Today in Thailand: multidisciplinary perspectives on the current tsunami disaster risk reduction

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Abstract: Thailand is one of the many countries in Asia that fell victim to the monstrous 2004 Indian Ocean tsunami. To date, there has been tons of effort to reduce disaster risk in Thailand. Nevertheless, there is still a considerable margin for improvement. This paper aims to review previous efforts and measures that have been taken to reduce Thailand’s risk to disasters, and highlight possible areas for improvement. We use the disaster risk management as a thought-framework for our review, where we discuss Thailand’s current disaster risk reduction (DRR) measures from a multi-perspective: the tsunami numerical simulation, tsunami warning system, tsunami evacuation sign, manuals and guidelines, evacuation shelters, housing recovery, hotel business and recovery, public awareness and media, and disaster education. In understanding the current state of disaster risk efforts, we will then highlight potential areas for improvement.

Despite not being a disaster-prone country compared with some other countries, Thailand has encountered a number of natural disasters. Table 1 shows a summary of the damage from natural disasters in Thailand for the last 50 years (1968–2018); and it is the geophysical natural disaster that resulted in the highest total number of deaths. When looking at Table 2, which focuses on the earthquakes that have affected Thailand over the last 50 years (1968–2018), it can be seen that there were four major earthquakes which occurred in 1995, 2004, 2011 and 2014.

The 2004 Indian Ocean tsunami and earthquake remains one of the deadliest natural disasters in recorded history (Imamura et al. 2017). The monstrous tsunami swamped the coast of many countries; one of the hardest hit countries was Thailand. In Thailand alone, almost 8345 people were pronounced dead and many remained missing (Leelawat et al. 2015). The devastating impact of the 2004 Indian Ocean tsunami remains a nightmare for the locals, reminding them that Thailand may not be emancipated from the wrath of future tsunamis.
The 2004 mega-quake and tsunami, coupled with several aftershocks, emphasized the need for implementation of disaster reduction measures. To strengthen the resilience of the community to potential tsunamis, the Thailand authorities and participating organizations have introduced several disaster risk reduction (DRR) programmes and measures. However, there are few studies in the literature that look at these measures holistically. This article aims to discuss the past and current tsunami DRR measures and approaches that are in place, based on current literature and observations from a field visit to Phuket. We will look at the measures and approaches adopted from a multidisciplinary perspective.

In our paper, we will discuss the progress of DRR measures in Thailand based on the disaster risk management (DRM) cycle (shown in Fig. 1). The DRM cycle can be segmented into four different phases: (1) preparedness for a natural disaster; (2) response; (3) rehabilitation and reconstruction; and (4) prevention and mitigation. Our research attempts to unravel measures taken to reduce the risk of potential disasters, based on each aspect of the DRM cycle. This paper will, ideally, provide a comprehensive coverage of existing disaster risk efforts, we use the DRM as a framework for thought, on which we base our literature review. For each phase of the DRM cycle, we focus on the essential risk reduction measures (shown in Fig. 1). Since Phuket was one of the regions hit hardest by the 2004 Indian Ocean tsunami, the measures implemented in this region (especially for the ‘response and rehabilitation’ phase) shape our research approach. Following the DRM framework of thought, we aim to piece together a complete picture of the existing disaster risk efforts in Thailand, and, ideally, contribute novel ideas and a fresh perspective to the DRM cycle. In piecing this review together, information was collected and cross-checked across several platforms, including official disaster risk platforms (i.e. the Department of Disaster Prevention and Mitigation) and academic papers.

### Preparedness for natural disasters

In Thailand, after the 2004 disaster, the government paid attention to reducing the tsunami risk. The official law, the Disaster Prevention and Mitigation Act, B.E. 2550 (2007), has been used since 2007. The main official organization that works with disaster-management-related tasks is the Department of Disaster Prevention and Mitigation.

#### Table 1. Summary of the damage based on natural disasters in Thailand from 1968 to 2018

| Disaster subgroup | Occurrence (people) | Total deaths (people) | Injured (people) | Affected (people) | Homeless (people) | Total affected (people) | Total damage (000 US$) |
|-------------------|---------------------|-----------------------|------------------|-------------------|------------------|------------------------|------------------------|
| Biological        | 7                   | 241                   | 0                | 43 373            | 0                | 43 373                 | 3 725 500              |
| Climatological    | 12                  | 0                     | 0                | 41 982 602        | 0                | 41 982 602             | 7 375 500              |
| Geophysical       | 4                   | 8347                  | 8496             | 76 050            | 0                | 84 546                 | 1 062 000              |
| Hydrological      | 81                  | 4159                  | 3509             | 59 771 476        | 204 737          | 59 979 722             | 46 842 808             |
| Meteorological    | 37                  | 1025                  | 514              | 5 151 808         | 113 741          | 5 266 063              | 892 600                |

Source: EM-DAT: The Emergency Events Database (Université catholique de Louvain (UCL) – CRED, D. Guha-Sapir – http://www.emdat.be, Brussels, Belgium: accessed September 2019).

#### Table 2. Summary of the occurrence of the earthquakes affecting Thailand from 1968 to 2018

| Year | Earthquake magnitude (ML) | Total deaths (people) | Injured (people) | Affected (people) | Total affected (people) | Total damage (000 US$) |
|------|---------------------------|-----------------------|------------------|-------------------|------------------------|------------------------|
| 1995 | 5.2                       | 1                     |                  |                   |                        |                        |
| 2004 | 8.0                       | 8345                  | 8457             | 58 550            | 67 007                 | 1 000 000              |
| 2011 | 6.7                       | 1                     | 16               | 58 550            | 67 007                 |                        |
| 2014 | 6.3                       | 1                     | 23               | 17 500            | 17 523                 | 62 000                 |

Source: EM-DAT: The Emergency Events Database (Université catholique de Louvain (UCL) – CRED, D. Guha-Sapir – http://www.emdat.be, Brussels, Belgium: accessed September 2019).
of Disaster Prevention and Mitigation (DDPM) in the Ministry of the Interior. In addition, the DDPM is also working hard to follow the priority actions and goals of the Sendai Framework for Disaster Risk Reduction (United Nations International Strategy for Disaster Reduction (UNISDR) 2015).

The first step in preparing the nation for looming tsunamis involves locating the tsunami-prone regions. Understanding the potential tsunami inundation depth, velocity and area in these regions will provide government officials, urban planners and disaster scientists with a better understanding of the disaster, which enables them to make more informed evacuation and recovery strategies. One method in which these factors can be studied is via tsunami numerical simulations. In addition to evaluating the tsunami hazard, having state-of-the-art warning systems and an established warning organization are crucial in preparing for disasters. The synergy between the tsunami numerical simulations and warning system can potentially reduce the time taken for evacuation and improve the efficiency of evacuation during a disaster.

Tsunami numerical simulation

Tsunami numerical simulations are essential tools for tsunami hazard evaluation and are implemented at the disaster-preparedness stage of the disaster management cycle. These tools, which have been developed by applying long wave theory in the deep seas and shallow water theory in shallow seas, simulate tsunami wave propagation. One notable simulation tool developed in 1995 by Tohoku University, Japan, is TUNAMI. Following its invention, this tsunami simulation tool has been used subsequently in other countries which are at risk of tsunami hazard (Imamura 1995). Using TUNAMI, one can simulate disturbances of a free surface caused by an earthquake, which in turn generates tsunami wave propagations. The formulation of TUNAMI opened doors for the development of numerical tsunami wave generation and propagation models. When attempting to simulate tsunami wave propagation on land, high-resolution topography data are required. This permits tsunami inundation area, depth and velocity of a region to be illustrated. In Thailand, high-resolution topography
data are provided by the Land Development Department at a grid spacing of 5 m and high-resolution near-shore bathymetry data are provided by the Royal Thai Navy from field surveys.

The accuracy of TUNAMI was verified with observed data from the 2004 Indian Ocean tsunami, and the model was subsequently applied to investigate tsunami-induced impacts on several countries, including Thailand (Ruangrassamee and Saelem 2009; Suppasri et al. 2011; Srivihok et al. 2014). In recent years, TUNAMI has been improved and is widely implemented in tsunami hazard areas around the world (Latcharote et al. 2016, 2018a, b). The latest version of TUNAMI, which is a nested-grid tsunami simulation using non-linear long-wave theory in a deep sea and nonlinear shallow-water theory in a shallow sea, has been used to evaluate future tsunami hazards in Thailand. In addition to the 2004 tsunami research, there were also several studies looking at potential tsunamigenic sources (Socquet et al. 2006; Cummins 2007; Okal and Synolakis 2008; Wang et al. 2013; Okal 2019). Focused regions include the northern Sunda megathrust, including the Arakan Trench and the Andaman Trench, as shown in Figure 2 (left). The nested-grid tsunami simulation with 15 m grid inundation was conducted to simulate tsunami hazards hitting built environments around the Andaman coast. As shown in Figure 2, this study selected the Andaman-Nicobar subduction zone as a potential tsunamigenic source to simulate a Mw 9.0 earthquake scenario along a fault length of 575 km and a width of 145 km. The results of the above-mentioned tsunami inundation simulation with high-resolution topography data in Khao Lak (Phang Nga Province) and Patong Beach (Phuket Province) are shown in Figure 2 (right). These inundation maps are examples of the potential tsunami inundation mapping that has been performed in Thailand.

In addition to the study area of Andaman, there are also some previous studies that focused on the possibility of tsunami in the Bay of Thailand (Ruangrassamee and Saelem 2009; Suppasri et al. 2012). However, the expected impacts are considered lower than on the western side of the country.

Tsunami warning system

Having a well-devised tsunami warning system will better prepare people for future tsunamis. Since the

![Fig. 2. Sunda subduction zone (left: the star indicates the epicentre of the Mw 9.0 earthquake scenario as a potential tsunamigenic source in the future) and the simulated tsunami inundation map (right: the light blue colours indicate the inundation areas).](image)
occurrence of the 2004 Indian Ocean tsunami, the need for a tsunami warning system has been highly regarded in Thailand; most probably due to the haunting death counts and loss of revenue from the tourism industry.

Following the 2004 tsunami, the National Disaster Warning Centre (NDWC) was established, based on the Hyogo Framework for Action 2005–2015 (HFA) (UNISDR 2005). The HFA recognizes early warning as a useful tool to reduce vulnerabilities, save lives, and help to protect livelihoods and national development gains, and to improve preparedness and response to natural hazards (UNISDR 2005, p. 2). Therefore, the installation of a tsunami warning system is one of the key vulnerability reduction programmes that has been implemented in Thailand (Thanawood et al. 2006), and an example of the tsunami warning siren can be seen in Figure 3. To date, the NDWC is still the official organization that is permitted to issue a tsunami warning in Thailand following the Disaster Prevention and Mitigation Act (2007).

As part of the broader support from the United States government (USA) for the Indian Ocean Tsunami Warning System (IOTW), at an early stage the NDWC in Thailand received a grant from the United States Trade and Development Agency (USTDA). This grant was primarily used to obtain technical assistance from the Pacific Disaster Centre (PDC) and partners in disaster management, and to improve the capabilities of the warning system.

Leelawat et al. (2015) found that the process of the NDWC issuing a warning has been improved from 20 minutes to about 5 minutes due to their systematic process and procedure.

Response
Swift response is pertinent for disaster evacuation. Following the 2004 Indian Ocean earthquake and tsunami, the people residing along the coast of Thailand had only a short time to flee the disaster scene. The slightest delay in evacuation could, and did, cost thousands of lives during the tsunami. In this section, we review the current disaster response measures and highlight the gaps.

We conducted a site visit to the Phuket and Phang Nga provinces in Thailand in early June 2019, with the intention of observing and studying the current state of tsunami preparedness in the region. Phuket and Phang Nga were chosen as our study sites as they were among the hardest hit areas during the devastating 2004 Indian Ocean tsunami. It is expected that a region which experienced a crisis at this scale would most probably take more precautions.

Tsunami evacuation sign
A paper by Suppasri et al. (2015) reported that there were design implementations which facilitated evacuation in several provinces within Thailand. One of
the notable implementations included tsunami evacuation signage. During our observation, we were graced with the opportunity of seeing several of these famed tsunami evacuation signs. Although there is continuity in evacuation instructions every 100 m (Suppasri et al. 2015), the heavy traffic observed on our field trip and as reported in Suppasri et al. (2015) could hinder smooth and effective evacuation should there be an impending tsunami. Furthermore, in several locations within the Phang Nga Province, many tsunami evacuation signs have been weathered and eroded (Suppasri et al. 2015). During our field visit in 2019, we observed that several tsunami evacuation signs in the city had been obscured by advertising posters.

Tsunami evacuation manuals and guidelines

Although many hotels located on the coastline of the six provinces in Thailand have instructions and information about the tsunami, we also found some different examples. By visiting one hotel in Phuket Province, we noticed that there was little to nearly no mention of tsunami evacuation. The resort resides in Thalang District of Phuket Province and sits no further than 200 m from the shoreline. Given its distance from the shore and its geographical location, the resort is situated in a tsunami risk zone.

Tsunami evacuation shelters

During our field visit to Phang Nga Province, we visited a tsunami evacuation shelter. The shelter was a triple-storey infrastructure, with the first floor being the ground floor and the third floor being the roof (as shown in Fig. 4). While the evacuation shelter did serve the purpose of evacuation, the shelter appeared to be poorly maintained due to a lack of use. The shelter was dusty and debris-filled, and the toilets also appeared to lack maintenance. The roof had speakers that probably served the purpose of communicating messages or as a tsunami warning siren.

Rehabilitation and reconstruction

During the 2004 Indian Ocean earthquake and tsunami, many houses and hotels along the coast of Thailand were destroyed. Many people lost their homes, and many hotel businesses flopped. In this section, we discuss the challenges faced by the Thailand authorities, organizations, citizens and hotel business owners in rehabilitation, and the measures they took to improve disaster recovery.

Housing recovery

Housing is one of the most important considerations at the disaster recovery stage and efforts to improve housing recovery should be studied. In our paper, we defined ‘housing recovery’ as the measures taken to house people via reconstruction, renovation and other housing programmes. We conducted a study on housing recovery efforts that follow various types of large-scale natural disasters. The scale of this study required the participation of various concerned stakeholders. The study concluded that some of the housing programmes which worked
particularly well included those that prioritized community participation during the post-disaster recovery. However, it should be noted that residents were only allowed to take part in the reconstruction process of self-built relocated house projects (Sararit and Kondo 2014b).

In addition, flexible management over 11 years following the 2004 Indian Ocean tsunami provided diverse types of post-disaster permanent housing. Nevertheless, most of the housing reconstruction and funding were fully supported through donations (Sararit 2018).

Following the occurrence of the notorious 2011 Thailand floods, the disaster which resulted in the greatest nationwide economic loss, the government introduced a ‘checklist’ to evaluate the progress of housing recovery. This checklist was used by the local governments to evaluate the flood relief’s financial support to the residents (Sararit and Kondo 2014a). However, many victims of the flood utilized only a small fraction of the provided funds to renovate the house by ‘repainting better’ and not ‘rebuilding better’. There was little reconstruction that enhanced flood protection.

The post-2014 Chiang Rai earthquake housing recovery is a relatively successful one when compared to the post-2011 Thailand floods recovery. Although the housing recovery was supported by the same local governments as those for the 2011 flood, a different approach was taken. Instead of simply providing residents with funds, they ensured that the funding provided was used to purchase materials for reconstruction. These efforts provided residents with opportunities to work with non-governmental organizations (NGOs) and to learn how to construct houses that would be resilient to future earthquakes.

Thailand’s overall post-disaster housing recovery has improved significantly since the 2004 Indian Ocean tsunami. The most considerable improvements were observed in the reconstruction system and the collaboration between different stakeholders. However, it is not correct to presume that the post-disaster reconstructed houses across Thailand meet the safety standards to cope with future disasters.

Hotel business recovery

Loss of life and infrastructure damage are usually the most highlighted consequences of a natural disaster. However, the economic losses associated with these disasters should not be overlooked. An example of a severe post-disaster economic trauma would be the business loss for the hotels located along the coast in Phuket, Thailand in 2005. When the 2004 Indian Ocean tsunami swallowed the coast of Phuket Province, many of the hotels situated within 500 m of the coastline, especially Patong Beach, were severely damaged. The occurrence of the tsunami, directly and indirectly, resulted in the overall hotel occupancy falling to below half of its usual occupancy. The decline in the number of tourists hit Phuket Province’s economy hard, as the hotel and restaurant industry accounts for a third of Phuket’s gross primary production (C9 Hotelworks 2015).

Interestingly, it was the tourists’ impressions and notions of post-disaster Phuket, and not the post-disaster reconstruction, that contributed significantly to the closure of the hotels. A study by Tang et al. (2019) showed that the usual tourist numbers lagged the completion of the reconstruction by 10.8 months. Despite having completed reconstruction, tourists to Phuket Province did not return as quickly. This lag was not anticipated by the hotel industry, and poor business led to the closure of many hotels. This incident serves as a reminder to various stakeholders to focus on providing a better tourism recovery plan.

Prevention and mitigation

Public awareness and media

Raising public awareness of natural disasters is essential to disaster mitigation. Only when people understand the risk that they are facing will they be better prepared for future disasters. Prior to the 2004 Indian Ocean earthquake and tsunami, the concept of a tsunami was not well understood, and was nearly unheard of by the Thai citizens and authorities. As Thailand governing bodies previously did not consider the possibility of a tsunami arriving at its coasts, it is not surprising that most of the country’s media platforms and channels paid more attention to the weather and sea-level related forecast.

After the establishment of the NDWC, there have been several collaborations between the media agencies, public sectors, academic institutes and international organizations. One of these collaborations was driven by the launch of the Thai Public Broadcasting (Thai PBS) channel in 2008. Such channels take on the role of supporting the country’s social development with high-quality, factually accurate news.

The M 8.6 strike-slip earthquake in April 2012 triggered a tsunami warning. Although there was no tsunami, the warning prompted people to immediately evacuate from the risk zone. However, most people chose to evacuate the coast by cars. It resulted in a traffic jam in Phuket Province. This shows that the people in Phuket Province were responsive to the warning of disaster but were not as aware of the measures to take should there be an impending disaster.

In 2011, the Great East Japan Earthquake tsunami and Thailand floods became the driving forces for the media to reshape their role in disaster mitigation and reduction. Instead of solely providing disaster-related news during times of crisis, they
launched initiatives to increase public disaster awareness.

An example of an initiative launched by Thai PBS is a TV programme titled "Ru Su Phai". This TV programme was first aired in 2012 as a public awareness programme, and it provided coverage on natural-disaster-related news and documentaries. "Ru Su Phai" (or Don't Panic) is a very comprehensive TV programme (see Fig. 5) that covers all phases of the DRM cycle. Many leading experts from various academic institutions were invited onto the programme to educate the masses.

In addition, the Disaster Communication Centre was established to train news reporters from both domestic and international news media (shown in Fig. 6). By attending this programme, the participants will learn how to communicate with people during times of crisis.

Furthermore, the Thai Meteorological Department (TMD) is also taking part in providing disaster-related information to the different media platforms.

Thailand’s media coverage on disaster-related news and documentaries has made giant leaps since the 2004 Indian Ocean earthquake and tsunami. When compared on the international stage, through the great effort of their contribution, the Thai media won the Best Human Story in the fourth ABU awards on Climate Action and Disaster Management Preparedness in 2019. They received their ABU award because their programme provided a great influence on society bearing in mind the contents related to DRR. In particular, there was an episode which also linked to other aspects, including the environmental issue. The episode talked about a monk in Ubonrachatani Province in Thailand who introduced solar energy to the community. Thus, it was not only about reducing the energy budget but the community could also reduce their CO₂ emissions.

Also, it was found that the annual tsunami drills organized by the DDPM have been engaged actively by local citizens, including students in the local areas. With this support from the government and local government, it can help the participants learn about what they should do in a real situation.

Disaster education programmes

In addition to increasing public awareness of disaster risk and its reduction strategies through media platforms, there are several formal disaster programmes that have emerged since the 2004 Indian Ocean earthquake and tsunami. According to an article by Preston (2012, p. 1), ‘disaster education is a new area of enquiry in the field’. There is much to learn about disasters; their risk, impacts and mitigation strategies.

There are three official governing bodies in Thailand that are responsible for disaster risk education (Siripong 2010): the Ministry of Education, Department of Disaster Prevention and Mitigation (DDPM); the Ministry of the Interior; and the National Disaster Warning Centre (NDWC). It is noted that currently the NDWC has been moved to be a part of the DDPM.

In this subsection, we will only be discussing disaster education that is delivered through formal

![Fig. 5. Ru Su Phai (Don’t Panic) TV programme aired on the Thai PBS Channel broadcasting the news of the 2016 Southern Flood in Thailand (photograph taken by the authors).](image-url)
One of the formal disaster education programmes is the ‘Capacity Development in Disaster Management in Thailand’. The goal of this project is to increase disaster preparedness in schools located in disaster-prone areas by disseminating disaster risk knowledge to more people (Siripong 2010). The Ban Tha Chatchai School in Phuket is a pilot school for this project.

This occurs not only in educational activities run by the schools in Thailand but also in many disaster education programmes run in collaboration with other countries that are conducted in elementary, middle and high schools in Thailand (Yasuda et al. 2018).

At the university level, there are many established disaster management degree programmes, many of which incorporate tsunami studies as one of their subjects. Some examples of the undergraduate programmes include: the Environmental Engineering and Disaster Management Programme of Mahidol University, Kanchanaburi Campus; the Disaster Management and Public Hazard Mitigation Programme of Valaya Alongkorn Rajabhat University; and the Disaster Programme of Suratthani Rajabhat University. Some examples of programmes offered at post-graduate level include: the Disaster Preparedness Mitigation and Management Programme of the Asian Institute of Technology; the Earth System Science Programme of the Interdisciplinary Graduate School of Earth System Science; the Andaman Natural Disaster Management Programme of the Prince of Songkhla University, Phuket Campus; the Disaster Management Programme of Naresuan University; and the Risk and Disaster Management Programme of the Graduate School, Chulalongkorn University. The number of formal disaster risk management programmes offered in Thailand today is extensive, indicating that disaster education has made significant progress since 2004.

Furthermore, in many places affected by the 2004 tsunami, monuments have been erected: for example, the Ban Nam Khem Tsunami Memorial Park (see Fig. 7) and the T.813 Monument in Phang Nga Province. In addition, there is also a campaign from people who were volunteers after the 2004 tsunami to build a Tsunami Memorial Museum as a place to share information from the 2004 event (Leelawat 2019). There was also a monument constructed of two boats in the Ban Nam Khem area; however, this area has now been renovated for other purposes.

Discussion and Conclusions

Based on our findings, this section provides the issues and discussion of some potential solutions including the issues of technology-based disaster response, tsunami evacuation signage, tsunami evacuation manuals and guidelines, and tsunami evacuation shelters.

Technology-based disaster response

The current tsunami warning system in Phuket provides residents and tourists at the scene
approximately 20 min to evacuate. This amount of time is very short. While the warning system by NDWC is considered advanced, there could still be large margins of human error which could occur (i.e. not being sure of which direction to evacuate). In times of crisis, the lack of systematic procedures in place and a lack of information pertaining to directions could result in slower evacuation. Plans and implementations to improve this process could focus on improving evacuation procedures through novel systems (i.e. coloured street lamps to show people the evacuation route). These novel evacuation systems could be coupled with state-of-the-art geographical information technology, which could better inform on the optimal evacuation route during times of disaster based on real-time information. This geographical information technology can provide speedy, reliable, scientific information, which allows decision-making personnel to make better decisions through more detailed information (Liu 2018). This advanced technology coupled with a coloured street-lamp lighting system could possibly reduce evacuation time by margins. Nevertheless, effectiveness of these technologies has yet to be tested.

Existing technologies focusing on identifying the presence of incoming tsunami could also reduce the vulnerability faced by the people near the shorelines of Thailand, by predicting incoming tsunamis at an earlier time. DART is a buoy system that serves as a near-shore and distant tsunami early warning system (Bernard and Titov 2015), and could possibly give people who are vulnerable to the disaster a head-start to evacuate the disaster zone.

Crowd sourcing for disaster-related information through social media platforms such as Twitter has also been increasingly popular (McCallum et al. 2016), and provides extremely useful information on disaster managements (Wang and Ye 2018). These novel uses of technology often have the following benefit: they have geocodes attached to them, allowing the pinpointing of the disaster location even quicker than some observatories. One of the biggest advantages of these crowd-sourcing platforms is that as much data could obtained for a fraction of the cost of collecting it from a conventional gauging station (McCallum et al. 2016). When combined with modern software technology, such as Hadoop, complex, large datasets can be condensed into simple solutions to deal with disaster-related problems (Dhamodaran et al. 2015).

Social media platforms also allow people to report and qualify more information pertaining to the disaster. In addition, they also allow identification of people’s needs (Goswami et al. 2018; McCallum et al. 2016). These social media platforms yield more valuable data than traditional techniques, as conventional methods ignore social sentiments (Dhamodaran et al. 2015). The geocodes attached to the posts from Twitter provide an additional advantage: it allows authorities to send alerts to people and rescue teams within the vicinity of the disaster, in which information could reach the masses faster than traditional methods (Dhamodaran et al.

Fig. 7. Ban Nam Khem Tsunami Memorial Park in Phang Nga Province (photograph taken by the authors on 7 June 2019).
2015). This crowd-sourcing technology could be coupled with the advanced geographical information technology to assist in disaster response and recovery. In recent years, global initiatives such as the Standby Task Force and Digital Humanitarian Network are also harnessing the power of near-real-time mapping to support humanitarian response efforts (McCallum et al. 2016).

**Tsunami evacuation sign**

As part of the evacuation procedure, tsunami evacuation signage still plays an important role in directing people towards evacuation shelters. Nevertheless, the constraints of heavy vehicle traffic in the region (as discussed above) hinder effective evacuation. Policies could be put in place to ensure that there will be an organized evacuation process. Furthermore, various stakeholders in disaster-prone regions should ensure that tsunami evacuation directions are within sight of the public. Annual disaster drills conducted in Phuket could also be implemented in other disaster-prone locations across Thailand. These disaster drills could serve as ‘performance reviews’, where they help to inform authorities in areas of the disaster response phase that could be improved upon.

**Tsunami evacuation manuals and guidelines**

Policies could be put in place to ensure that resorts and hotels provide guests with disaster risk evacuation information. However, these policies will also require constant regulation to ensure that evacuation information is available to guests (i.e. random spot-checks to see if evacuation instructions are provided). One of the ways in which hotels can save costs in providing disaster-related materials is to provide e-pamphlets, which provide similarly thorough instructions through electronic delivery. These pamphlets could possibly be accessed by QR code technology.

**Tsunami evacuation shelters**

Local authorities might have to put emphasis on shelter conditions. Shelters are homes to people during times of tsunami, and must be regularly maintained so that they can perform their function during times of disaster. Poor shelters could lead to the spread of diseases and great discomfort. One possible means of keeping shelter conditions up to standard is to use the shelter for community engagement activities, such as get-together sessions, or even converting these shelters into part-time multipurpose halls. Continual usage of these shelters will ensure that basic amenities, such as toilets and lighting, are up to ‘liveable’ standards.

**Disaster education implementation**

As we found, many academic institutes have decided to provide courses or curriculum for disaster risk management. Nevertheless, these seem to only catch the interest of students or residents in the risk or disaster-experienced area. Therefore, there is still a need to discover the factors that influence the intention to study disaster risk management in less-disaster-experienced areas.

**Conclusions**

Although it has been almost 15 years since the 2004 Indian Ocean earthquake and tsunami disaster that swamped many Asian and African countries, we still have to make sure of our preparedness in order to reduce the vulnerability and risk from upcoming similar disasters in the future. This article reviewed and summarized the important issues along the DRM cycle from the past to the current situation in Thailand, one of the highly impacted countries. Despite a big effort and contribution from many concerned stakeholders, both public and private organizations, it can be seen that there are still many issues requiring the attention of people.

With more knowledge, more technology and more experience (Imamura 1995; Latcharote et al. 2016, 2018a, b; Leelawat et al. 2016, 2017, 2018), some information and communication technologies and research are expected to help each phase of the DRM cycle. The lessons learned from multi-perspectives are expected to help related organizations and citizens to increase their awareness in terms of a tsunami, as well as other disasters.

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