ORIGINAL ARTICLE

Aquatic disaster activation plan and tactic: The natural history and management conceptual framework of aquatic disasters

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ABSTRACT

Introduction: In the past decades, water-related disasters had been accounted for about three-quarters of all-natural disasters worldwide. Asia is the most affected region with more than 45% of fatalities and more than 90% of the victims affected by aquatic disasters. Aquatic events progress differently and rapidly as compared to inland disasters. Thus, apart from additional equipments and trained aquatic rescuers, aquatic disaster operation requires specific strategies and tactics.

Materials and Methods: This qualitative study was conducted using mixed methods involving the Delphi method and decision-conferencing approach. Two rounds of open-ended questionnaires were sent to subject matter experts from rescue agencies that involved in aquatic disaster rescue and management. Feedback from the panel was reviewed, the natural history of different aquatic disasters was appraised, and the decision-analysis model on the command, control and management of aquatic disaster was developed. The model was then reassessed through an iteration process at decision-conferencing among the expert panel until the final framework was accepted by all members of the panel.

Results: The fast progression of aquatic disasters with multiple hazards on the scene and unique technical challenges of the operation increase the risk of rescuers to become victims themselves. The developed conceptual framework, namely Aquatic Disaster Activation Plan and Tactic (ADAPT), was found able to guide rescuers in risk assessment, judgment, and response in aquatic disasters based on strategies and tactics for different phases along the natural history of aquatic disasters.

Conclusion: With realistic scenario-based training and drills, ADAPT can be the blueprint in aquatic disaster management. It is designed to facilitate rescue agencies and organizations in preparing and executing the technical aquatic rescue operations safely, according to the resources available and the capability of the respective rescue organization.

KEYWORDS:
Aquatic disasters; conceptual framework; decision-analysis model; natural history; risk assessment

INTRODUCTION

Aquatic disasters had occurred more frequently in recent years. Millions of people worldwide had endured various aquatic catastrophic events with thousands of deaths as well as damages to infrastructures and the environment. Malaysia has had its share of major aquatic disasters. A National Security Council decree, Directive No. 20, dictates on preparation, response, and management of disasters.[1,2] Despite having a well-organized incident management system, the rescue operation and management at the scene of aquatic disaster were not well defined.

Due to the fluidity of the water, events in water tend to progress by the minutes. The window period to save lives is narrow. The situation at first hour differs from that of few hours later, the aim and response to the same event also differ with time. Even if the direct injury from the aquatic disaster was not life-threatening, the victim was still threatened with the risk of drowning and hypothermia. Besides that, managing aquatic disasters requires distinguished rescue personnel, equipment, and strategies. Slight error in judgment during the response to aquatic disaster could spell catastrophe, risking lives, and resulting collateral damages. Understanding the progression of aquatic disasters and guidance to an efficient response could minimize the destruction effect and facilitate faster recovery of the affected communities. Thus, the study objective is to appraise the natural history of aquatic disaster and to develop a framework that guides the response and coordination of mass casualty aquatic rescue.

MATERIALS AND METHODS

This study adopted a mixed methods approach (Figure 1) which involved the Delphi method and decision conferencing approach.[3] It was conducted from March 2019 until March 2020. First, the researchers assembled a panel of local experts in aquatic disaster management. The members of the panel consisted of commanding officers assigned by agencies from the Special Malaysia Disaster Assistance and Rescue Team (SMART), National Disaster Management Agency (NADMA), Malaysia Civil Defence Force (MCDF), Malaysian Maritime Enforcement Agency, Fire and Rescue Department of Malaysia (MMEA), representatives from the local life-saving societies, lecturers in emergency medicine of local

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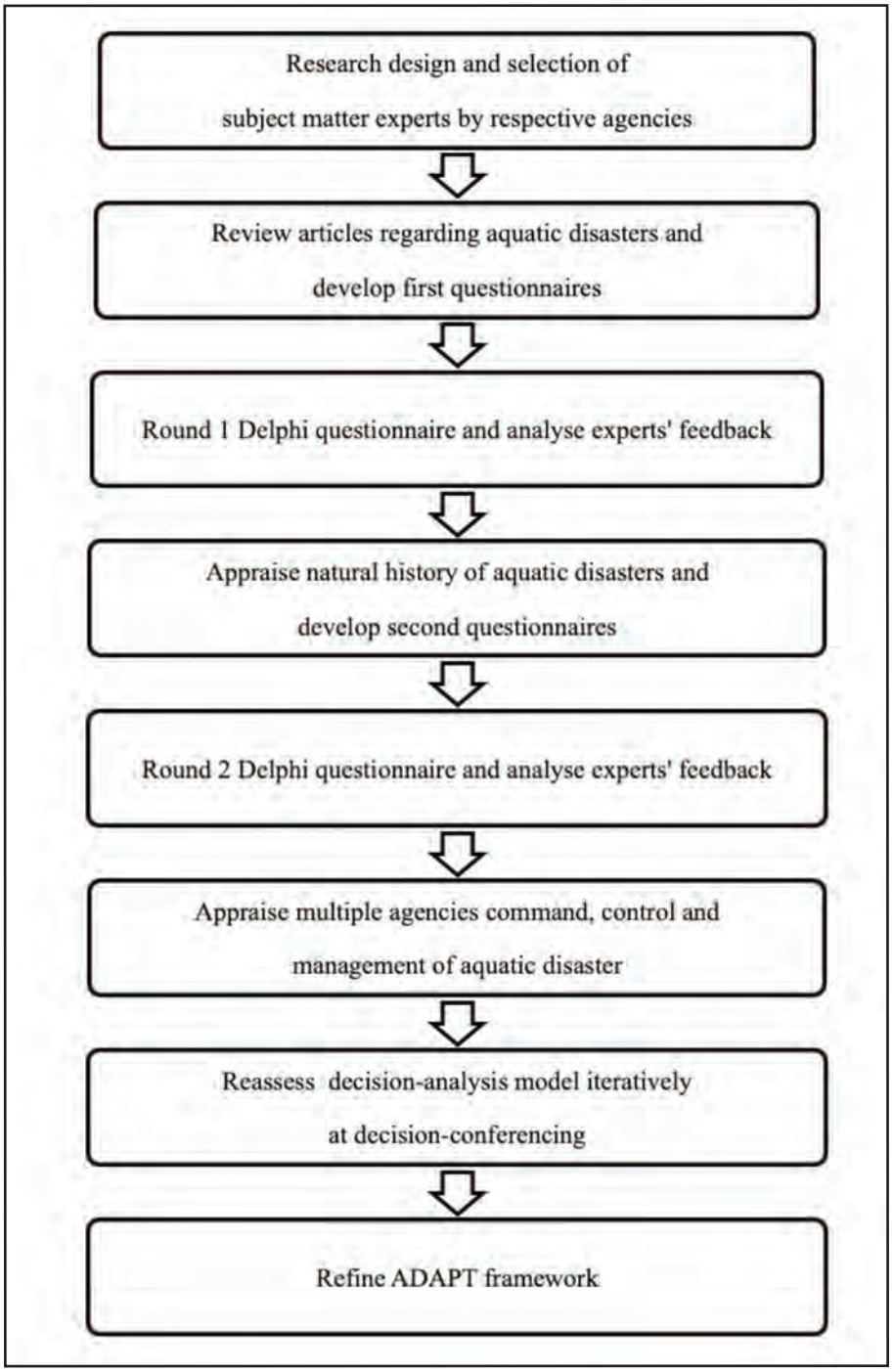

Fig. 1: Schematic diagram of ADAPT framework development methodology

universities, as well as emergency physicians from the National Heart Institute and the Ministry of Health of Malaysia (Table I). The experts had 7–35 years of experience in aquatic rescue and disaster management.

To develop the first round Delphi questionnaire, the researchers did a search and reviewed articles regarding previous aquatic disasters that occurred in Malaysia.[3-5] After risk assessment with geographical factors and climate in consideration, articles on aquatic events occurred in other countries that could possibly happen in Malaysia were also reviewed. The aquatic disasters reviewed were grouped into the following types: Storm and flood, tsunami, dam accident, watercraft accident or capsized, jetty collapse, offshore oil rig accident, aircraft accident into costal water, and mass refugee boat drift. Based on the scenarios described in the articles, a set of open-ended questions were designed to foster an understanding about natural history of different aquatic disasters, the magnitude of the events, and their destructive impact.

Table I: Representation of subject matter expert panel

Agency/Organization	Number of representative
National Security Council	1
National Disaster Management Agency and Special Malaysia Disaster Assistance and Rescue Team	1
Malaysia Civil Defence Force	5
Malaysian Maritime Enforcement Agency	3
Fire and Rescue Department of Malaysia	5
Ministry of Health Hospital	2
School of Medical Science, Universiti Sains Malaysia	1
Sultan Ahmad Shah Medical Center, International Islamic University Malaysia	1
Life Saving Society of Malaysia	5
Total	24

Table II: Comparison of general characteristic and principle of management between inland disaster and aquatic disaster

Characteristic/ Principle of management	Inland Disaster	Aquatic Disaster
Onset of incident	Onset is often unexpectedly without any warning.	Usually warning of the incident is detectable via surveillance systems. Anthropogenic aquatic incidents may occur more abruptly.
Accessibility to incident site	More accessible. Depending on the terrain, generally accessible by vehicle on road or by air. Bystanders and rescuers are ready to be recruited to assist at incident site.	Relatively less accessible. Incident site is accessible with watercrafts on water and by air. Rescuers trained in aquatic rescue are recruited to response at site of the aquatic incident.
Topography of the incident site	Physical features at inland incident site are relatively static, if progression occurs; it tends to happen in stages.	Physical features at aquatic incident site changes continuously due to fluidity of water and constant currents.
On scene risk	Low to moderate risk on scene depends on the nature of the disaster once scene safety is established via risk assessment and risk management.	Being in water on scene is high risk for drowning accident and environmental injuries. The risk is higher with additional environmental hazards.
Rescue window [a]	Within minutes to first 3 hours. (Platinum ten minutes and golden hour concepts)	Within seconds to minutes for victims who are not able to stay afloat on the water.
Principle of field triage	Victims are commonly triage according to the vital functions of respiration, circulation and mental status.	Victims are triage according to behavior in water to estimate their tendency of being submerged.
Search of victims	Victims often are static at the site of incident.	Victims are often being moved away from the site of incident by water flow and currents.
Principle of treatment on scene	Simple treatment to establish airway patency and stop bleeding.	Establish floatation for victims and retrieve them from water.

The first questionnaires were emailed to the subject matter experts to elicit individual views and responses. The responses from first-round questionnaire were analyzed and the aquatic disaster natural history was determined. The findings led to a framework for aquatic disaster management and the second round Delphi questionnaire was formulated and resent to the expert panel. The results from second questionnaires were analyzed by researchers to elaborate the role of rescue agencies as well as the command and control system in aquatic disasters. Both questionnaires were validated using face validation method by two emergency physicians with 13 and 20 years of experience, respectively, in emergency service and disaster management.

Subsequently,the experts had foregathered for decision-conferencing.[3] The decision-analysis model was presented to the panel and was reassessed iteratively with various aquatic disaster scenarios. Experts from multiple rescue agencies responded according to the framework and the coordinated response between agencies were elaborated and refined until the decision model was accepted by the panel.

RESULTS

The first round Delphi questionnaire addressed various aquatic disasters circumstances along the timeline. A common pattern of progression was observed, and the natural history of aquatic disasters was extrapolated and compared with inland disaster (Table II).

The 'physiology' of aquatic disasters comprises five distinctive sequential phases. The time lapse for each phase varies between the events and is dependent on the peculiarity of the situations. The discrete situations at different phases demand different directions and responses within a particular disaster. The phases and the appropriate response are being explained as follows (Table III):

Phase A - the "Alert" phase. This is the early phase or the pre-disaster period of an aquatic event during which the warning of a disastrous event is reported while the disaster has not yet actually happened. The objectives of management at this phase is to alert all agencies involved and the communities about the anticipated disaster, to take counteraction in preventing the incident from progressing into a full-blown

Table III: The description of general natural history and the aims of response to aquatic disasters

Phase	Features	Aim
A (Alert)	- Early phase during which the warning of a disaster is reported while the disaster has not actually happened.	(i) Taking counter-action to prevent the incident from progressing into a full-blown disaster; (ii) Taking necessary steps to minimize the destruction and loss of environment, infrastructures as well as human lives in the event of inevitable disaster.
B (Battle)	- Acute phase of the disaster. - The victims are either passing instantaneously from the impact of event or surviving temporarily with a high risk of mortality from life-threatening injuries and drowning if not being rescued within minutes.	(i) Battle to save lives, time is the essence; (ii) Intend to keep as many victims staying afloat as possible, to retrieve them out of the disaster zone, and to treat life-threatening injuries as quickly as possible.
C (Clear-up)	- The scene (disaster zone) is seemed "lifeless", no survivor is found during or after the acute phase of the disaster. - It can be due to either the high magnitude of the disaster resulting zero survivor; or all the survivors have been retrieved to safety; or all the survivors succumbed and drowned.	(i) Clearing the remains left by the disaster; (ii) The main task during this phase is to search and recover the bodies (corpses) and physical structures (e.g., airplane in plane crash or ship in shipwreck), followed by body and structures identification.
D (Dissolve)	- After the remains and physical structures are removed from the scene. - Decontamination is necessary if the disaster involves pollutants; omitted if no pollutant involved.	(i) Decontamination by containing, removing and cleaning pollutants to minimize exposure and negative effect to the population and environment; (ii) Dissolve the search and rescue mission ("stand-down") once all operations and efforts have completed.
E (Elevate)	- Usually take place after the aquatic disaster and its apparent impact had subsided. - The negative impact of disaster is elevated as the environment and communities return towards pre-disaster condition.	(i) Rebuild existent structures, infrastructures, and the society; (ii) Mitigate risks of aquatic disaster through education, training and drills, engineering, and construction; (iii) Law enforcement and execution in preventing risks from illegal activities.

Table IV: Model matrix for ADAPT framework which was used to summarize the tactics for different phases in various aquatic disasters that Malaysia is at risk

Aquatic disaster	Phase A	Phase B	Phase C	Phase D	Phase E
Flood/Typhoon					
Tsunami					
Dam overflow/failure					
Vessel capsized or accident					
Jetty collapse					
Mass refugees boat drift					
Offshore Rig Accidents					
Plane crash into sea					

disaster if possible, to take necessary steps in minimizing the destructive impact or loss of human lives, infrastructures as well as the environment if the imminent disaster approaches.

Phase B - the 'Battle' phase is the acute phase of the disaster. It marks the onset of the aquatic disaster and may last for hours. The force and magnitude of disastrous event peaks at this phase. The victims are either passing instantaneously from the impact of event or surviving temporarily but at high risk of mortality from life-threatening injuries and drowning if not being rescued within minutes. Surviving victims could be seen struggling to stay afloat, anchoring themselves to objects or structures, moving to higher platform, and performing other self-help gestures. The aim of response is to battle against time to save lives. The rescue operation intention is to keep as many victims staying afloat as possible, retrieving them out of the water or disaster zone, and treating life-threatening injuries as quickly as possible. Time is the essence in this phase.

Phase C - the 'Clear-up' phase occurs hours after the beginning of the disaster and may last for days or weeks depending on the complexity of the disastrous event. During phase C, the disaster zone is seemed 'lifeless' or motionless. No survivor is found during or after the acute phase of the disaster. It can either be zero survivors resulted from high impact and magnitude of the disaster, or all the survivors have been retrieved to safety with the remaining succumbed and drowned. The response in this phase intends to clear the remains left by the disaster. The main task is to search and recover the remains of the fatal victims and physical structures (e.g. airplane in plane crash or ship in shipwreck), followed by bodies and structures identification.

Phase D - the 'Dissolve' phase follows after the physical bodies and objects are being removed from the scene. The time period of transition into dissolution phase varies; generally, it is expected in few days to weeks after the occurrence of the disaster. Certain aquatic events (for example, oil rig accidents, watercrafts, or aircrafts accidents,

etc.) involve pollutants and contamination of the environment. In such instances, dissolution phase calls for decontamination of the contaminant. Agencies specialized in handling specific contaminant should contain, neutralize, and remove the pollutant to minimize the exposure and potential negative effect to the community and environment. After decontamination has completed, or in accidents that have no pollutant involved, providing all other search and rescue missions are completed, it is reasonable to dissolve operations and stand down at the aquatic disaster scene while recovery efforts are continued.

Phase E - the 'Elevate' phase ensues when the particular aquatic disaster and its apparent impact had subsided, about weeks to months down the progression of the event. It involves recovery effort to elevate the negative impact of the aquatic disaster and mitigation to return the environment and community to pre-disaster condition. It also reflects the elevation of the level of resilient against similar aquatic disaster in future. To achieve its aims, reconstruction of existent structures and infrastructures, mitigation of aquatic disaster through education, training and drills, engineering and construction, as well as relevant law enforcement and execution along with other mitigation measures are necessary.

DISCUSSION

The early warning system is a set of function in disaster risk communication and management. It aims at early detection, dissemination of information, prevention, and mitigation before disaster, as well as coordinating response and recovery during and after disaster.[6-8] According to ADAPT framework, Phase A involves risk surveillance and early warning is issued when disaster risk is present. The Malaysian Meteorological Department plays an important role in detecting natural aquatic disasters. It continuously monitors seismic waves, river and sea levels, weather and rainfall, earthquake in surrounding regions and tsunami threats. With quantitative precipitation forecasting, it provides reliable and accurate real-time flood warning and responses with adequate leadtime. In addition, the Drainage and Irrigation Department also provides forecast and early warning with Integrated Atmospheric and Radar Satellite Model-Based Rainfall and Flood Forecasting.

Since the tsunami in 2004, the National Tsunami Early Warning System was developed. Apart from monitoring earthquake and seismic wave, closed-circuit television cameras were installed in strategic locations to monitor for any threatening waves. Real-time data collected are transmitted through satellite for analysis. It also establishes connection for data with the US National Oceanic and Atmospheric Administration's Pacific Tsunami Warning Centre in Hawaii as well as the Japan Meteorological Agency in Tokyo.[8,9] It is able to alert the respective agencies and warns the country of possible tsunami occurring at surrounding oceans. The disaster threat is being alerted with sirens, Fixed-Line Disaster Alert System via telephone, short messaging systems, telefax, information and communication technology webpage and social networking media, mass media broadcasting system, as well as through public announcements.[8,9] In addition, the Government Integrated Radio Network is used for risk-communicate and coordinate management of disaster by multi-agency disaster responders.

Once the rescue agencies are alerted of an impending disaster, the Royal Malaysia Police and the Fire and Rescue Department of Malaysia are assigned to assess the risks and hazards on scene, as well as to estimate the magnitude of the probable disaster. As the disaster has not yet occurred during Phase A, the rescue agencies carry out surveillance of the risks and progression of the situation periodically. With unmanned aerial vehicles, rescue agencies may have a bird's-eye view of the situation without exposing to hazards on site. As the secretariat of disaster operation, MCDF sets up Disaster Operation Control Centre (DOCC) where risk communication and event reporting occur. DOCC and the operation are led by NADMA. After estimating the magnitude of impending disaster, DOCC identifies high-risk areas and considers opening the designated Disaster Relieve Centres. The communities may be instructed to evacuate to the relief centre by local authorities in coordination with the Royal Malaysia Police.[1]

In case of anthropogenic aquatic disasters, for example, dam failure, ferry accident, jetty collapse, mass refugees boat drift, and offshore rig accidents, often incident occurs unexpectedly and is reported by people nearby or those experiencing the unfortunate event via the Malaysia Emergency Response System hotline. The Royal Malaysia Police usually verifies the report about the event before initiating the aquatic disaster protocol. In imminent dam failure, for example, technical problem in the dam operation with the water reaches dangerous level; besides surveillance and evacuation planning, the dam operator should alert local authority regarding the dam water level and technical problem. Rescue agencies, dam engineer, and relevant technical experts should counteract the situation to prevent the incident from progressing into full-scale catastrophe. When the hazards are successfully elevated and the risks of the disaster resolve, the operation may stand down and mitigation plan for the disaster should be continued and strengthened. If the counter-measures are unsuccessful and disaster progresses, swift response and evacuation in Phase A could minimize the destructive impacts that follow.

Phase B is the zero hour, it begins at the moment the disaster actually happens. Disasters like tsunami, dam failure, watercraft accident, jetty collapse, offshore oil rig accident, aircraft accident in costal water, hit vigorously, leading to instantaneous destruction; while others, such as flood, mass refugee boat drift, have gradual course and peak after some time. In disasters with drastic course, as tsunami or dam failure, rescue agencies should ensure the safety of their officers and surroundings by carrying out surveillance from a safe distance even during Phase A. Ironically, rescue operation should not be carried out in the early minutes or hours during Phase B if the situation is perceived as likely to endanger the rescuers. Furthermore, the on-scene rescuers should retreat to safety if their position becomes unsafe with the progression of the event.

Rescue is only permissible when the situation is safe. Its timing varies among different disasters; it may be earlier in the gradual course disasters and latter in drastic course disasters after diminution of the disaster force. At this stage, rescue agencies actively search for victims. Search and rescue at coastal waters is led by the MMEA while that at inland waters is led by the Fire and Rescue Department of Malaysia. Other special search and rescue units, such as SMART, may be deployed to the scene to assist in the operation if necessary. The priority for rescue and retrieval is given to alive and injured victims. Fatal victims will be retrieved at Phase C after the retrieval of all living victims.

To complicate the matter, the window period to rescue in Phase B is particularly narrow. An average person can hold their breath for about 30–60 seconds before gasping for air instinctively. Thus, the concept of 'Platinum Ten Minutes' may not be appropriate, as struggling victims in water may perish within 60 seconds.[10] Hence, the rescue strategy in Phase B is to distribute buoyant aids to as many surviving victims, as soon as possible. When the victims are able to maintain buoyancy and respiration, it prolongs the rescue window period and increases the chance of survival. The victims are triaged according to the level of rescue urgency, retrieved, and treated for life-threatening injuries.[11] It cannot be stressed enough that timely response is utmost valuable to prevent fatal drowning. Rescue operation should be swift and in coordinated manner to do the greatest good for the greatest number.

With time, the scene becomes lifeless, marking the end of Phase B and the beginning of Phase C. It may be after the evacuation of all surviving victims leaving those who succumbed to injuries and drowning. It may also be when no survivor is found after thorough search at Phase B. During Phase C, rescue agencies continue the search and recovery of victims' bodies. The corpses and body parts are sent to forensic unit for identification and postmortem. The remains of vehicles and structures involved in the disaster are also recovered. The remnants of a plane crash and the shipwreck after a marine accident are important evidence for an investigation to determine the cause of accident and the preventive recommendations.

During search and recovery, it is essential for the rescuers to continuously monitor the risks and hazards brought by weather and water condition. Hazards such as storms, wind, limited light source and visibility at night, rapid water currents, and waves often threaten rescuers' safety and complicate the rescue when present. In contrast to the Phase B, the victim's outcome from search and recovery in Clear-up Phase is no longer time-dependent. Therefore, it is reasonable to defer search and recovery in Phase C when the condition is hazardous, and only to resume when the condition is favorable.

The term 'dissolve' describing Phase D has two connotations: 'dissolve' the pollutants, and 'dissolve' the operation. 'Dissolve' of pollutants, or in another word, decontamination is necessary in disasters that involve chemicals or pollutants, such as oil spill from drilling rig, nuclear power plant accident following earthquake and tsunami, etc. While Fire and Rescue Department of Malaysia serves as a rescue agency, the Department of Environment leads decontamination of oil spill or other pollutants; whereas the Atomic Energy Licensing Board is the leading agency in providing expertise and technical services in managing radiological, nuclear, or other hazardous material spillage. Efficient and timely decontamination minimizes detrimental effects on the environment, specifically to the marine plants, animals, as well as the communities. At the same time, Public Health officials survey for infectious disease outbreak and psychological health among the victims at Disaster Relieve Centres as well as the rescuers and frontliners. Nonetheless, decontamination sub-phase is omitted in disasters without any pollution or contamination.

Once decontamination process and other search and rescue missions are completed, the rescuers send reports to Evaluation Committees at DOCC to estimate losses and recovery from the disaster. DOCC may then summon 'dissolve' of the operation, all rescue agencies stand down and end the search and rescue mission. Despite the stand down of the rescue agencies on site, the recovery of the communities at the areas affected is ongoing, facilitated by the recovery agencies until the social, health, and economy functions of the communities return to the normal state.

Dissolving of the search and rescue operation marks the transition to Phase E. Besides focusing at elevating the destructive aftermath with recovery plans, it also intends to elevate the level of resilience and capability to withstand challenges of similar disaster thereafter. Aquatic disasters typically lead to large-scale destruction. Therefore, the recovery and mitigation work requires substantial efforts from the recovery agencies, governmental and non-governmental organizations (NGO) as well as the communities. Rubble and damaged structures need to be removed and disposed properly, while the standing buildings, infrastructures, and affected environment need to be cleaned. The Malaysian Public Works Department and the local authorities can pool their machines and resources to work together with NGOs and the local communities in cleaning and rebuilding houses and infrastructures. The victims are sent home once their homes are cleaned or rebuilt, and ready to be resided in.

Meanwhile, a 'post-mortem' examination on the aquatic disaster should be performed by surveying the affected area, inspecting the collected remains, and analyzing data to identify the cause and contributing factors of the disaster. The task force includes authority, relevant agencies, and the subject matter experts to produce a comprehensive report before formulating a mitigation plan. Holistic approach to risk mitigation is pertinent. Mitigation measures should include education and drills involving communities and governmental agencies, construction of structures that better withstand the forces of aquatic disasters, legislation processes, and law enforcement in regulating human activities.

Among other steps of mitigation, mangrove forests are found to be effective as a defense against the force of tsunami.[12] Thus, mangrove trees were planted for coastal protection and

research in that regards.[13] Apart from that, programs on preparation and response have been carried out among communities, one worth mentioning is the school-based tsunami education and development of evacuation plans and conducting drills, a project conducted by United Nations Development Programme in Malaysia in collaboration with the National Disaster Management Agency (NADMA) and the Ministry of Education.[2,14] Tabletop exercises and drills of different scales have also been carried out by rescue agencies. These on-going programmes enhance the nation's response and management of future disasters.

On the other hand, legislation and law enforcement are essential in prevention and mitigation of certain aquatic disasters by regulating human activities. For example, the forestry laws are intended to prevent illegal logging and forest clearing. With forests conservation, rainwater can be retained, preventing run-offs and further flooding. Besides that, the maritime laws help to reduce ferry or ship accidents by prohibiting overloading the watercrafts, and the risk of disastrous collapsing of jetty is also preventable with structures adhered to the building safety regulations. These laws and regulations must go hand-in-hand with stern enforcement and execution. The recovery efforts in Phase E may be ended when the environment and the communities have recuperated to normal state; however, the prevention and mitigation measures should be a continuous effort to prevent mainly anthropogenic aquatic disasters and strengthen the nation's resilience against aquatic disasters.

At any phase during aquatic disaster, if the situation overwhelms the national resources or expertise, the country may request and accept international aid through the National Security Council to assist the national disaster response.

STRENGTH AND LIMITATIONS

The anonymity nature of Delphi method enabled the exploration of ideas without socially induced bias; however, it is vulnerable to investigator bias on the synthesis and feedback process. On the contrary, the decision-conference method lacks anonymity, but expert panel in the same physical space can scrutinize the model framework for investigator's manipulation bias.[3,4] Thus, the mixed-method approach combining the two methods complements one another in the study. The ADAPT framework is developed from the consensual opinion of subject matter experts. Although it was examined repetitively, the framework has not been applied in actual disastrous situation. A full-scale drill is necessary to further test the framework. The endorsement of ADAPT follows 'all-or-nothing' rule. If adopted, all agencies should conform to the framework. Any disparity brings asynchronous and uncoordinated response that may result in confusion, conflict between agencies, discrepancy and overlapping roles, as well as wastage of resources. When all agencies and organizations have committed, drills are necessary to refine the multiple agencies response.

CONCLUSION

ADAPT is a conceptual framework of coordinated response against aquatic disasters for effective and efficient response. It is a universal framework to lay out technical details which include agencies involved, human resources and machinery supports, as well as specific taskforce and availability of aid necessary at each phase for any aquatic disaster (Table IV).

ADAPT may also be adopted by other non-rescue organizations. Corporate companies that are at risk of a particular disaster may develop an emergency action plan for their employees to guide their actions before, during, and after the aquatic disaster. Governmental organizations at local, district, state, and national levels can construct the contingency plan based on the hazards and scale of the possible disasters, as well as review resources allocated for managing the aquatic disaster at every level. Once ADAPT framework is developed, a tabletop exercise based on the framework should be carried out at each level and organization to evaluate the plan and explore the novel solution for possible unprecedented situations.

ADAPT is designed to complement the contemporary incident management system and serve as a platform for the development of an inclusive overall aquatic disaster management system. Not only it defines the disasters according to its constantly changing situation, it also serves as a guide to a systematic command, control, and coordination for multi-agency response to the rapidly progressing aquatic disasters. ADAPT may be as general as universal aquatic disaster management framework, or as unique as tailor-made emergency action plan considering the local culture and resources.

REFERENCES

1. National Security Council (Majlis Keselamatan Negara). Order No. 20 (Revised) National Policy and Mechanism of Disaster Management (Arahan No. 20 (SemakanSemula) Dasar dan MekanismePengurusanBencana Negara). Chapter VI: Mechanism of Disaster Response (Bahagian VI: MekanismeTindakBalasBencana). 1997:9-16.
2. Said AM, Mahmud AR, Abas F. Community preparedness for tsunami disaster: a case study. Disaster Prevention and Management. 2011; 20: 266-80.
3. Grime MM, Wright G. Delphi Method. WileyStatsRef: Statistics Reference Online. 2014: 1-6.
4. Gunaydin HM. The Delphi method [Internet]. [Place of publication unknown]: Optimization Group. 2006. [cited March 2020].Accessed from: https://www.researchgate.net/profile/Huesnue-Guenaydin/publication/308653253_The_Delphi_Method/links/57ea495008aef8bfcc9901ff/The-Delphi-Method.pdf. 2006.
5. Fletcher AJ, Marchildon GP. Using the Delphi method for qualitative, participatory action research in health leadership. Int J Qual Methods. 2014; 13(1): 1-18.
6. Malaysian Meteorological Department Web Site.Laman Web Rasmi JabatanMeteorologi Malaysia [Internet]. Malaysia: Malaysian Meteorological Department. [cited March 2020]. Accessed from: http://www.met.gov.my/.
7. World Health Organization. Useful Definitions and Early Warning Information for Natural Hazards [Internet]. Geneva (Switzerland): World Health Organization; 2011 [cited March 2020]. Accessed from:https://www.who.int/hac/events/drm_fact_sheet_early_warning_natural_hazards.pdf.

8. Bradley DT, McFarland M, Clarke M. The effectiveness of disaster risk communication: asystematic review of intervention studies. PLoSCurr. 2014; 6:ecurrents.dis.349062e0db1048bb9fc3a3fa67d8a4f8.
9. Center for Excellence in Disaster Management and Humanitarian Assistance (CFE-DM). Malaysia Disaster Management Reference Handbook [Internet]. Hawaii: Center for Excellence in Disaster Management & Humanitarian Assistance; 2016 [cited March 2020]. Accessed from: https://reliefweb.int/sites/reliefweb.int/files/resources/disaster-mgmt-ref-hdbk-Malaysia.pdf
10. Daban JL,Falzone E,Boutonnet M,Peigne V, Lenoir B. Wounded in action: the platinum ten minutes and the golden hour.Soins; la revue de referenceinfirmiere. 2014;788: 14-5.
11. Oliveira RB, Szpilman D, Queiroga AC, Mocellin O. START method as a triage tool for aquatic disaster situations. In: Justin Scarr, editor. World Conference on Drowning Prevention 2015 Program and Proceedings. World Conference on Drowning Prevention 2015; Belgium: International Life Saving Federation; 2015. p. 327.
12. Dahdouh-Guebas F,Jayatissa LP, Di Nitto D,Bosire JO, Seen DL, Koedam N. How effective were mangroves as a defence against the recent tsunami?. Curr Biol. 2005;15(12): R443-7.
13. Ghazali N, Zainuddin K, Zainal MZ, Dali HM, Mahmud MR. The potential of mangrove forest as a bioshield in Malaysia. 2016 IEEE 12th International Colloquium on Signal Processing & Its Applications (CSPA) [Internet]; 2016 [cited March 2020]:322-327. Accessed from: https://www.researchgate.net/publication/305525656_The_potential_of_mangrove_forest_as_a_bioshield_in_Malaysia.
14. United Nation Development Programme (UNDP) Asia and the Pacific. Malaysia Strengthening School Preparedness for Tsunami in Asia and the Pacific [Internet]. Thailand: UNDP Bangkok Regional Hub; 2018 [cited March 2020]. Accessed from: https://www.asia-pacific.undp.org/content/rbap/en/home/programmes-and-initiatives/SchoolTsunamiPreparedness/Malaysia.html.