of findings to other disaster-prone areas in Indonesia with different socio-cultural and institutional contexts. Second, while the qualitative methods allowed for in-depth insight, the quantitative component of the research was modest in scale, potentially limiting the breadth of statistical generalization. Third, the study primarily focused on the roles of disaster education and communication media and did not explore other crucial elements of disaster risk governance (such as detailed institutional coordination mechanisms, budgetary processes, or extensive private sector engagement) in great depth. These areas could be avenues for further investigation.

Future research should consider comparative multi-site designs across several coastal and inland regions to explore how different contexts influence communication effectiveness and literacy outcomes. Longitudinal studies would be valuable to assess the long-term retention of disaster education and the sustained impact of communication interventions—especially in a post-pandemic setting where public engagement patterns may have changed. Moreover, studies should examine ways to formally integrate traditional ecological knowledge and community-led practices into official disaster curricula and policies, and assess how this integration might improve institutional legitimacy and community responsiveness. In conclusion, building a disaster-resilient community in Pangandaran and similar settings requires robust infrastructure and early warning technology and sustained investment in people-centered communication, institutional trust-building, and the systematic integration of indigenous and scientific knowledge in disaster management. By embracing a multi-channel, inclusive approach and fostering collaboration across public, private, and community sectors, disaster-prone communities can significantly enhance their preparedness and capacity to bounce back from future crises.

Data availability statement

The datasets generated and analyzed during the current study are not publicly available due to ethical restrictions and confidentiality agreements with research participants. The data contains qualitative interview transcripts and observational field notes that could potentially reveal the identities of individuals or communities involved. Requests to access these datasets should be directed to edwin.rizal@unpad.ac.id.

Ethics statement

The studies involving humans were approved by Universitas Padjadjaran Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from the

participants or the participants' legal guardians/next of kin due to the minimal-risk nature of the research, which involved non-sensitive interviews with adult community members and public officials in their professional or community roles. Verbal consent was obtained from all participants after they were informed about the purpose of the study, their voluntary participation, and the confidentiality of their responses. No personal identifiers were collected, and all data were anonymized in accordance with institutional ethical guidelines.

Author contributions

ER: Conceptualization, Data curation, Formal analysis, Funding acquisition, Supervision, Writing – original draft, Writing – review & editing. YW: Investigation, Project administration, Software, Writing – review & editing. TS: Methodology, Project administration, Validation, Visualization, Writing – review & editing. CN: Conceptualization, Data curation, Formal analysis, Methodology, Resources, Writing – original draft, Writing – review & editing. FS: Resources, Software, Visualization, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This research was supported by Universitas Padjadjaran through the following internal schemes of Internal Research Grant—Directorate of Research, Commercialisation, and Community Engagement.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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