Different vantage points amongst different stakeholders in NATECH (NAtural hazard-triggered TECHnological) disasters: A case from the 2018 Mt. Anak Krakatau eruption and tsunami

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Abstract. Previous literature on natech (Natural hazard-triggered TECHnological) disasters argue prevailing difficulties in establishing collective response and sharing common knowledge amongst different and a variety of stakeholders. We aim to describe such challenges using a case study and examine the relationship amongst the actors. Our case study focused on the 2018 Mt. Anak Krakatau eruption and the tsunami triggered by it. In this disaster, one of the largest industrial zones in Indonesia was partially affected. Our study largely explains the results based on some series of discussions with private companies and representatives of the residents collected in 2019 (from February to July). We also referred to the publicly available information, which relevant agencies in the Government of Indonesia issued. Although there were no physical damages in the factories and no causalities, staff in many facilities were worried about the situation and the surrounding residents were also scared how things would be going. The residents were not able to behave in collectively organized manner, because they faced with a lack of the synthesized and coordinated information and instructions. The residents were fully aware of the risk of natech disaster, but such awareness was not necessarily connected with reasonable risk perception and organized behaviours. Relevant organizations complied with their own protocols, but it did not necessarily bring better consequences. The meteorological agency disseminated information in their limited capacity. The volcano monitoring agency paid the limited focus on the volcano and its adjacent sea area. The national and local disaster management agencies tried to integrate technical information, but it took time. The companies carefully gathered information, but their priorities initially went to their internal response, including taking care of the families of their employees. These findings indicate that efforts were done in the right course separately and it is hard to achieve harmonized response under great uncertainty during a crisis.
1. Introduction

Previous literature on natech (Natural hazard-triggered TECHnological) disasters argue prevailing difficulties in establishing collective response and sharing common knowledge amongst different and a variety of stakeholders (Gill & Ritchie, 2018). Showcasing the Izmit Earthquake (also known as the Kocaeli Earthquake) that struck Turkey in 1999, which caused a massive fire at the TUPRAS Izmit refinery and the acrylonitrile spill at the AKSA acrylic fiber production plant, Girgin (2011) described the complexities and the great difficulties in emergency situations taken by the local government, the local people, the chemical plants and the search and rescue teams. In the case of Great East Japan Earthquake, Yu et al. (2017) introduced a natech case (a fire at a refinery), and revealed that factories, local governments and local residents tried to behave in an organized-manner but such behavior was not shown in a real crisis.

The present study looks into Mt. Anak Krakatau that erupted in the night of Saturday 22 December 2018, and tsunami was associated with that eruption. The detailed mechanism of tsunami generation is still examined in progress, and studies on the local people’s behavior is very limited. The study by Takabatake et al. (2019) is a quite exceptional research, and their research focused in the severely inundated areas by tsunami. Apart from the heavily inundated areas, we aim to shed light on a fact that the tsunami wave reached one of the largest chemicals and steel industry areas, Cilegon, in Indonesia. Cilegon is located in the western edge of Java Islands and is known as one of the most well-known and significant heavy industrial areas in Indonesia (Lestari et al., 2018). The government of Indonesia and ASEAN (Association of Southeast Nations) had already fully paid attention to the potential threats of natech scenario prior to the Anak Krakatau eruption and tsunami. After the Indian Ocean Tsunami 2004, the Indonesian government carried out the national tsunami simulation in 2007 (Rahayu, 2012). Additionally, the Cilegon city government developed tsunami early warning system (Wir Yadnata et al., 2019). These efforts finally reached a large-scale preparation exercise. On November in 2018, just almost two months earlier from the eruption and tsunami, ARDEX (ASEAN Regional Disaster Emergency Response Simulation Exercise) was conducted in Cilegon (AHA Centre, 2018). The reason that Cilegon was selected as the host place for the event was that ARDEX-2018 aimed to respond to natech issues. However, the real phenomena of the 2018 eruption and tsunami was totally different from the scenarios which were prepared before.

![Figure 1. Location of Cilegon](image)

Note: This map was made by the authors using the Google Map.

In Cilegon, the height of tsunami was approximately 30 cm, and the wave did not cause the natech incident. According to the media reports, some facilities of a large-scale chemical company (PT Chandra Asri) were struck by waves, but the impact was minor. On-line media articles (e.g., Selatsunda.com, Detik Finance and Bantennews) reported that the factories are prepared for automatic shut-downs in case of emergencies. Yet, Kompas –the biggest Indonesian media– indicated that inaccurate information was disseminated, and a huge confusion was observed (Kompas, 2018). Tribunnews introduced a story that the local people in Cilegon were seriously confused by the tsunami
incident and their behavior seemed like a panic (Tribunnews, 2018). JawaPos mentioned that the police officer denied an inaccurate information, which sea water reaches 7 meters in the Port of Merak in Cilegon. While there were no substantial damages in Cilegon, the local people may have faced with the unusual situations and such social disorder is required to be verified.

The authors have had started some series of studies and practices in Cilegon since 2017 (Jibiki et al., 2018), and been observing that all of the local government, local industry and local communities well understand risks of volcano eruptions, tsunami and natech events. As noted above, it was certain that Cilegon did not have any natech damages, but the society was influenced by a threat of the natech. Thus, we preliminary aim to describe such social phenomenon using a case study and examine the relationship amongst the actors.

2. Method
Our study largely explains the results based on some series of discussions with private companies and representatives of the residents collected in 2019 (from February to July). We also referred to the publicly available information, which relevant agencies in the Government of Indonesia issued.

2.1. Visiting the private companies
We visited 9 companies in Cilegon from 11th February to 15th February 2019. Details of the 9 companies are 4 chemical companies, and 5 steel and metal industry.

2.2. A focused group interview at community level
We conducted a focused group interview (FGD) on Saturday 20th July 2019.

In total, 22 participants were invited in the FGD. The participants are a head of a village (locally called “kelurahan”), two staff from the village office, representatives of the neighborhood associations (known as “RT (Rukun Tetangga)” and “RW (Rukun Warga)” in Indonesia), and staff of a volunteer group (locally called “Destana (Desa Tangguh Bencana)”).

The village, Lebak Gede, locates nearby a LPG facility (Pertamina: a state-owned energy company) and it has the coastal line of Sunda Strait behind the LPG tanks.

3. Results
3.1. Response of the local people
Based on our focused group discussion, we observed that the local people faced with great confusion. First, some types of information caused the residents’ disorganized actions. According to the FGD participants, they heard different information on the height of tsunami and the inundation areas from the different information source. Later, they understood that the information was not accurate. One FGD participant heard about tsunami from a person who got off a boat from the Sunda Strait. Some of the FGD participants directly heard big sounds of the eruption, and these sounds caused a panic. Also, the hawks made the situation worse. Others heard a big sound, which generated by a phenomenon that the rope of the ship was broken (cut-down). Furthermore, unknown persons used the loud speakers of the mosques without any permission and screamed, and it caused a great confusion among the local people. One FGD participant witnessed that waves came back and forth to the coastal line, but it was difficult to understand what happened because the night of 22nd December was the full moon, and the rise and the fall of the tides were bigger.

Second, the FGD participants indicated fear for natech. During the initial days soon after the eruption and tsunami, they heard that an expert from a local university (University of Sultan Ageng Tirtayasa) said in a forum at the local disaster management agency (the Forum PRB inauguration meeting) that Cilegon was safe because the Lotte Chemical was still operating. On the other hand, the local residents were worried about contamination with tsunami and chemical spill at that time. The local office of Pertamina did not provide official information or warning immediately after the disaster occurred, but later (not clearly mentioned in FGD) did that through some residents who work at Pertamina. The
community tried to get information informally about what happened inside the LPG facility and whether any incidents occurred. Initially, the residents officially asked to the local office of Pertamina if they would provide information, but Pertamina did not respond to such an official communication.

3.2. Response of the industry
The companies in Cilegon carefully gathered information, but their priorities initially went to their internal response, including taking care of the families of their employees.

Many companies run the 24 hours operations usually, and in the night of the eruption and tsunami, many employees worked at each facility. Also, the companies needed to take care not only their own employees, but also their contractors and subsidiary workers in the factories. Families of the employees were worried and they asked their husband and children to be evacuated. But, the factories needed the employees in order to maintain the appropriate operation. From the onset of the disaster (approximately 21:00 in the evening) to the next morning, the companies had to manage these situations.

Some companies have their own tidal gauges and monitored changes of the waves. The chemical factories mainly receive the raw materials supply from ships on the Sunda Strait by piping and jetty. In order to maintain smooth and safe transportation of the raw materials, they always carefully monitor the sea level changes using their own devices. At the night of 22nd December, they witnessed the sea level change. In the same time, they received many messages in their mobile phones, some from their friends and others from their colleagues, and they noticed that the tsunami was happening.

However, as we describe in the next section, the national government did not provide integrated disaster information, and the government itself was confused by such a sudden and unfamiliar disaster. BMKG (Badan Meteorologi, Klimatologi, dan Geofisika or Agency for Meteorology, Climatology and Geophysics) was not able to immediately issue tsunami warnings, and PVMBG (Pusat Vulkanologi dan Mitigasi Bencana Geologi or Center for Volcanology and Geological Hazard Mitigation) also did not provide quick information and did not change the volcanic alert level. Thus, for the companies, it was almost impossible to refer to and rely on the government information.

3.3. Response of the national government authorities
As the preliminary study, we visited official websites of the government bodies and examined how they reacted. We focused on three major bodies: BMKG, PVMBG and BNPB (Badan Nasional Penanggulangan Bencana or National Disaster Management Agency). The reasons we selected these three bodies are BMKG is responsible for tsunami warnings, and PVMBG is dealing with the volcano monitoring. BNPB is considered as one of the main disaster management bodies, in which by law is stated as the National Disaster Management Agency.

These agencies released official information through their websites, and we specifically focused on the initial stage of their response. As the shortcoming of this study, we do not gather social media information such as the Twitter and the Facebook. The analysis of the social media role is our future work.

In the case of the Anak Krakatau eruption and tsunami, one of the most confusion thing was that it was scientifically and technically difficult to issue tsunami warnings just after the incident. As BNPB issued their information on 23rd December, BNPB used a term “Gelombang Tinggi (high wave)” instead of a term “tsunami” (see Table 1 on the next page). BMKG repeatedly explained and emphasized that their tsunami monitoring was developed based on scenarios that the tectonic style earthquakes induce tsunami. BMKG claimed that the Anak Krakatau case was a different type of the disaster and they were not able to issue tsunami warnings.

For the volcano monitoring, PVMBG issued a press release on December 27th and notified that the seismic devices set at Mt. Anak Krakatau was lost at 21.03 of 22nd December, and it implied the eruption. Also, PVMBG added that they were able to use the seismic station for the subsequent monitoring in Sertung Island, located nearby Mt. Anak Krakatau. This information is very important for the public, because it shows PVMBG struggled with a situation that they needed to evaluate the activities.
of the Anak Krakatau using the limited resources, and it implies that it is very difficult for PVMBG to make detailed and accurate assessment of the volcanic activities.

Table 1. Information issued by the national government authorities

| Date               | Source                                      | Details                                                                                             |
|--------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------|
| 23 December 2018   | <PVMBG>                                    | Pers Riis Aktifitas Gunungapi Anak Krakatau, Minggu 23 Desember 2018 (Press Release for Anak Krakatau Volcano Activity, Sunday, December 23, 2018) |
|                    | <BNPB>                                     | Dampak Gelombang Tinggi, 3 Tewas dan 21 Orang Luka-Luka (High Impact Waves, 3 Killed and 21 Injured) 01:20 WIB |
|                    | <BNPB>                                     | Korban Tsunami Terus Bertambah, 20 Meninggal Dunia, 165 Luka-Luka dan 2 Hilang (Tsunami Victims Continue to Increase, 20 Dead, 165 Injured and 2 Missing), 05:52 WIB |
|                    | <BNPB>                                     | Benar, Tsunami Menerjang Pantai di Selat Sunda (That's right, the Tsunami Crashing Beach in the Sunda Strait), 07:08 WIB |
| 26 December 2018   | <BMKG>                                     | Masyarakat Diminta Menjauhi Pesisir Pantai Selat Sunda Hingga 1 Km (People Are Asked To Stay Away From The Sunda Strait Coastal Coast To 1 Km) |
| 27 December 2018   | <BMKG>                                     | Kepala BMKG Berharap Media Tangkal Hoaks dan Imbauan Jauhi Pantai Selat Sunda (BMKG Head Hopes Media Prevent Hoaks and Appeal Away from Sunda Strait Beach) |
|                    | <PVMBG>                                    | Pers Riis Aktivitas Gunungapi Anak Krakatau, Kamis 27 Desember 2018 (Press Release of Anak Krakatau Volcanic Activity, Thursday, December 27, 2018) |
|                    | <PVMBG>                                    | Peningkatan Status Aktivitas G. Anak Krakatau Dari Level II (Waspada) Menjadi Level III (Siaga) (Increased Activity Status of Anak Krakatau from Level II (Waspada) to Level III (Siaga)) |
|                    | <BNPB>                                     | Status Gunung Anak Krakatau Dinaikkan Siaga (Level III), Radius Berbahaya Diperluas Menjadi 5 Km (Status of Mount Anak Krakatau Raised Siaga (Level III), Dangerous Radius Expanded to 5 Km), 09:00 WIB |
| 31 December 2018   | <BMKG>                                     | BMKG Ungkap Kronologi Tsunami Selat Sunda (BMKG Reveals Sunda Strait Chronology) |

1. http://www.vsi.esdm.go.id/index.php/gunungapi/aktivitas-gunungapi/2563-pers-riilis-aktivitas-gunungapi-anak-krakatau-minggu-23-desember-2018
2. https://bnpb.go.id/dampak-gelombang-tinggi-3-tewas-dan-21-orang-luka-luka
3. https://bnpb.go.id/korban-tsunami-terus-bertambah-20-meninggal-dunia-165-luka-luka-dan-2-hilang
4. https://bnpb.go.id/benar-tsunami-menerjang-pantai-di-selat-sunda
5. https://www.bmkg.go.id/berita/?p=masyarakat-diminta-menjauhi-pesisir-pantai-selat-sunda-hingga-1-km&lang=ID&tag=selat-sunda
6. https://www.bmkg.go.id/berita/?p=kepala-bmkg-berharap-media-tangkal-hoaks-dan-imbauan-jauhi-pantai-selat-sunda&lang=ID&tag=selat-sunda
7. http://www.vsi.esdm.go.id/index.php/gunungapi/aktivitas-gunungapi/2567-pers-riilis-aktivitas-gunungapi-anak-krakatau-kamis-27-desember-2018
8. http://www.vsi.esdm.go.id/index.php/gunungapi/aktivitas-gunungapi/2566-peningkatan-status-aktivitas-g-anak-krakatau-dari-level-ii-waspada-menjadi-level-iii-siaga
9. https://www.bnpb.go.id/status-gunung-anak-krakatau-dinaikkan-siaga-level-iii-radius-berbahaya-diperluas-menjadi-5-km
10. https://www.bmkg.go.id/berita/?p=bmkg-ungkap-kronologi-tsunami-selat-sunda&lang=ID

4. Discussion

Although there were no substantial physical damages in the factories and no causalities, the staffs in many facilities were worried about the situation and the surrounding residents were also scared how things would be going. A thorough analysis in this study suggests that the residents were not able to behave in collectively organized manner, because they faced with a lack of the synthesized and coordinated information and instructions. The residents were fully aware of the risk of natech disaster, but such awareness was not necessarily connected with reasonable risk perception and organized
behaviors (Britton, 1988). Relevant organizations complied with their own protocols, but it did not necessarily bring better consequences. The meteorological agency disseminated information in their limited capacity. The volcano monitoring agency paid the limited focus on the volcano and its adjacent sea area. The national and local disaster management agencies tried to integrate technical information, but it took time. The companies carefully gathered information, but their priorities initially went to their internal response, including taking care of the families of their employees. These findings indicate that efforts were done in the right course separately and it is hard to achieve harmonized response. That phenomenon is consistent with the findings that Girgin (2011) and Yu et al. (2017) analyzed. In Indonesia, the national government has its own unique system for disaster risk reduction, and many bodies are involved in emergency response. Moreover, the coordination between bodies is often not easy because they are not under the same ministry or coordinating ministry. For examples, PVMBG belongs to Ministry of Energy and Mineral Resources, and that Ministry is under the coordination of Coordinating Ministry of Maritime and Investment. BMKG is an autonomous body and under the coordination of Coordinating Ministry of Maritime and Investment. BNPB is an autonomous body and under the coordination of Coordinating Ministry of Human and Culture Development. Meanwhile, Ministry of State Enterprise and Ministry of Industry are responsible for the industry, and these two ministries are under the coordination of Coordinating Ministry of Economies. Taking into consideration such complexity of the government structure, it seems to be inevitable a situation that different information comes from different sources and emergency response is to be individual rather than collective, especially in sudden-onset and unfamiliar crisis just as the Anak Krakatau case.

This research is the preliminary effort and provide suggestions for future directions of studies. First, we carried out only one group interview to explore the local people’s response. It is quite obvious that the findings need to be strengthened and to be generalized. In Cilegon, the industry zone is divided into three parts, and we consider it is reasonable to implement surveys in each zone for synthesizing findings. In order to clarify behaviors of the national government authorities, we focused on the official information on their websites. However, we need to also study their social media articles, because many people accessed them in order to seek reliable information and guidance. Considering the warning and evacuation studies, different types of factories need different length of time for the safety procedure and shutdown. Such time constraint definitely relates with the calculation of the lead time in warning dissemination. We underscore these aspects are essential to advance this preliminary study.

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