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Beyond Technology: Investigating Socio-cultural Aspects of the Indonesian Tsunami Early Warning Systems (InaTEWS) in Central Sulawesi, Indonesia

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Abstract

The 2018 Central Sulawesi earthquake and tsunami have sparked off a serious debate on the efficacy of the Indonesia Tsunami Early Warning Systems (InaTEWS). The 'cascading disasters' suggest an apparent failure of early warning chain and technological deficiencies that resulted in a heavy death toll. This article examines how factors beyond technological aspects such as socio-cultural factors and local memories of past disasters play a significant role in mitigating communities against disasters. Methodologically, this paper followed a qualitative approach based on in-depth interviews and direct observation to develop arguments. Findings show that tsunami risk perception, local belief, and faith affected community response capacity. Besides, lack of education in disaster preparedness, coupled with ignoring history of tsunamis, limited the ability of people to react appropriately when disasters unfolded. However, in the absence of an alert system, the coastal community in Donggala demonstrated the best practice of tsunami preparedness by harnessing local knowledge. The community in Donggala has been preserving the tsunami memories from 1938 and 1968 through oral transmission across generations about *bombatalu* or *lembotalu* (three waves) stories. In conclusion, this paper recommends a people-centred approach to the Indonesia Tsunami Early Warning Systems (InaTEWS) against disasters in the future.

Keywords: InaTEWS, tsunami, a people-centred approach EWS, Central Sulawesi, local knowledge.

Introduction

A series of dreadful disasters struck the Indonesian province of Central Sulawesi on 28 September 2018. A 7.5 magnitude strike-slip earthquake triggered tsunami waves and soil liquefaction, causing tremendous damages and numerous fatalities. The National Disaster Management Authority (BNPB) reported a death and missing toll of 4,340, 172,635 people had been forcedly displaced, and 4,438 were injured. Also, the catastrophe resulted in economic losses of approximately US$830 million in four regions, namely Palu, Donggala, Sigi, and Parigi Moutong.[1] This was the most destructive tsunami in Indonesia since the 2004 Boxing Day Tsunami in Aceh Province.

The tragedy in Central Sulawesi has raised concerns over the Indonesia Tsunami Early Warning System (InaTEWS). The InaTEWS had been installed across a large part of the Indonesian archipelago, including in Central Sulawesi. However, it was still unable to save lives. Post-tsunami investigations revealed that a massive submarine landslide had contributed to and intensified the occurrence of tsunami in Palu and Donggala.[2] While the existing InaTEWS can forecast tsunamis generated by strong earthquakes, it could not detect submarine coastal and submarine landslide. So, it is evident that the InaTEWS did not consider local hazard characteristics.

Many studies have focused on understanding local hazard characteristics in Central Sulawesi because producing a precise prediction and tsunami hazard calculation through specific parameters and technological instruments is very challenging.[3] Moreover, several

[1] "Infographics: Tsunami and Earthquake in Central Sulawesi," *BNPB* accessed May 20, 2019, https://bnpb.go.id/infografis-gempabumi-m74-tsunami-sulawesi-tengah.
[2] Abdul Muhari et al., "Solving the puzzle of the September 2018 Palu, Indonesia, tsunami mystery: clues from the tsunami waveform and the initial field survey data," *Journal of Disaster Research*, 13 (2018): 1.
[3] Tjipto Prastowo, "Evaluation of earthquake parameters used in the Indonesian Tsunami Early Warning System," *Earthquake Science* 29, 1 (2016): 28.

months after the tsunami in Central Sulawesi, another tsunami unexpectedly hit hard The Sunda Strait (West Java).[4] In that case, there were no available warning systems, and the short travel time following tsunami initiation presents a significant challenge for mitigating coastal tsunami impact.[5]

Apart from technological deficiencies, the Central Sulawesi tsunami illustrates a lack of attention to socio-cultural elements that caused extensive damage. The Indonesian Meteorological, Climatological, and Geophysical Agency (BMKG) Jakarta, as the host institution of InaTEWS, claimed there was no instrumental error, nor any human mistake in the warning systems.[6] Nevertheless, there was a substantial and fatal gap in the warning chain which is indicated by unclear coordination in the downstream level and the community's incapability to respond appropriately during the catastrophe.[7] Therefore, examining the significance of factors beyond the technological purview of the EWS is crucial to accelerate the function of the InaTEWS in the future.

Socio-cultural aspects, such as tsunami risk perception and tsunami memories, are pivotal to mitigate communities against disasters. Even the most advanced EWS technology would be useless without adequate response capacity and warning dissemination. Previous studies have shown the significant contribution of socio-cultural aspects in EWS in the past tsunami events. One of the most extraordinary success stories was on Simeulue Island (Aceh), where thousands of people were saved by a local narrative

[4] The tsunami in Sunda Strait was caused by the volcanic eruption of Anak Krakatau between Java and Sumatra Islands on 22 December 2018. The disaster killed 437 people, 31,943 people were injured, and 16,198 were forced to flee their home.
[5] Stephan T. Grilli et al., "Modelling of the tsunami from the December 22, 2018 lateral collapse of Anak Krakatau volcano in the Sunda Straits, Indonesia," *Scientific reports* 9, 1 (2019): 13.
[6] Daryono, "The tsunami early warning systems did not fail," *Kompas*, October 13, 2018, https://kompas.id/baca/opini/2018/10/13/peringatan-dini-tsunami-tidak-gagal/
[7] UNDRR and UNESCO-IOC, "Limitations and Challenges of Early Warning Systems: A Case Study of the 2018 Palu-Donggala Tsunami," *IOC Technical Series*, 150 (2019): 3.

story so-called *Smong* during the 2004 Indian Ocean Tsunami.[8] Another example is from December 2002, when the tribal community in Tikopia Village (Solomon Island) survived the dreadful Cyclone Zoe through heeding to natural signs from hut to hut and taking shelter under rocky overhead cliffs.[9] Both these instances demonstrate the power of local knowledge that could save lives in absence of an early warning system.

Since Central Sulawesi also has a strong cultural background, this study aims to understand socio-cultural aspects to disaster mitigation efforts, especially with regard to EWS implementation. This paper is structured as follows: firstly, it provides a historical overview of past tsunami events in Indonesia and then specifically in Central Sulawesi; secondly, it delineates local knowledge and tsunami memories to understand the Central Sulawesi tsunami's impact and contribution to EWS; and, thirdly, it explains implementation of people-empowering approaches against future disasters in Central Sulawesi and its drawbacks.

This paper used a qualitative approach with case study methods to answer "why" and "how" questions, investigated in context, examined in its real-world setting.[10] The semi-structured interviews were conducted with 33 informants in Central Sulawesi (Palu, Sigi, and Donggala) and Jakarta, comprising government officials, NGO representatives, academics, and community.

[8] *Smong:* in Simeuluean local language it means strong earthquake, receding seawater, and a big wave that sweeps across the land. The story has circulated since 1907 within the community.
[9] Loti Yates & Linda Andersson-Berry, "The environmental and societal impacts of cyclone Zoë and the effectiveness of the tropical cyclone warning systems in Tikopia and Anuta Solomon Islands," *The Australian Journal of Emergency Management*, 19, 1 (2004): 16-20.
[10] Robert K. Yin, *Case study research: Design and methods* (Los Angeles: Sage, 2014), 16.

The people-centred EWS and why it is crucial in the context of Central Sulawesi

In the 1990s, the role of EWS was recognized as a fundamental instrument to reduce casualties, property damage, and socio-economic disruption. At the beginning of the decade, early warning entailed incorporating scientific and technical abilities of hazard identification and forecasting together with effective communication, the commitment of public policy, and the active participation of the local communities.[11] Two main elements determine the success of early warning: First, the accuracy of forecast in predicting the severity of the hazards in a particular time and a specific place. Second, the appropriate warning dissemination to the community to avoid the hazards or mediate the harm.[12]

After the deadliest Indian Ocean Tsunami on 26 December 2004, the United Nations' Secretary-General called for establishing a global EWS for all communities. UNISDR suggests that the establishment of EWS must be developed based on a people-centred approach. It is a genuinely end-to-end system that consists of four interrelated elements: risk knowledge, monitoring and warning service, dissemination and communication, and response capability. This approach requires collaboration between several key actors at all levels.

[11] Terry Jeggle, "Bringing Early Warning to the People—Public and Partnership Responsibilities for Early Warning," *Early Warning Systems for Natural Disaster Reduction* (2003): 13-14.
[12] John Twigg, "The human factor in early warnings: risk perception and appropriate communications," *Early Warning Systems for Natural Disaster Reduction* (2003): 20.

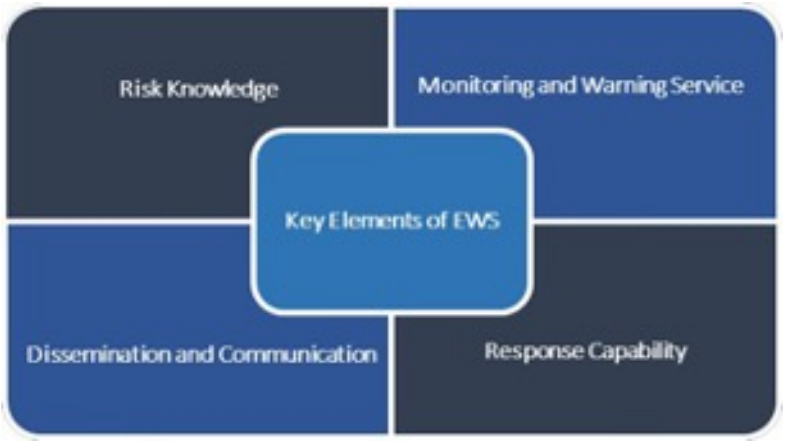

Figure 1. Four elements of people-centred EWS.[13]

To accommodate all social-cultural elements into the people-centred EWS is an arduous task. The host institution should provide room for critical reflection at the grassroots level, including ground experiences and lessons learned to increase public participation in EWS.[14] The public-private partnership model also can be adopted to ensure the sustainability of EWS.[15] Besides, integration between EWS with other development priorities could guarantee the system's sustainability, for instance, livelihoods improvement, natural resource management, and community empowerment programs.[16]

Several case studies conducted over the past 40 years have pointed out several critical links between the different components of EWS.[17] The findings indicate some valuable factors that could improve the efficacy of EWS such as (1) building active communication networks to align scientific research into practice; (2) depiction of

[13] Own design based on "Developing Early Warning Systems: A Checklist, Third Early Warning Conference," UNISDR, 2006.
[14] Di Jin & Jian Lin, "Managing tsunamis through early warning systems: A multidisciplinary approach," *Ocean & Coastal Management* 54, 2 (2011): 199.
[15] Rohan Samarajiva, "Policy commentary: mobilizing information and communications technologies for effective disaster warning: lessons from the 2004 tsunami," *New Media & Society* 7, 6 (2005): 731.
[16] Frank Thomalla & Rasmus Klocker Larsen, "Resilience in the context of tsunami early warning systems and community disaster preparedness in the Indian Ocean Region," *Environmental Hazards* 9, 3 (2010): 263.
[17] Carolina Garcia & Carina J. Fearnley, "Evaluating critical links in early warning systems for natural hazards," *Environmental Hazards* 11, 2 (2012): 133.

accountability and responsibility based on the local context to establish effective decision-making procedure; (3) recognizing the significance of risk perception and count on effective warning response; (4) attention to different characteristics between technocratic and participatory approaches in the diverse background.[18]

Figure 2. EWS with factors to improve the linking of sub-systems.[19]

Emphasizing the local context of EWS will help us explore intriguing and complex issues in the context of Central Sulawesi and provide us with insights on how the community perceived the technology, which in this case is the InaTEWS: whether it could have been valuable or it was something that they simply took for granted. The technological problem was most visible in the tsunami tragedy, but it could be the easiest way for leading institutions to hide the root causes since a tsunami did not occur for the first time. The following part of this paper will discuss at length the implementation of the InaTEWS in Central Sulawesi and its challenges.

[18] Ibid.
[19] Designed by the author based on Carolina Garcia & Carina J. Fearnley, "Evaluating critical links," 133.

Tsunami hazard in Central Sulawesi

The Indonesian archipelago is most prominent for tectonic activity and associated catastrophes such as earthquake, volcano, and tsunami.[20] With more than 17,000 islands and a range of approximately 5,125 km from the Papua New Guinean border in the east to the island of Sumatra in the west, Indonesia is also specifically well-known as one of those countries that are most at risk from deadly tsunamis.[21]

Some unique geo-tectonic position factors explain the occurrence of tsunamis in Indonesia. First, Indonesia sits at the junction of four major lithospheric plates, namely Eurasia, Indo-Australia, the Pacific, and the Philippine, which generate volcanic activities and frequent earthquakes.[22] Second, more than 127 active volcanoes cover almost all of the main islands in Indonesia or the so-called 'ring of fire.' The movements of colliding continental plates beneath the ring of fire resulting in active tectonics, which can be an underlying cause of tsunamis and earthquakes.[23] Third, Indonesia is located along the most active continental margin, namely the Sunda Arc. The Indo-Australian plate is subducted at the rate of 70 mm/y under the Eurasian plate.[24]

Data compiled from 1600 – 1999 reveals approximately 105 tsunami events occurred in Indonesia. Of these 105 tsunamis, 95 tsunamis were caused by tectonic earthquakes in the active seismic zone and subduction areas, volcanic eruption caused nine

[20] Jörn Lauterjung, Ute Münch, and Alexander Rudloff, "The challenge of installing a tsunami early warning system in the vicinity of the Sunda Arc, Indonesia," *Natural Hazards and Earth System Sciences* 10, 4 (2010): 641.
[21] N. Horspool et al., "A probabilistic tsunami hazard assessment for Indonesia," *Natural Hazards and Earth System Sciences* 14, 11 (2014): 3105.
[22] Warren Bell Hamilton, "Tectonics of the Indonesian region," *US Government Printing Office*, 1078 (1979): 3.
[23] Anthony Reid, "History and seismology in the Ring of Fire: Punctuating the Indonesian past," *Environment, Trade and Society in Southeast Asia*, 300 (2015): 62.
[24] K.R. Newcomb & W.R. McCann, "Seismic history and seismotectonics of the Sunda Arc," *Journal of Geophysical Research: Solid Earth* 92, B1 (1987): 421.

events, and one was caused by landslide.[25] At the same time, data from official BMKG recorded 30 major earthquakes from 1991 to 2009.[26] The data also mentions that 14 out of 30 events resulted in a destructive tsunami; the tsunami in Flores in 1991, East Java in 1994, Biak Island (northern coast of Papua) in 1996, North Moluccas in 2000, Aceh (Sumatra) in 2004, Nias Island (west coast of Sumatra) in 2005, West Java in 2006, and Bengkulu Province in 2007. On average, tsunamis struck Indonesia at least once in every two years, from 1991 to 2009.

At the national level, research shows that most of the coastal area in Indonesia is vulnerable to tsunami hazards.[27] The tsunami-prone regions include the western coast of Sumatra, the southern coast of Java, the northern and southern coasts of the West Nusa Tenggara (NTB) and East Nusa Tenggara (NTT) provinces, Bali, Maluku and North Maluku Provinces, the northern coast of Papua, and most of the Sulawesi coastline. The aforementioned coastal regions have a high tsunami probability of events occurring every ten to fifty years with at least 3-metre waves per event. Besides, most of the coastal area in Indonesia is densely populated. Hence the risk in most of the tsunami-prone regions is exceptionally high.[28]

The Central Sulawesi province has been struck by tsunamis on several occasions. Prior studies have shown evidence concerning the tsunamigenic occurrences in Sulawesi, especially the Palu-Koro fault movement was identified as the primary trigger of various

[25] Latief Hamzah, Nanang T. Puspito, and Fumihiko Imamura, "Tsunami catalog and zones in Indonesia," *Journal of Natural Disaster Science*, 22, 1 (2000): 25.
[26] "Indonesia Tsunami Early Warning System: Concept and Implementation," *BMKG* accessed on May 20, 2019,https://www.gitews.org/tsunami-kit/en/E2/further_resources/InaTEWS%20-%20Concept%20and%20Implementation.pdf.
[27] Horspool et al., "A probabilistic tsunami," 3105.
[28] Finn Løvholt et al., "Historical tsunamis and present tsunami hazard in eastern Indonesia and the southern Philippines," *Journal of Geophysical Research: Solid Earth*, 117, B9 (2012): 2

natural hazards in Central Sulawesi, e.g., earthquake, tsunami, landslide, and soil liquefaction.[29]

There are several reasons behind multiple occurrences of tsunamis in Central Sulawesi. First, Central Sulawesi has a long shoreline along epicentres, which means it has a high level of exposure to tsunamis generated by the sea earthquakes.[30] Second, Sulawesi island was formed in complicated active fault systems, trenches, trusts, and subduction zones, which can trigger massive earthquakes and tsunamis.[31] The Palu-Koro fault, which divides Sulawesi into two parts, has a high active tectonic activity. The movement of rock formations is 35-44 mm/year,[32] which causes a complex array of active and inactive subducted slabs in the north to drive very high hazards along the northern arm of the island.[33]

So, the tsunami phenomenon in Central Sulawesi is mostly triggered by complicated geo-tectonic and geological factors. Regarding the area of the exposure, almost all the cities in Central Sulawesi suffer from an equal tsunami risk. Even Sigi Regency, which is not located in the littoral, has a probability of a local tsunami in the Lindu lake area, even though the propensity is not as high as a tsunami in the ocean.[34]

According to the tsunami catalogue from 1692 – 2000, 24 tsunamis were recorded in Sulawesi.[35] However, only eight tsunami cases can be scientifically proven and are

[29] Olivier Bellier et al., "High slip rate for a low seismicity along the Palu-Koro active fault in central Sulawesi (Indonesia)," *Terra Nova*, 13, 6 (2001): 463
[30] Achmad Yasir Baeda, "Seismic and tsunami hazard potential in Sulawesi Island, Indonesia," *Journal of International Development and Cooperation* 17, 1 (2011): 17.
[31] John A. Katili, "Past and present geotectonic position of Sulawesi, Indonesia," *Tectonophysics*, 45, 4 (1978): 322.
[32] Olivier Bellier et al., "High slip rate," 463.
[33] A. Cipta et al., "A probabilistic seismic hazard assessment for Sulawesi, Indonesia." *Geological Society, London, Special Publications*, 441, 1 (2017): 152.
[34] Abdullah, *Tsunami in Palu Bay and Palu-Koro Fault: The commemoration of 90 years of Air Laut Berdiri and Anticipation of the Tsunami* (Palu: Tadulako Publishing, 2017), 8.
[35] Hamzah, Puspito, and Imamura, "Tsunami catalog and zones," 25.

closely related to earthquake events based on historical data compiled by the International Tsunami Information Center (ITIC-IOC) in Hawaii, The US, and existing research on tsunamis in Indonesia. All of the tsunami cases had generated from more than 6-magnitude earthquakes; and, therefore, they caused enormous destruction. The previous tsunami events had also severely affected coastal cities in Central Sulawesi (e.g., Palu, Donggala, Mamuju) with different degrees of exposure.

Location	Date	Magnitude	Max Run-up (m)	Affected areas, related phenomena, and casualties
Makassar Strait	1 Dec. 1927	6.3	15	West/Central Sulawesi, Palu Bay; subsidence 0.5-12m; 14 dead, 50 injured.
Makassar Strait	19 May 1938	7.6	3	Central Sulawesi (Palu, Parigi, Donggala), Tomini Bay; 22 dead, 15 missing.
Makassar Strait	11 Apr. 1967	6.3	8	West Sulawesi (Tinambung); 58 dead, 100 injured.
Celebes Sea	14 Aug. 1968	7.4	10	West-central Sulawesi, Palu Bay; subsidence 2-3m (Mapaga villages), 500m inland inundated. More than 200 dead.
Makassar Strait	23 Feb. 1969	6.1	10	South Sulawesi, Majene; 64 dead.
Makassar Strait	8 Jan. 1984	6.6	-	West Sulawesi, Mamuju, no record.
Celebes Sea	1 Jan. 1996	7.9	3.4	West Coast, Central Sulawesi, Simuntu – Pangalseang; Subsidence 0.5-2m; 9 dead, 63 injured.
Pelang Island	4 May 2000	7.5	6	Central Sulawesi (Luwuk, Banggai Island, Peleng Island; 41 dead, 228 injured, 10,5000 families lost their homes.

Table 1. List of tsunami occurrences in Sulawesi Island.[36]

[36] Efim Pelinovsky et al., "The 1996 Sulawesi tsunami," *Natural Hazards*, 16, 1 (1997): 30; G.S. Prasetya et al., "The makassar strait tsunamigenic region, Indonesia," *Natural Hazards* 24, 3 (2001): 295; Achmad Yasir Baeda, "Seismic and tsunami hazard," 20.

The first massive tsunami in the past 100 years in Central Sulawesi was recorded on 1 December 1927 in Palu Bay. The incident occurred in three regions, namely Palu, Donggala, and Biromaru (Sigi). The tsunami was triggered by a 6.3 Mw earthquake, which occurred due to the Palu-Koro fault movement. Since then, the tsunami was memorialised by local people as *"air laut berdiri*" (i.e., "standing seawater") phenomenon due to the height of the wave, which reached 15-meters.[37]

Among more current cases, a tsunami occurred on 14 August 1968 in Donggala. The International Tsunami Information Center (ITIC-IOC/UNESCO 1968) reported Donggala Regency, especially the coastal village of Tambu, had been swept away and 200 people died. Moreover, the newsletter informed that Tuguan, a small island, and its inhabitants disappeared under the tsunami wave. On 1 January 1996, a 2-meters high tsunami in Tonggolobibi village in Donggala left behind a death toll of 9, 63 people injured, and destroyed more than 400 houses.[38] The next major incident was recorded on 4 May 2000, when the Banggai archipelago in Central Sulawesi was badly hit by a 6-metre tsunami wave and it caused riots in Banggai Island and Peleng Island.[39]

The untold story: Tsunami risk (mis)perception in Central Sulawesi

On 28 September 2018, the grand opening of the biggest cultural event in Sulawesi Island, entitled "The Wonderful Palu *Nomoni* Festival,"[40] was held along Palu Bay. Since morning, thousands of people from several regions had already gathered to commemorate

[37] Abdullah, "*Tsunami in Palu"*, 21.
[38] Efim Pelinovsky et al., "The 1996 Sulawesi tsunami," 29.
[39] "Indonesia: Earthquake/Tsunami Appeal No. 11/2000," *IFRC* accessed June 6, 2019, https://reliefweb.int/report/indonesia/indonesia-earthquaketsunami-appeal-no-112000
[40] *Nomon*i is a word from Kaili language (the native tribe of Central Sulawesi). *Nomoni* lexically means resounding. The yearly festival is held to celebrate the anniversary of Palu as well as to boost tourism through cultural performances, tradition, and art from Sulawesi.

the 40th anniversary of Palu City. When the first foreshock appeared in the afternoon, many people ignored it. The magnitude was relatively low; most of the people in Palu perceived the earthquake as a normal phenomenon. Hence, they did not realize that the earthquake could be a prelude to an even bigger disaster.

However, when the second tremors were felt in the evening, the condition had worsened to a complete mess. Buildings and houses began to slowly collapse, including the iconic *Ponulele* Bridge (Yellow Bridge), which sits over the Palu Bay. The panic-stricken visitors and coastal residents randomly ran away to the place which they considered to be safe. There were no clear instructions from either the authorities or the community leaders with regard to where the people could safely evacuate themselves. Most of the people were clueless about how to properly react in the disastrous situation of an earthquake.

In a few minutes, the community was terrified when the massive high waves smashed the coast. Surprisingly, most of the locals have never thought that a tsunami could happen in Palu. As far as they understood from the local narrative, a tsunami could never be possible since Palu is located in a bay. They were convinced that the bay would not be exposed to a tsunami as massive as one in the regions close to the ocean. Hence, many people did not believe when the real tsunami crashed in their region. This knowledge of tsunamis was misleading, so it limited people's ability to evacuate themselves during the catastrophe.

Many people in Palu defined the 2018 Central Sulawesi tsunami as a tremendous unpredictable disaster not only because it had caused massive destruction, but also because the people had not expected the tsunami at all. The community was ignorant of the high

risk of tsunami in their region, although this was not the first time that a tsunami had struck. The most common perception in Palu City was of the bay area being not prone to tsunami hazards. The people did not know the source of common knowledge since it had been memorialised a long time ago. Nonetheless, they took this knowledge for granted without knowing the scientific argument behind it. So, most people did not perceive the tsunami as an imminent disaster that could threaten Palu Bay.

Even though Central Sulawesi has a long history of tsunami incidents, not all residents in Palu are aware of it. Most people, especially the younger generation, have limited knowledge about past tsunamis. The older generation is well-acquainted with local knowledge, such as oral stories about the tsunami events. But the oral stories were never transmitted to the younger generation in Palu.

In the past, the native tribe of Palu, the so-called Kaili, had their own local knowledge of the tsunami. While people in Donggala called tsunami as *lembotalu,* most people in Palu define tsunami phenomena in Palu as *bombatalu*. According to historians and archaeologists, both terms have the same meaning, but the root of language was different. *Lembotalu* was from the Mandar language, and *bombatalu* was taken from the Kaili language. In Palu, the *bombatalu* refers to past tsunami events that occurred in 1927. At that time, towering 15-metre waves crashed thrice on the Mapaga region, Donggala. Moreover, the local elders have their words for another disastrous phenomenon called *naledo* (buried under mud), which is very similar to soil liquefaction. Another word is *lingu,* meaning an earthquake.[41]

[41] Academic 02, interview by author, May 16, 2019.

By definition, Palu means lifted soil taken from Kaili language *topalu'e.* The name itself connotes that disasters have unfolded in Palu for a long time. Unfortunately, the local knowledge has never been considered within the community in Palu. In other words, the local knowledge was being unsuccessfully transferred across generations. The case is different among the community on the coast of Donggala, where the people still preserve the oral stories.[42]

Based on the findings, two underlying arguments explain the interruption of local knowledge among the community in Palu. First, the population of Palu City is dominated by migrants from other regions in Sulawesi and even other islands in Indonesia, e.g., Kalimantan, Bali, and Java. Hence they do not know about the history of tsunami events or have little idea of local knowledge about *bombatalu* or *lembotalu*. Second, as a developing city, Palu has transformed into a modern city. Many young generations no longer engage with their cultural tradition and do not understand their roots. They consider folklore as urban legend that has never been a true story. However, in the countryside of Palu, many people still believe in the superstitions.

Scientific vs Peccatogenic

The local leaders in Palu and Central Sulawesi have a special privilege in society. As respected figures in the community, they often allude to the risk perception within the community. Their role is to enforce the local customary law, and their thought often determines the public perspective. In the context of the disaster, the people's perception of the tsunami in Palu and Donggala was most likely influenced by the local leaders.

[42] Activist 01, interview by author, May 20, 2019.

Back in 2017, a group of scientists embarked on the Palu-Koro expedition that was organized to record the tsunami traces in the Central Sulawesi region. At the end of 2017 and around the beginning of 2018, the expedition team suggested reliable disaster mitigation in Palu which has a vast potential of the repetitive seismic cycle. The team presented their results to the national, regional, and the local governments. However, no specific actions were initiated in response to the high risk of the tsunami that might potentially occur anytime.

One of the geology experts from Tadulako University (Palu) also published a book about the Palu-Koro fault movement nine months before the Central Sulawesi tsunami. The book illustrates the worst-case scenario induced by a tsunami and the potential mitigation measures for the Central Sulawesi coast. Not unlike the recommendations from the expedition team, the results of scientific studies were never taken seriously by the local government.[43]

Disregarding scientific knowledge, in this case, was highly influenced by cultural factors. One of them is the *nakapali* norm,[44] which cannot be separated within the community in Central Sulawesi, especially the Kaili tribe. In more recent terms, the *nakapali* norm is very similar to the quote "*careful what you wished for*." In this context, local leaders believe that people should not predict or simply say terrible things because they would turn into reality. For example, if a scientist says that a tsunami can occur in Palu, it means that they wish for a tsunami to strike this region. The influence of Islam as

[43] Academic 01, interview by author, May 16, 2019.
[44] In Kaili language, *nakapali* means a taboo or restriction that should be avoided. If a certain taboo is broken or prohibited act is performed, there will be a rather negative consequence. This norm tends to teach local people to be positive thinkers.

the majority religion in Central Sulawesi has indirectly legitimized the *nakapali* norm. One of the tenets of the faith is that people should not precede destiny. As human beings, the people do not know what God's destiny for the future is. Thus, the best technology of TEWS would not be of substantial help if God has already decided to destroy a specific region.

The information about the high risk of tsunami probability in Palu and Donggala would only make people anxious. When people feel worried, they tend to not feel comfortable with their life. So, the local leaders often offer religious reasoning to make the community feel psychologically relaxed and secure. The religious dogma was utilized for the sake of a peaceful feeling within the community. But in the end, this sense of security can lead to hazardous consequences.

> Ok, scientific knowledge is from a man. Nevertheless, a man cannot defeat the knowledge from Allah SWT (God). That (tsunami) was destiny. A man can predict, but Allah SWT will determine everything. We are only human with full of weakness. […] We have to elevate our faith to Allah SWT, self –introspection, *dzikir* (pray) more, and more.[45]

In terms of tsunami risk perception, cultural factors play a significant role in Palu and Donggala. A large number of local people believe the recent tsunami is a punishment from God. After the tsunami, many people connected the tremendous catastrophe with the *Palu Nomoni Festival*. This issue was covered in local and international media. Although this event had aimed to introduce the traditional culture of Central Sulawesi, local people banned Palu Nomoni. Based on their previous experience, this event has turned out to be disastrous for the people in Central Sulawesi. *Palu Nomoni* was held three times in Palu and all of them coincided with disasters.

[45] Community 17, interview by author, May 18, 2019.

> The first festival in 2016, there was an earthquake in Bora Village Sigi Biromaru district. There was also a white crocodile that appeared during the grand opening.[46] The second festival in 2017, there was a windstorm along the coast of Palu. Moreover, the third in 2018 was a tsunami, earthquake, and soil liquefaction. I think it is pretty clear now that Palu Nomoni was the primary source of disasters.[47]

The local leaders were convinced about a *nasala adat* or misinterpretation and wrong implementation of traditional Kaili rituals. For example, the *Balia* rituals should have been performed only in front of the river.[48] They believe the river has a good nature since the water is flowing. However, at the festival, the organizer held the ritual in front of the ocean. According to the local leaders, this practice broke the rules and disrespected the ancestors. Their myth warns that the nature of the ocean could bring bad influence (e.g., diseases, disasters, harm) to the land along with the waves. After the tsunami, confronted by the debris of the tsunami and earthquake, the people expressed their disappointment with the government. They blamed the *Palu Nomoni Festival* and the organizer as culturally insensitive to the native tribe.

[46] In some Indonesian cultures, white crocodiles are believed to be incarnate animals (myth) that could be the sign of upcoming disasters.
[47] Community 11, interview by author, May 16, 2019.
[48] Kaili tribal medical treatment tradition that worships the gods and ancestral spirits.

Figure 3. One of the writings on the ruins of the house mention "Akibat Palu Nomoni" (a consequence of Palu Nomoni).[49]

The religious groups in Palu and Donggala concurred with the opinion of the local leaders, but for different reasons. They have influential religious leaders, the *Habib.* As a respected figure, *Habib* also has a strong influence on the community. In this case, they believed the Palu Nomoni Festival had indeed caused disasters since it was not sanctioned by the Islamic beliefs. The *Balia* ritual is categorized as *shirk* or worship of anything besides God. *Shirk* is one of the severe sins in Islam. Sooner or later, those who have indulged in *shirk* will receive punishment from God. In this case, God has given punishment directly during the festival.

Others connected the tsunami with the wrongdoings by the community in Palu and Donggala. For example, the area around Kampung Lere is well-known as a place for prostitution, gambling, alcohol, and peddling of drugs. These practices are considered as prohibited actions in Islam. So as in the case of Petobo and Balaroa, the areas most affected by soil liquefaction, were believed to be centres of gambling and prostitution. The religious

[49] Photograph was taken by the author.

leaders in Palu interpreted that sinners finally got the punishment that they deserve from God.

> If you see the pattern, the area full of immoral (according to Islam) was demolished first. In one region, behind a mosque, there was a karaoke bar with prostitute service. The waves destroyed it. […] I believe it was also a punishment from Allah SWT as well as a warning for us to be closer to Allah SWT.[50]

The strong cultural influences on perception of tsunamis could hinder the efforts of tsunami risk reduction. Seven months after the tsunami, the local government decided to stop the Palu Nomoni Festival forever. This news pleased some people since they thought that the trigger of the tsunami has disappeared. However, the risk of tsunami is very much present underneath the coast of the Central Sulawesi area due to the Palu-Koro fault movement.

The misperception of tsunami risk can lull the community into a false sense of security. Seven months after the tsunami, some people decided to resettle their homes in the coastal areas. The national government, through the Ministry of Public Works and Public Housing, has approved the hazard map zone of Palu City and the surrounding area. It states crucial rules about the red zone area, where the people are prohibited from building permanent housing in 100-200 meters along the coastline. However, some people ignored the regulation. They want to stay nearby in coastline since all of them are fishermen or work in the fishing industry.

[50] Community 09, interview by author, May 17, 2019.

Too little, too late: Disaster preparedness program shortcomings

Questions and concerns about tsunami risk reduction efforts in Palu and Donggala were raised shortly after the tragedy. Ideally, with the rapid population development in the coastal region and high risk of tsunami propensity, the responsible stakeholders should have encouraged and prioritized disaster risk preparedness. However, to carry out a meaningful disaster preparedness effort in Palu and Donggala was very challenging, especially in terms of political commitment.

At the national level, the Indonesian Disaster Management Law (No. 24/2007) delineates the pivotal role of disaster preparedness. The regulation can be found in Article 34 of Article 47 of the law. Article 37 Number 2 explains some actions that should be undertaken as preparedness measures at the local level which include developing a culture of disaster awareness, disaster risk identification and monitoring, and participatory disaster planning. This tell us that Indonesia has a strong commitment to disaster risk reduction. Nevertheless, the implementation of the law at the local level remains weak.

The local authorities in Central Sulawesi have undertaken significant measures with regard to tsunami risk preparedness. Back in 2012, under the reign of the former city mayor, Rudi Mastura (2005-2015), Palu had designed a contingency plan to combat the earthquake and tsunami hazards along the coast of Palu and including the West Coast of Donggala. This contingency plan running over 51 pages was prepared to deal with an earthquake with the epicentre on the Palu-Koro Fault with magnitudes of 7.4 MW, depth of 10 km, and shock duration of 40 seconds. The tsunami was estimated to be 4.3 metres high and would strike Palu Bay in 15 minutes. In such a scenario, the impacts were illustrated as follows: collapsed bridges, damaged roads, power outages, lack of access to

clean water, disrupted communications, limited logistics, price increases, and a high number of refugees. So, the projected scenario of the 2012 contingency plan was quite similar to the tsunami tragedy on 28 September 2018.

In the contingency plan, BNPB, in cooperation with the local authorities, held an event entitled "*Gladi Nasional Penanggulangan Bencana*" (National Disaster Management Rehearsal) at Talise Beach on 19 November 2018. Interestingly, the rehearsal included a tsunami drill which was followed by hundreds of community representative from five sub-districts of the Palu coastal region: Layana, Talise, Besusu Barat, Lere, and Silae. Also, the representatives from each city in Central Sulawesi attended the tsunami education and tsunami drill program. The participants intended to be disaster preparedness cadres in case of an emergency in their region. Around 100 participants had joined the disaster training. Besides being disaster preparedness cadres, they were also affiliated with the community program, namely Safer Community Disaster Risk Reduction (SCDRR).[51]

The tsunami drill program was useful for the community. In the tsunami simulation, the community in Palu, Sigi, and Donggala received information regarding evacuation route details and avoiding more severe damages. Unfortunately, according to former participants, disaster training in 2012 was solely ceremonial. The participants attended the event at Talise Beach, listened to the lecturer, and were reimbursed for transportation and food. There was no follow-up action after one-day of the tsunami drill.[52] The disaster preparedness cadres had never organized regular meetings to discuss the current disaster

[51] Local Government 01, interview by author, May 21, 2019.
[52] Community 10, interview by author, May 19, 2019.

condition in Palu Bay. Hence, when disaster battered the region on 28 September 2018, many people had forgotten how to evacuate themselves.

Since the initiation of the contingency plan in 2012, technically, there was no significant political commitment at the local level. Based on the contingency plan document, the technical plan should be updated regularly according to city development, population growth, infrastructure establishment, etc. Along with the transition of city leadership, the contingency plan had never been discussed at the local level anymore. In summary, there was no development concerning the disaster policies after the regime changes in Palu.

The local authorities argue that the disaster policies in Palu and Donggala have regularly been discussed in the annual meeting of provincial Musrenbang (Multi-Stakeholder Consultation Forum for Development Planning). There was a contingency plan, but there is no mitigation plan in the Central Sulawesi coast. However, the authority representative confesses that it is very challenging to include the mitigation plan into the city development planning. For example, in this year, Musrenbang (2019-2020), BPBD Palu, requested eight additional tsunami sirens for the coast of Palu and Donggala. The eight additional sirens will be placed in the western and eastern parts of the coast. The proposal for constructing the new tsunami sirens was briefly rejected by the provincial government since, at that time, there was no newly updated technology for tsunami sirens.[53]

For BPBD Palu, tsunami siren is essential to establish an effective warning communication with the community. On 12 April 2019, a 6.8 MW earthquake hit Banggai

[53] Local government 03, interview by author, May 21, 2019.

Island (Central Sulawesi). BPBD Palu received a warning and had immediately deployed the emergency response troops to alert the community with portable speakers. However, nobody trusted the manual warning from BPBD Palu.

Apart from the additional tsunami sirens proposal, BPBD Palu has conducted the training program for the community. Since 2017, BPBD Palu has built four disaster-resilient *kelurahan* (urban squatters) and has trained about 180 people as disaster preparedness cadres. Also, BPBD Palu encourages local and religious leaders (Islam and Christian) to participate in DRR efforts. In the future, BPBD Palu aspires to train eight disaster preparedness cadres in every urban squatter as partners to disseminate the warning and act as evacuation leaders in the case of an emergency.

Since 2017, the training programs of BPBD Palu were successfully implemented, but the outcome was still not visible. The BPBD Palu has experienced difficulties to sustain the program due to the lack of budget. As a responsible institution in the disaster-preparedness program, the BPBD Palu only receives approximately US$78,000 per year, and 40% of the budget is allocated for operating costs. Practically, it is not a strong budget to design good mitigation programs since BPBD has the responsibility to undertake three issues: pre-disaster, disaster, and post-disaster. To create better disaster mitigation planning, BPBD Palu usually establishes cooperation with NGOs.[54]

The BMKG Palu has also instituted some excellent initiatives since 2017. In cooperation with BPBD Palu, they have conducted risk assessment in the urban squatters' level in Palu. The map includes the hazards, potential exposure, and information on past disasters in Palu. The results of the risk assessment were about to be launched at the Palu

[54] Local Government 02, interview by author, May 16, 2019.

Nomoni Festival 2018. Unfortunately, the tsunami struck before the disaster kit could be disseminated to the communities. The BMKG Palu's leaflets on disaster management had also designed the evacuation routes and safe assembly points before the disaster occurred.

How native oral stories saved the people from a tsunami

"Ane lingu biasa nepone lembotalu"

"If there is an earthquake, usually (followed) with three high waves."

One verse of this proverb is quite prominent for the coastal communities in Donggala Regency. The proverb tells the story about the *lembotalu,* which means three strokes of the water cresting on the soil. Previously, most of the people did not know the term tsunami - they only knew *lembotalu*. Although it is not very clear when the oral stories began, but this story has been inherited from generation to generation.

Until now, the *lembotalu* story has saved thousands of people on the coast of Donggala. In remembrance of past tsunami events, the community understands how to react correctly during an emergency. Amongst them in RT (neighbourhood) 04 Labean Village, Balaesang sub-district, Donggala, there was no casualty. All of the coastal residents in RT 04 had evacuated themselves on the hills after the first foreshock in the afternoon.

According to the elders, the 2018 tsunami was very similar to the previous tsunami events in 1938 and 1968. In the past too, the tsunami had affected Labean Village. Common to these three tsunamis was a strong earthquake that had hit the region at the outset. So, by learning from past experiences, the coastal community considers the

earthquake as the natural alert of the tsunami event. That is why there were no fatalities in RT 04 Labean Village, even though many houses and boats had been ruined.

In Labean Village, the narrative story of *lembotalu* is related to the tsunami in 1968 because some tsunami survivors are still alive. However, the elders are convinced that *lembotalu* story has been passed on for hundreds of years since the famous volcanic eruption of Mount Krakatau in 1883. Endowed with the strong *tutura* or *mo tutura* (storytelling) culture, the tsunami survivors in Donggala transfer the knowledge to the younger generation. The survivors do not want to repeat the dark story of numerous fatalities in 1938 and 1968.

One informant who had experienced a tsunami in 1968 always narrates the story in great detail on every occasion to the family, relatives, and neighbours. He did not experience the tsunami in 1938, but he had heard the story from his parents. However, in 1968, when he was 20 years old, he finally experienced *lembotalu*. At that time, he worked as a *gerobak* driver around the beach.[55] He had witnessed how scary the three high waves were. Also, he still precisely remembers the details of that gloomy morning:

> It was Thursday morning. After *subuh* (early morning prayer), I went to the beach with my *gerobak* to escort the officer at the port. When I arrived at the beach, I heard the sound of an explosion. There was a strong earthquake afterward. Very strong until I could not handle my vehicle. The cows were anxious; their tails stood up and then ran away. In a few seconds, I saw the first wave in front of me. I have swept away around 50 meters but luckily could reach the firm root of the trees. I saw the second wave, it was not too high, but it was water with mud. I was released a little bit. However, the third wave was the highest one. Very high and muddy water was about 5-meters. I think many people died because of the third wave.[56]

[55] Traditional cart with two or four wheels which can be pulled by animals such as horses, cows, buffaloes, or goats.
[56] Community 24, interview by author, May 22, 2019.

Hence, based on his experience, he had led the community to avoid the coastal area after the first foreshocks were felt in the 2018 tsunami. He also informed the neighbourhood to bring logistics for a couple of days since he felt a bigger disaster would probably strike soon after. They reckon that the signs of the tsunami in 2018 were nearly the same with the tsunami in 1938 or 1968. However, the impact was more destructive. For them, the self-evacuation process is relatively reactive, so that the people already know the appropriate response should an earthquake and a tsunami strike.

In Tompe Village, Sirenja sub-district, Donggala, many people know about the story of *lembotalu* as well. Their response was similar to the community in Labean Village, they immediately evacuated themselves after the first earthquake. In Tompe Village, the earthquake was stronger since the epicentre was around Sirenja sub-district. All of the people evacuated themselves in a higher place in Sibado Village. Many coastal people in Tompe Village decided to move since they remembered the story of *lembotalu.*

> Yes, I heard lembotalu story many times. In 1968, I was only 3-years old. I did not clearly remember the event at that time. However, my father always told me this story. He said the coconut tree is high, but the waves could be even higher. He told me that one woman died in a tragic condition. She was naked, her entire body was full of wounds, and her long hair snagged at the tip of a coconut tree.[57]

Although, in the end, the tsunami exposure was relatively low in Tompe Village, it is worth noticing that the coastal people of Donggala possess a decent degree of disaster preparedness. Without instructions or warnings sounded in advance, people immediately evacuate themselves to avoid the possibility of the worst situation.

On the day of the tsunami, the coastal people also observed the natural signs which encouraged their decision to evacuate. The natural signs included, for instance, the extreme

[57] Community 16, interview by author, May 22, 2019.

low tide and the movement of animals (sheep, cows, buffalos, birds, and cats) to a higher ground during the earthquake. The community thought that animals have a stronger instinct than humans. Some people also heard the sound of ocean waves resembling boiling water before the tsunami crashed. The extreme heat in the ocean during the past two days before the tsunami was a natural sign of the tsunami too. However, those natural signs need further scientific investigation to validate their accuracy.

Additionally, in Pangga Village, Banawa sub-district, Donggala, the community perceives the tsunami as a part of the risk of living in the coastal region. Therefore, apart from reading the natural signs, they have been growing mangroves along the coastline for a long time. The local people believe mangroves are effective in reducing tsunami currents. Besides, the people had been following the birds' sound and behaviour around the mangroves as natural signs of the tsunami; for example, the birds promptly stop chirping if a disaster is about to come. The local people interpret mangroves as the symbol of protection from oceanic hazards and the balance of nature's coastal life.

Preserving tsunami memories

"Goya-goya gontiro. To' Kabonga Loli'o. Palu, Tondo, Mamboro Na' Toyomo. Kayumalue Melantomo."

"Earthquake in Ganti Village (Banawa, Donggala). Also, emerge in Kabonga and Loli. They look into the down. The people in Kabonga, Loli Oge, Palu, Tondo, and Mamboro have sunk. Only Kayumalue safe (from the tsunami)."

Besides the *tutura* (storytelling) culture, the local people of Central Sulawesi, especially the Kaili tribe, have a strategy to preserve the tsunami memories through poetry and song. The aforementioned verse of poetry is an interpretation of the earthquake and

tsunami tragedy in 1938. Up to now, the poetry is eminent amongst the elders in the Kayumalue region, North Palu, the only place which was saved from the tsunami in 1938. At times the people living there still share their memories of past tsunami events through those lyrics.[58]

Well-known as *kayori*, the poems or rhymes in the Kaili tribe aim to deliver a meaningful message to the people. The topic is not only limited to disasters and environment, but also concerns wise advice, love life, education, and peace messages. Nowadays, few people in the city of Palu or Donggala share their messages through *kayori*. However, the indigenous people living in the mountains or rural areas along Palu Bay still practise it.

Another form of oral story is the *dadendate,* which in Kaili language means a long song or a long melody. This culture originates from Taripa Village, Sindue sub-district, Donggala. Unlike *kayori*, many people still perform *dadendate* on some occasions, such as rituals or traditional ceremonies, weddings, and cultural events. The *dadendate* features moral values, advice, information, or news, and narration of history.

The artists and local musicians from Sigi Regency still perform the *dadendate* with *lalove* (traditional wind instrument). According to one of the artists, the lyrics in the *dadendate* often have a deep meaning. Some of the lyrics can be also related to the disaster in Palu Bay. One song contains the famous proverb of the Kaili tribe, namely *Agina Mainga, Ne' Maonga* (better to be alert and cautious than to drown). However, it is quite challenging to establish that the lyrics are connected to the tsunami events in Palu and Donggala.

[58] Academic 02, interview by author, May 16, 2019

To foster local knowledge and tsunami memories in the Palu Bay, NGOs in Central Sulawesi have begun initiatives through contemporary and traditional art, and disaster literature. The activists realize the significance of tsunami memories as an effective measure to promote disaster awareness, especially among the younger generation.[59] The lessons learnt from the tsunami in Donggala inspired them to be more active in improving earthquake and tsunami risk preparedness. Forum Sudut Pandang is one of the NGOs which is very active in expanding disaster literacy after the tsunami 2018. Their program comprises performance art entitled *Yellow Tsunami Memories*, building tsunami traces based on a field survey of tsunami deposit by scientist, publishing book about tsunami survivor stories "*yang kitorang rasa waktu gempa*" (what we felt during the earthquake), creating songs, poetry, and a documentary short film about the tsunami and earthquake tragedy.

Discussion: Going beyond technology

The results demonstrate the insufficiency of a technological fix to save the community at risk. The lack of attention to non-technical elements resulted in a major catastrophe. Theoretically, the InaTEWS model adopted a people-centred approach framework by UNISDR. This framework consists of four inter-related elements: risk knowledge, monitoring and warning service, warning dissemination and communication, and response capability. However, the implementation of InaTEWS was still very much focused on a

[59] NGO 01, interview by author May 23, 2019.

technical fix and it neglected the local context. This case study illustrated that when the technical component collapsed, the whole system plunged into an immediate downfall.

Furthermore, in terms of hazard, the InaTEWS could only detect tsunamis triggered by a direct earthquake. The system did not reckon the intrinsic characteristic of the Palu-Koro fault, which can generate local tsunamis, although previous studies had argued that the active movement of the Palu-Koro fault could generate a tremendous earthquake and tsunami. Moreover, the Palu Bay has a long history of tsunamis potentially arriving in less than five minutes after the main tremor. These allude to the fact that the establishment of the InaTEWS disregarded past tsunami events. Consequently, the performance of InaTEWS in the 2018 Central Sulawesi tsunami was not sufficient.

Some scholars underscore the complex interlinks between socio-cultural, economic, and political problems as an integral part of a successful EWS.[60] That argument can be explored in this case study where the social-cultural aspect plays a significant role in the tsunami risk perception of some communities. In Palu, some people perceived the earthquake as a normal situation and considered a tsunami as an impossible disaster that cannot take place in the Palu Bay area. Unfortunately, the inaccurate individual risk perception led to disastrous consequences.

The strong influence of local and religious leaders also determined the tsunami risk perception of the community. Some people adhere to strong beliefs about the tsunami as a punishment from God instead of developing an understanding of tsunami based on scientific knowledge. When the community is convinced of the beliefs or higher powers

[60] Carolina Garcia & Carina J. Fearnley, "Evaluating critical links," 133; Ignacio Farías, "Misrecognizing tsunamis: ontological politics and cosmopolitical challenges in early warning systems," *The Sociological Review* 62 (2014): 61.

that could hinder the effectiveness of EWS. Similar attitudes shaped people's responses to disasters in Nepal and Bangladesh, where people neglected the warnings since they surrender everything to God's plan.[61] So, the involvement of local leaders and religious leaders needs to be positively acknowledged with regard to the development of the EWS in Palu and Donggala.

The availability of scientific and practical knowledge as well as a comprehensive understanding of disaster risks is required to enable sound functioning of the EWS.[62] The case studies of Palu and Donggala illustrate that all knowledge related to disasters has already been incorporated in the community. However, the knowledge transmission from previous tsunami events was missing in Palu. The reason for a failure in transfer of knowledge was the lack of institutional education involvement (e.g., school curriculum) and the cultural factors.[63] So, tsunami preparedness education must accommodate formal education (e.g., tsunami drill, tsunami safe schools) and existing local knowledge.

The disruption of transfer knowledge concerning past tsunami events also happened in the 2010 tsunami in Mentawai, where the cultural link to the past tsunami events is less evident.[64] So, knowledge management through various forms about past tsunami events needs to be well-documented and well-disseminated throughout

[61] Sonja Ayeb-Karlsson et al., "I will not go, I cannot go: Cultural and social limitations of disaster preparedness in Asia, Africa, and Oceania," *Disasters* 43, 4 (2019): 752.
[62] Alcántara-Ayala, Irasema and Anthony Oliver-Smith. "Early Warning Systems: Lost in Translation or Late by Definition? A FORIN Approach." *International Journal of Disaster Risk Science*, 10, 3 (2019): 317.
[63] Anawat Suppasri et al., "A decade after the 2004 Indian Ocean tsunami: the progress in disaster preparedness and future challenges in Indonesia, Sri Lanka, Thailand and the Maldives," *Pure and Applied Geophysics* 172, 12 (2015): 3313.
[64] Miguel Esteban et al., "Recent tsunamis events and preparedness: Development of tsunami awareness in Indonesia, Chile and Japan," *International Journal of Disaster Risk Reduction*, 5 (2013): 93.

generations. An example is Japan, which enhances awareness through formal education, monuments or marks creation, and oral transmission.

Unfortunately, in the decentralized system in Indonesia, a comprehensive disaster education is a complex task to accomplish. It includes five associated national decrees, twelve ministry regulations, and regional or district regulations.[65] However, disaster education is essential as an integral part of the risk knowledge element in a people-centred approach to EWS. The lack of financial budget and inefficient institutional adjustment is a clichéd argument to explain the absence of disaster education in Palu and Donggala. This is a phenomenon in Banda Aceh as well, where 56% of public elementary schools are highly exposed to the risk of tsunamis but ironically primary disaster education does not feature in their curriculum.[66]

Interestingly, in terms of response capability, the findings show different capability levels between the community in Palu and Donggala. In the absence of a functional TEWS, the coastal people in Donggala saved themselves from the tsunami with memories from the previous tsunami events in 1938 and 1968. However in Palu, most people did not understand the local knowledge since many inhabitants are migrants.

In Donggala, with an influential storytelling culture spanning generations, the community preserves the tsunami memories. When the first earthquake occurred, many people evacuated themselves to a higher ground. Therefore, when the tsunami hit their region, the fatalities were less. The attention to the earthquake as a sign of a tsunami was

[65] Mizan Bustanul Fuady Bisri and Aiko Sakurai, "Disaster education and school safety governance after the 2004 Indian Ocean Tsunami in Indonesia: from national policy to local implementation," *Disaster Risk Reduction in Indonesia*, eds. Djalante et.al., (Cham: Springer, 2017), 189.
[66] A. Sakurai et al., "Exploring minimum essentials for sustainable school disaster preparedness: A case of elementary schools in Banda Aceh City, Indonesia," *International journal of disaster risk reduction*, 29 (2018): 73.

also recognized during the 1960 Pacific Ocean Tsunami, which affected coastal people in Chile, Hawaii, and Japan. The 2010 Chilean Tsunami prompted the coining of the term 'tsunami cultural legacy' where the community remembers and learns from the past tsunami events in 1960.[67] Local knowledge or mental models about previous events are thought to be put into action when a disaster strikes.[68]

The employment of local knowledge as natural warning signs in Donggala is evident from other case studies too. On a global scale, the role of local knowledge has been prominently recognized in some case studies as a complementary of technical EWS to various hazards. For example, despite the failure of warning transmission from Australia, the people in Tikopia village (Solomon Island) survived the cyclone attack. The local people took attention to natural signs and took cover under rocky overhead cliffs.[69] The tribal community in Rajasthan (India) anticipate climatic disasters such as incoming droughts and floods by observing the colour of clouds, the unusual sounds and changes in water flow, colour of water, direction of the wind, and the unusual behaviour of wildlife like ants, birds, and snakes.[70]

In Indonesia, the inherited oral story of *Smong* saved thousands of inhabitants in Simeleu Island. Likewise, in Mentawai Island (Sumatra) has an ample potential of local knowledge that can be employed as a coping capacity against disasters, e.g., the empowerment of local leaders, the folklores or urban legends (oral stories), and traditional music instruments for warning tools.

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[67] Miguel Esteban et al., "Recent tsunamis events," 87.
[68] Matthew Lauer, "Oral traditions or situated practices? Understanding how indigenous communities respond to environmental disasters," *Human Organization* 71, 2 (2012): 186.
[69] Loti Yates & Linda Andersson-Berry, "The environmental and societal impacts," 16.
[70] Pareek Aparna & P. C. Trivedi. "Cultural values and indigenous knowledge of climate change and disaster prediction in Rajasthan, India," *Indian Journal of Traditional Knowledge* 10, 1 (2011): 185.

Despite the success involved, local knowledge has many shortcomings. The natural signs can become tricky and misinterpreted without strong scientific knowledge. For example, extreme low tide is considered by the community as one of the tsunami signs. However, scientific studies have revealed that low tide can be a normal phenomenon in the ocean. Besides, to read the natural signs through the different colours of the ocean and clouds will not be of help if and when a tsunami occurs in the night.

Nevertheless, local knowledge can be and should be tapped to complement the technical components of the EWS.[71] So, a sustainable and culturally compatible framework is necessary to link the existing local knowledge and scientific knowledge for the mitigation of disasters. In the context of Palu and Donggala, the oral stories of *bombatalu* or *lembotalu* have proved to be useful in increasing the tsunami risk knowledge and tsunami readiness. So, the efforts to design a better implementation of the EWS should consider incorporating local knowledge.

Apart from improving the technical aspect, enhancing a people-centred approach has emerged within the governments and NGOs. In other words, the governments and NGOs have been addressing socio-cultural aspects of EWS, such as disaster education and training, scientific and local knowledge organizations, designing effective media and communication tools for EWS. However, these programs are not a novelty in Palu and Donggala.

Nowadays, to ensure sustainability and the effectiveness of people-centred approach programs (e.g., community empowerment, capacity building, risk mapping)

[71] Jessica Mercer et al., "The potential for combining indigenous and western knowledge in reducing vulnerability to environmental hazards in small island developing states," *Environmental Hazards*, 7, 4 (2007): 245.

remains problematic. In general, the lack of political commitment is the predominant factor in hampering the efforts to create a successful InaTEWS. The case of the 2012 contingency plan in Palu is an example of how intricate the DRR efforts regulation becomes during transition of regimes.

A sustainable policy from one political leader to the next will strengthen and complement better DRR policies in Palu and Donggala. Besides, community participation in the policy-making often assures the sustainability of EWS services.[72] Unfortunately, the EWS program and policies at the downstream level still follow a top-down approach with a lack of community initiatives. The allocation of low budgets has aggravated the DRR efforts, including the TEWS project in Palu and Donggala.

Conclusion

The tsunami in Palu and Donggala illustrates the failure of the technical components of the InaTEWS. The community did not receive any alerts in advance before the tsunami struck. As a devastating consequence, thousands of people were swept away by harrowing tsunami waves since a big festival had been organized along Talise Beach, Palu.

In summary, the newly developed technology of InaTEWS can only detect tsunamis that are directly triggered by earthquakes. It indicates the lack of attention to human elements at the local level. Though the past tsunami and earthquakes have revealed the hazardous movement of the Palu-Koro fault in Palu Bay, efforts to strengthen the community risk knowledge were few and far between. The last tsunami drill event recorded

[72] Denis Stanley Chang Seng, "Improving the governance context and framework conditions of natural hazard early warning systems," *IDRiM Journal* 2, 1 (2012): 25.

was conducted on 19 November 2012. The contingency plan of Palu city was not undertaken any more by local authorities since its initial planning in 2012.

This paper highlights the significance of social, cultural, political, and economic elements in the development of the EWS. However, it does not argue that the technical aspect of the EWS is less critical. Rapidly improving information communications and technology will enhance the technical capacity of EWS instruments to make precise forecasts about one or multiple hazards. All in all, the development of the EWS should acknowledge the local characteristics of the risk (exposure, hazard, and vulnerability).

This study suggests policy implications for better EWS practice in Indonesia. Article 44 of the Indonesian Disaster Management Law (No. 24/2007) defines early warning as "*immediate warning activities to the public about the possibility of a disaster occurs in a place by an authorized institution*." The law has not yet considered the community-based early warning, which actually could save people at risk, for example, the case study in Donggala Regency. Apart from incorporating local knowledge in the EWS, it is necessary to include disaster education into curriculum into public schools as stated in the mandate of Article 34 to Article 47 of the Indonesian Disaster Management Law (No.24/2007).

The dynamics of InaTEWS development in Palu and Donggala remain debated upon and hence require further investigations. Specifically, during the phase of rehabilitation, the national government made a controversial decision to construct a 7.2 km sea-wall along the coast of Palu.[73] This plan was initiated by the Japan International Cooperation Agency (JICA) based on the experience of the Great East Japan Earthquake

[73] Muhammad Arshandi, "The city of Palu supports sea-wall development by JICA," *Antara*, May 8, 2019.

in 2011. The soft-launch of a sophisticated technology called Indonesia Earthquake Early Warning System (InaEEWS) by BMKG Jakarta in August 2019 shows that DRR efforts are still limited to a technocratic approach. Can reckoning the unpredictability of tsunami occurrence from a technocratic point of view reduce tsunami risk in the Palu Bay?

After the tsunami in Central Sulawesi, followed by the tsunami in West Java and southern Sumatra in the same year, the national government has initiated a brand-new early warning procedure. On 15 August 2019, BMKG held a soft launching ceremony of the InaEEWS in collaboration with the Institute of Care Life (ICL) - China. As part of trials, ten sensor tools had been installed in Banten (West Java), and in the next phase, 190 sensor tools will be installed in West Sumatra, Lampung, and West Java. If this trial is successful, the system will be expanded to all over Indonesia.

The national government's decision to establish a new measure with the technical approach could be controversial. Notably, recent publications concerning the assessment of InaTEWS in Aceh Province has illustrated the numerous limitations to produce an inclusive multi-hazards EWS; for instance, limited activity on risk knowledge and monitoring elements, lack of coordination between responsible stakeholders, inadequate understanding of the critical role and responsibilities of local institutions, and inadequate recognition on vulnerability elements.[74]

[74] Sofyan Sufri et al., "Progress in the early warning system in Aceh province, Indonesia since the 2004 earthquake-tsunami," *Environmental Hazards* (2019): 25.

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