What we can learn from 2018 liquefaction in Central Sulawesi: Stories from the survivors

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Abstract. This paper provides the stories of the liquefaction survivors about their experiences during and after the disaster. It is a phenomenological study that used the semi-structured interview to obtain the data. The data were acquired from 30 participants. There are some important points that can be summarised from the stories of the survivors. During the disaster, local people inclined to underestimate the quake at the beginning of the shaking. It could indicate the level of their risk perception and awareness on disaster. In addition, a unique finding from this study was that the survivors had conducted the initial intervention priority as basic resources for survival such as shelter and information of the victims’ identity. Also, regarding the post-disaster data, the results indicated that the survivors experienced the symptoms of trauma due to the disaster. It indicates that the psychological aspect of the survivors was neglected during the recovery process. On that regard, long-term traumatic recovery activities should be put into accounted during the recovery processes for all the victims of a disaster regardless of their ages and genders. Another implication of this study is the opportunity to use these stories into learning activities, both in learning about science or disaster mitigation.

1. Introduction
In 2018, a major earthquake with a magnitude of 7.4 Mw struck Palu, the capital city of Central Sulawesi, along with the surrounding regencies of Donggala, Parigi Moutong and Sigi. The strong ground shaking triggered other disasters such as tsunami, liquefaction and landslide in different parts of the region. While the intense quake destroyed buildings such as public facilities and houses, the tsunami destroyed the coastal areas. In Southern Palu, soil liquefaction buried the whole villages and a landslide closed the main access of Dolo to the outside which isolated the survivors for a couple of weeks.

People in Sulawesi have been familiar with an earthquake along with the tsunami and landslide. Due to the geographical situation of Indonesia, the locals have witnessed these events frequently through mass media or by direct experiences. However, liquefaction had left the survivors with the most disbelief. Although the earthquake alone had caused tremendous damages, the trace of liquefaction was insanely horrifying to the affected areas. In the Central Sulawesi case, the liquefaction happened owing to the soil structure which is composed of thick alluvial deposits and contains silt and clay, and it has shallow groundwater that then promoted the flowability of the liquefied soil [1–3].

Months after the event, liquefaction and its catastrophic effects had attracted the attention of engineers and seismologists to learn about the soil profiles in Central Sulawesi. Numerous research had been conducted to measure and investigate the Palu-Koro fault system and the causes of that hazardous disaster (e.g. [4–6]). The other studied the methodology for constructing house and building and groundwater control to reduce the risk of liquefaction [7,8]. However, the extent of possible chronologies of the event and resulting community impacts are not well understood or well documented.
There is a dearth of understanding about the processes people go through the deadly events. The scarceness of documents of survivors’ stories indicated the lack of space currently given to talk and share their experiences, and to be heard. Listening to the actual stories of the survivors is imperative especially in terms of the post-disaster recovery process [9].

After the disaster, we learned that the local people defined liquefaction as Nalodo, which means collapsed in the mud. The existence of a local term for liquefaction denotes that liquefaction had occurred before. However, the information resources about this phenomenon, such as notes and studies are scarcely reached by the public. This study aims to document the stories of survivors during the disasters and after the disaster to prevent their stories being erased by time. The narrative of the survivors can be used to unfold details that cannot be seen through scientific theories. In addition, the existence of the documents containing survivors’ stories can depict what they had been through during the disaster. Deepening understanding of what had happened in people's lives can be used as a means to gauge the level of resilience and vulnerability of the survivors in the aftermath of the disaster. Furthermore, it can be utilized as a source for emotional and political investigation and as a base for formulating the proper approach for post-disaster trauma recovery. To be more specific, this study aims to provide an overview of the liquefaction experiences from the perspectives of the eyewitnesses, during and after they survived from the disaster, including the descriptions of soil liquefaction, the survival attempts from mud trap and the post-disaster life.

2. Method
In this study, we focus on survivors' experience during the liquefaction disaster, henceforth we used a phenomenological methodology. The use of phenomenology as a study of phenomena is to describe how things appear to people through experiences and to provide a detailed explanation of people’s real life experiences [10].

Participants in this study were the survivors of the earthquake on 28 September 2018, who had experienced the direct soil liquefaction event. We used purposive sampling to identify the primary participants based on our judgment and the purpose of the research. In order to trace additional participants, we used snowball sampling by asking one participant to recommend others for interviewing. There were 30 participants, 16 were women, 14 were men. Their ages ranged from 40 to 55 years old.

The interviews were conducted by the research team and two volunteers from the affected areas. Before the interview, we gave the guide of the interview to them and highlighted the information that should be gained from the participants. We intended to make the interviews as conversations that were loosely structured to allow the participants to tell their experiences. We used semi-structured interviews which began by asking the participants “Can you tell me about the event, from the moment before the event to the moment when you felt that you had been saved?” The follow-ups questions were based on the initial stories of the participants.

Prior to the interview, the interviewers explained the purposes of the interview to participants and they read the consent forms. Interviews were conducted in places that were chosen by the interviewees which were mostly in their houses. We interviewed participants face to face approximately 22 months after the disaster. The length of the audio-taped interviews ranged from 4 to 30 minutes. We used pseudonyms in lieu of participants’ names to protect confidentiality.

Audio-taped were transcribed before being analyzed for codes and categories. The constant comparative method was used to analyze data by assigning codes by sorting the data into groups of categories that should reflect the purpose of the study [11]. Then, the group of categories translated from Bahasa Indonesia into English by the second author.

3. Result and Discussion
3.1. During the disaster
3.1.1 First Responses to the Quake
Most of the survivors indicated sharing the common first responses to the quake, such as running to the open space. However, some underestimated the shaking at the beginning. They stated that experiencing frequent earthquakes made them dismissive of the quake. As Jamal expressed:
Before the disaster, my family and I were at the house. After the first shock at around 4 pm, we have been used to earthquakes like that because we are in Palu. We can say that this (the quake) happens very often here so we were still at home calmly like usual. And then we were shocked, we were shaken very intensely then we left our house.

Some survivors perceived the mainshock would be a low-level earthquake thus they intended to stay inside their homes before going outside. These frequent low-intensity shaking led people to ignore the disaster before the mainshock occurred. This finding supports the previous studies that reported how experiencing the frequent and minor effects of small quakes can lead people to decrease their awareness and preparedness toward disaster [12–14].

3.1.2. Confronting the Soil Liquefaction

The time interval between the quake and liquefaction was short. The liquefaction occurred right after the quake stopped. Seven participants mentioned that before the mud came, they saw black-thing came from the upper areas (eastern area) along with a strange loud sound. For instance, Azis said:

Suddenly, I heard a roaring sound...not long after I heard that sound, I looked towards the upper area (eastern part of Jono Oge) and I saw there were black waves. I did not know that that was mud.

Moreover, participants likened the devastating experience of being trapped in the current of mud as being in the blender machine. For example, a participant explained:

When being dragged, I was twisted, sank, hit wood, and was crammed between them... the mud was like hard, soft and hot... and wavy, like sea waves... My mind was very chaotic, I was dragged by mud, I felt like my body was twirled in mud, do you know how fruits in a blender machine? Yes, that was how my condition at that time, all of my body was covered by mud. I could not stop or direct my body when I was dragged by it because it was so strong.

The location of Petobo and Jono Oge districts was less than 10 km from the epicenter. This close distance to the epicenter might result in a strong sound, like roaring and thunder sound, heard by the participants. Although the sound does not contribute to the estimations of macroseismic intensity, it caused massive fear and panic to survivors [15]. Some participants also experienced lateral spreading ground failure when they pointed out how they were running at the same place because the road they were stepping on was also moving. The road remained the same in shape, but they moved as the result of liquefied soil under the surficial soil layers. They also saw the shift up and down movement of their houses while moving. It indicates that all types of ground failure due to liquefaction occurred. In addition, the hot temperature of mud indicated the possibility of soil boiling.

From the stories, there were some science concepts found, such as sound, substance characteristics, and types of ground failure. Since the disaster curriculum currently has gained the attention of the central and local government in Indonesia, including the actual incident stories in the disaster or science curriculum could give positive influence for students. It is in accordance with the statement of Saleh and Pendley [16] and Rae [17] who believed that a safety or disaster curriculum should involve the real cases or experiences of the disaster and accidents.

3.1.3. Escaping from Liquefaction

The participants encountered different circumstances and situations during their attempt to stay alive amidst the current of mud. They told stories about their efforts to survive while they were dragging and buried by the mud; what they had been through and the states of their mind while waiting for the fortunes and miracle to come. The length of hours of survivors trapped in the mud before getting out of or being rescued from the mud was varied, ranging from 1 hour to more than 10 hours.

While swayed away and surrounded by the mud, participants indicated the importance of the existence of hard and solid objects to hold. They helped the survivors to stay on the surface. Nusa labeled the solid objects as the treasure. He claimed that most of the survivors were those who were capable of climbing to the roofs of the sinking houses. Other objects that the participants used to help them were above the surface roots and the stems of the fallen trees, the cable of power poles and timbers.
It shows that it is imperative to look for a light yet solid material for footing while escaping from the earthquake.

In the middle of confusion due to the unprecedented and horrific situation, most of the participants expressed their reliance on and surrender to God. When they were asked how they could survive, most of the participants expressed that they begged the almighty for help. In addition, they claimed that surviving from that terrific event was owing to God’s help and that that time was not yet their ajal or the time to die. Besides, survivors also stressed the imperative of being mindful and focused on that situation. Although previous studies have reported the significance of religion for mental problems after the disaster (e.g. [18–20]), there has been no study found which specifically researches what and how is the role of belief and religion for the survivors during a disaster. It has not been justified, however, turning to God might help the survivors to stay calm in a chaotic situation. In the liquefaction case, they claimed that focus and mindfulness helped them to mind what they can hold onto and what they can step on. Running hastily without a destination will increase the risk rate for injury [21]. Further, self- and mutual aids are significant in the early time of rescue after the disaster.

3.2. Peri-Disaster
3.2.1. First quick response after the disaster
After surviving from the mud, most of them reported that they were escorted or were ordered to gather at the mosques in a neighboring village. When they arrived, some people wrote their identity and built emergency tents with available materials. A participant reported:

When we (the survivors) were taken to the mosque, our names were immediately recorded, to make it easier for the family to find a family that was washed away by the mud, then my son came to find me.

Participants have shown that they had done the initial intervention priority as basic resources for survival such as shelter and information of the victims’ identity [22]. It was a unique finding because socialization related to disaster mitigation is scarcely conducted for locals. Disaster education even disseminates very slowly in Central Sulawesi. It is interesting how, albeit a dearth of information about the first aids, the locals have had the initiative to provide the refugee camp and the dissemination related to disaster mitigation. The residents in Central Sulawesi had experienced multiple earthquakes. It needs further investigation whether these first quick responses were promoted by their disaster subculture due to the frequent disastrous hazards that had affected them.

3.3. Post-disaster: The Trauma
Due to the deadly and near-death experience, the participants indicated the post-disaster trauma by remembering the event. A participant said that she even could not stand the sound of the wind. She will immediately feel scared and uneasy if she hears disaster news, such as floods, and the sound generated by the wind. She recalled:

It's hard to tell (about it). The wound reappeared. I remembered my family. If I tell you the story, what appears in our mind is the destruction of the Petobo (her village). It’s like a wound, it hurts my heart. When I told you this story, I got goosebumps. Alhamdulilah, all of my family survived. But since we (the neighbours) were from the same neighbourhood, the same tribe, we were one family. It is painful.

It indicates that the participants' feelings are still trapped in the situation. The memories of losing family members, loved ones, and their properties put the victims in a state of despair and shock. Moreover, survivors of liquefaction suffered from losing their neighbourhood where they had spent their entire life. The neighbourhood is associated with both human and social capital. Losing it was like losing the entire community, the families and all the memories of their lives. A sense of losing a place was the most catastrophic impact of natural disasters on the survivors [23]. The liquefaction forced the survivors to reside in a new environment and community. They experienced the environmental change, the loss of resources, daily routine, social support which connect with stressors [22,24].

This study does not highlight the psychological effect of disaster experience. However, a glimpse of the survivors’ answers supports broadening concepts regarding the nature of disaster impact on acute stressful experiences (e.g. [25–27]). It demonstrates how the survivors fail to recover from that horrific experiences.
event. It indicates that many survivors may experience trauma after perceiving a mortal risk to themselves at the event. This issue needs to be addressed since pre-existing trauma could risk developing psychopathology after a disaster [27,28]. Also, injured survivors of the previous earthquake would likely get injured again in future events due to the trauma [21]. Moreover, long-term psychological distress could be experienced by the survivors especially by those who had severe traumatic experiences [24]. Accordingly, survivors should get support in terms of mental aids to recover from this trauma.

4. Conclusion

The geographical situation of Indonesia leads to the frequent earthquakes felt across the country. However, these recurrent events have caused local people to underestimate the quake on 28th September 2018. Instead of increasing the awareness and preparedness of disaster, disaster experiences with an insignificant impact on them and their surroundings seemed to generate their ignorance towards the possibility of immediate risk from a disaster. The collected data of this study indicated that all types of ground failure; flow failure, ground oscillation and lateral spreading, occurred in this event. Further, since most of the survivors mentioned God in their stories, it is intriguing to find the role of their faith in God during the disaster, such as how they feel about the disaster and the process of their survival. The results could benefit on how to build resilience for mental recovery. Moreover, although this study was not weighed in the psychological aspect, it is worth considering for future work. The high frequency of rejection from survivors to participate could be a sign of posttraumatic stress disorder (PTSD). Also, there is information from the participants regarding the occurrence of the liquefaction that can be involved in science and disaster curriculum. We are contemplating whether it would be possible to include the survivors’ stories into classroom activities as a method for disaster risk reduction (DRR) education dissemination. Bringing more contextual topics to the classroom would certainly increase students’ engagement. However, it requires further investigation whether it will trigger students’ interest in learning, or trigger their nightmare.

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