ORIGINAL ARTICLE

CIWEM Chartered Institution of Water and Environmental Management | Journal of Flood Risk Management | WILEY

Community responses on effective flood dissemination warnings—A case study of the December 2014 Kelantan Flood, Malaysia

Nor Eliza Alias[1,2] 🔴 | Nurul Atika Salim[2] | Shazwin Mat Taib[2] | Mohd Badruddin Mohd Yusof[2] | Radzuan Saari[2] | Muhammad Wafiy Adli Ramli[1] | Ilya K. Othman[2] | Kogila V. Annammala[1] | Halimah M. Yusof[3] | Norazlina Ismail[4] | Ali Yuzir[5] | Stephen Blenkinsop[6]

[1]Centre for Environmental Sustainability and Water Security (IPASA), Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia

[2]School of Civil Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia

[3]Faculty of Management, Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia

[4]Faculty of Science, Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia

[5]Disaster Preparedness and Prevention Centre, Malaysia-Japan International Institute of Technology (MJIIT), UTM Kuala Lumpur, Kuala Lumpur, Malaysia

[6]School of Engineering, Newcastle University, Newcastle, Upon Tyne, UK

Correspondence
Nor Eliza Alias, Centre for Environmental Sustainability and Water Security (IPASA), Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia.
Email: noreliza@utm.my

Abstract

Early flood warnings are important to allow sufficient time for evacuation. Although warning systems are now in place, key questions remain as to their effectiveness in sending information to the public, which may in part depend on the media used. This paper assesses the effectiveness of warnings disseminated to the public for the December 2014 Kelantan Flood, Malaysia. The flood was the worst in decades making it an appropriate case study with which to assess public awareness and perceptions associated with flood warnings and their dissemination. The effectiveness of warnings issued via different media was assessed by questionnaire. Results show that 56% of respondents received warnings prior to the flood, a majority of them through television and information shared among the public. While the preferred medium of warning is not dependent on age, assessment of peoples' response to warnings shows that with increasing age responsiveness to orders and readiness to evacuate decreases. To increase the number of people receiving the warnings, short message service (SMS) communications sent from the authorities to a wider audience may be considered, as information shared among the public is observed to be most effective in reaching the greatest number of people.

KEYWORDS
community response, disaster management, effective flood warning, flood disaster

1 | INTRODUCTION

Flood frequency and intensity have been observed to increase due to climate change impacts and land use changes (Akter, Quevauviller, Eisenreich, & Vaes, 2018; Biniyam & Kemal, 2017; Didovets et al., 2019; Luo et al., 2018; Luo, Apip, Duan, Takara, & Nover, 2018). An effective flood early warning system (EWS) may help to significantly reduce loss of life and asset damages (Basher, 2006; Min Wu & Kanamori, 2005). Early warning systems are defined by UNISDR (2009) as "*the set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organisations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.*" The role of EWS received increased attention after the December 2004 tsunami in the Indian Ocean (Golnaraghi, Douris, Luther, Maximuk, & Aliagha, 2015). A report produced by the United Nations (UN, 2006) based on early warning surveys concluded that despite available advanced warning systems there are numerous gaps and shortcomings, particularly in developing countries in terms of effectively reaching and serving the needs of those at risk. The United Nations through UNISDR (United Nations International Strategy for Disaster Reduction) have identified four main elements for an effective community-based early warning system: knowledge of the risk; monitoring and warning services; warning dissemination and communication; and emergency response (UN, 2006).

Identification of the most effective dissemination methods and responses of people to warnings are important. These may differ depending upon community behaviours and level of economic development. This is partly due to responses being potentially influenced by the behaviour of the public and how they relate to the means of delivery. Warnings disseminated through phone applications (apps) or websites, for instance, might be effective for a developed country but may be less so for a newly industrialised country, and relatively ineffective in a less economically developed country. For example, the Pew Research Center (2015) showed a strong relationship between internet access, cell phone ownership, and a country's per capita GDP. EWS are now in place in many locations due to technology and information-technological growth. An important question however is, are these systems enough to provide an effective means of risk reduction? Risk in this sense is quantified through the relationship between the natural hazard, exposure, and vulnerability (UNISDR, 2015). Vulnerability of a society towards hazards may therefore be reduced if an effective EWS exists and so assessment of the effectiveness of existing warning systems is therefore crucial. Such an assessment may be conducted by obtaining responses and feedback directly from the public.

Post-event studies involving feedback and interviews with people on the effectiveness of EWS have previously been conducted to assess and design effective community-based early warning systems. Areas of questioning have included the medium of dissemination, characteristics of a community-based EWS, lead time for early warning, trust, knowledge of hazard, perceptions, response, and awareness of EWS (Fakhruddin et al., 2015; Garcia, 2012; IFRC, 2013; Lamichhane, 2011). Comprehensive analytical post-event studies of the effectiveness of EWS are crucial. Ideally, a full early warning system cycle for flood risk management proposed in Figure 1 should be completed. The effectiveness of a warning therefore depends, in part, on the dissemination method used to communicate warnings to users of these systems, including the public. An assessment of these methods should be available to develop and improve warning systems.

Existing studies have tended to focus more towards the development of a disaster management framework (Ahmad, Othman, Zakaria, & Mohd Rodzi, 2014; AlBattat & MatSom, 2014; Baharin, Shibghatullah, & Othman, 2009; Billa, Shattri, Mahmud, & Ghazali, 2006; Jeeva & Puthiyidam, 2014; Mohd Rodzi, Zakaria, Ahmad, & Yahya, 2014) or tools and technology related to flood warnings such as producing and disseminating the warnings using new technologies; radar and communication, the internet, mobile devices, and social networks (Billa, Mansor, & Mahmud, 2004). It has long been understood that it is important to know how technological advances in EWS can be used to more efficiently trigger appropriate reactions of populations to prevent losses from natural hazards (White & Haas, 1975). Studies contributing direct inputs from the public such as interviews and questionnaires related to the effectiveness of systems are very much needed. In Malaysia,
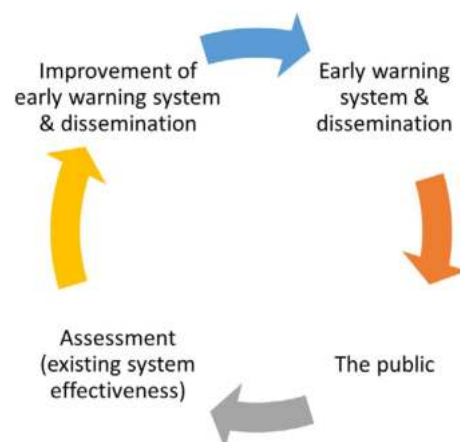

FIGURE 1 Early warning system (EWS) cycle

Khalid et al. (2015) assessed the effectiveness of an EWS during the Cameron Highland flood disaster in Malaysia on October 23, 2013. They indicated that the responses of 22 flood victims affirmed that the EWS was confusing. It was found that the siren's emergency warning sound could not be differentiated from the sound used during its normal operation (non-emergency cases) and therefore communities had failed to respond positively to it during an actual emergency. These findings provided additional information that could help improve the existing system, particularly on the use of the siren (Basher, 2006; Khalid et al., 2015). However, the effectiveness of other methods of warning dissemination also needs to be assessed for particular populations. This paper therefore addresses this gap using a case study of the December 2014 Kelantan flood in Malaysia.

Kelantan is a Malaysian state located on the east coast of Peninsular Malaysia and is exposed to the north-east monsoon (Figure 2). In December 2014, it was hit by the worst recorded flood in its history due to the combination of the enhanced rainfall phase of the Madden Julian Oscillation (MJO) and a more intense monsoon than normal, resulting in high intensities of rainfall. During this flood event, several rainfall gauges recorded more than the 200-year return period rainfall amount and most historical records were exceeded (Alias, Mohamad, Chin, & Yusop, 2016). Figure 3 shows the number of victims evacuated during flood events between 1965 and 2014 for several districts in Kelantan with the magnitude of the December 2014 flood reflected in the total of more than 40,000 evacuees in the Kota Bharu district alone, exceeding all historical records.
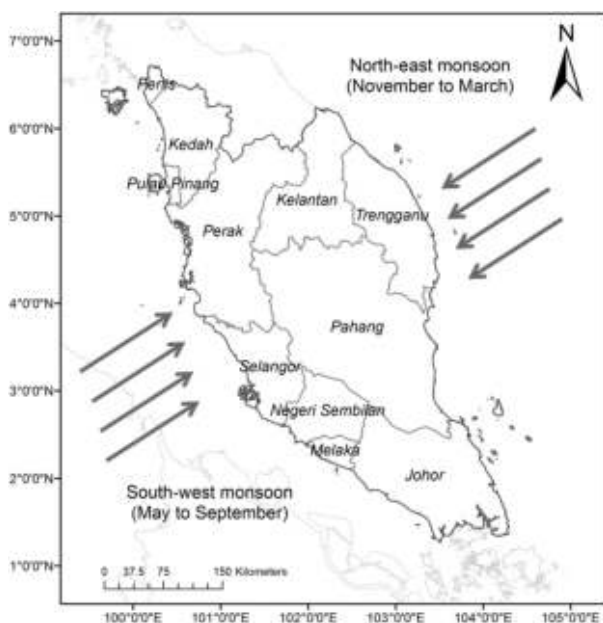
In response to the Kelantan flood, important questions needing to be addressed which arose were: (a) whether people received any warnings; (b) what was the medium or source of warnings received; and (c) what were people's responses upon receiving a warning. These questions are important in order to improve existing EWS. By identifying the most effective warning media, an improved strategy for issuing warnings could be achieved. In this way, the number of people receiving warnings prior to the flood would potentially be increased, contributing to reduced loss of lives and assets. Further questions also arise on the willingness of individuals to evacuate. A reluctance to evacuate is one of the scenarios reported anecdotally by the authorities during the flood. Identifying those groups of people who have difficulties in adhering to evacuation orders is important as it provides information for planning and implementing awareness programmes for better evacuation strategies in the future.

This paper therefore investigates the effectiveness of warning dissemination methods in response to the December 2014 Kelantan Flood. Before this event, the government, through its Department of Irrigation and Drainage (DID), had implemented various flood-warning systems, communicated to the public by methods including sirens near selected rivers, short message service (SMS) (limited to targeted authorities), websites, and social networks. One means of assessment is to obtain feedback from the public as to whether they received those warnings and from that information, improvements of the existing system can be undertaken. Public perception associated with the flood and early warnings is assessed with feedback collated from questionnaire surveys conducted in Kelantan subsequent to the flood, including a survey related to EWS and the means by which warnings are being conveyed to the community.

2 | STUDY AREA AND METHODOLOGY

Malaysia is located near the equator and being surrounded by sea, it experiences rainfall almost all year round. Seasons in Malaysia are therefore categorised into two: monsoon and inter-monsoon. The monsoon seasons are the north-east monsoon (November to March) and south-west monsoon (May to September), the remaining months are inter-monsoonal (Figure 2). Monsoons are influenced by movement of winds due to pressure differences between the land and ocean arising as a result of temperature differences. The north-east monsoon, commonly known as the winter monsoon in Asia, is formed during winter in the northern hemisphere. During this time, the land is colder than the sea resulting in winds flowing from the Siberian high towards the Pacific Ocean to the South China Sea. These winds,
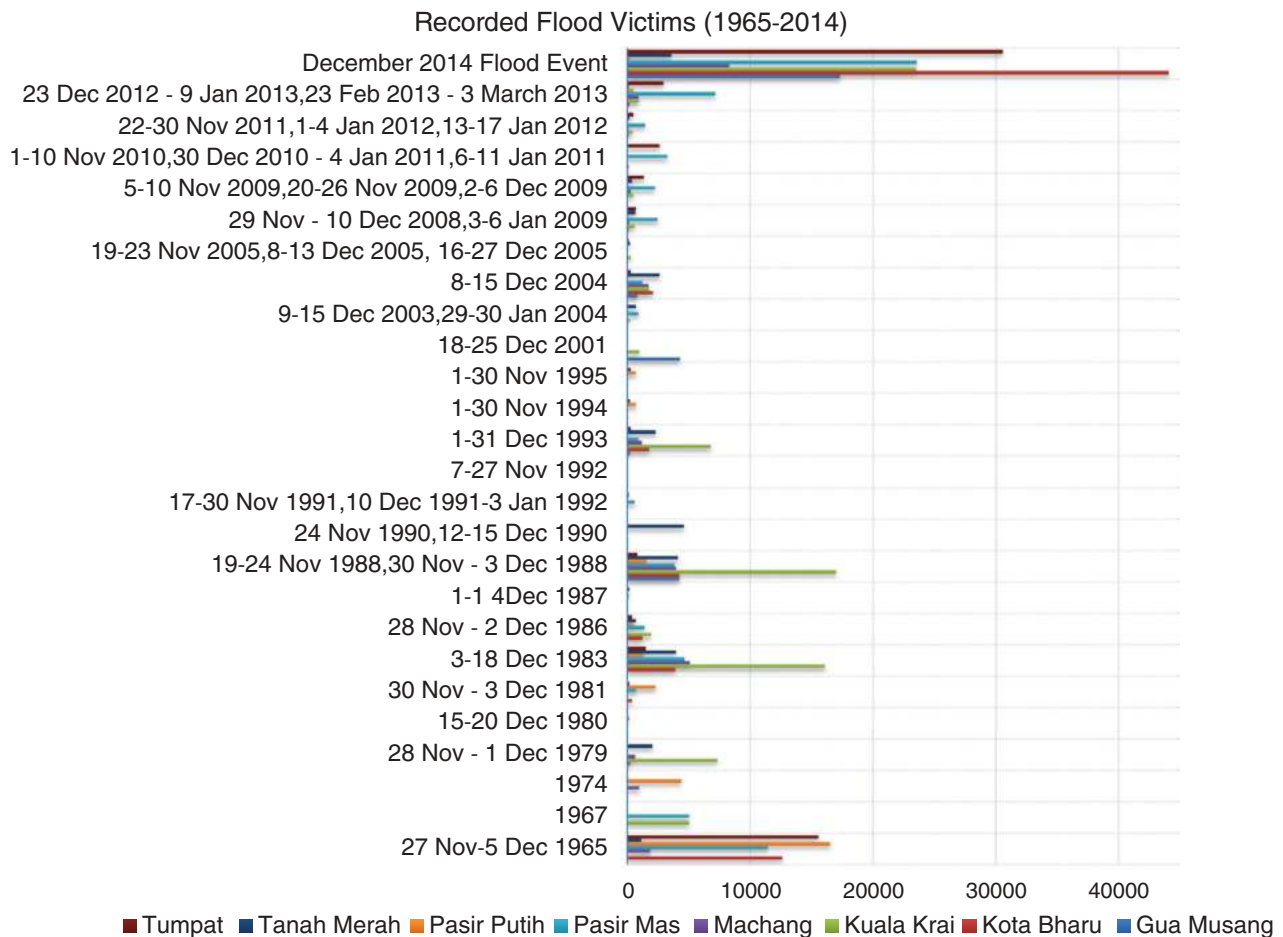

FIGURE 2 Peninsular Malaysia and its monsoon seasons

Recorded Flood Victims (1965-2014)

FIGURE 3 Record of flood evacuees for different districts in the state of Kelantan (1965 to 2014). Data were collected and analysed from unpublished documents and a flood records database obtained from the Department of Irrigation and Drainage, Malaysia

carrying moisture, deposit it as rainfall to the east coast of peninsular Malaysia. This area therefore experiences floods every year.

Due to its location and climate, flood catastrophes have proven to provide the most frequent disasters in Malaysia as documented by the EMDAT International database (Basher, 2006; Guha-Sapir, Below, & Hoyois, 2016). Guha-Sapir et al. (2016) show that floods have had the highest impact in terms of damages (Figure 4). Economic losses associated with individual events estimated in the range of 11 to 600 million US dollars. While the total number of people affected (those who require immediate assistance during a period of emergency) has reached hundreds of thousands.

According to the World Risk Index study published for 2016 (Garschagen et al., 2016), Malaysia ranks 86 out of 171 countries in terms of the highest risk of natural disaster which includes earthquake, storms, floods, droughts, and sea level rise. The index consists of four components: exposure (to natural hazards), susceptibility, coping capacities, and adaptive capacities. Globally, Malaysia is in the middle rank

for vulnerability and lack of adaptive capacities and ranks low for susceptibility in the event of a natural hazard. This means it has a low likelihood of suffering harm, but has quite a high rank in terms of lack of coping capacities (encompassing measures and abilities that are immediately available to reduce harm and damages in the occurrence of an event).

2.1 | Questionnaire development

Subsequent to the December 2014 Kelantan flood, a set of critical questions were developed and used to construct a survey to obtain a preliminary assessment immediately after the flood. The pilot survey included 10 short questions requiring mostly yes or no responses along with some open-ended questions. The pilot survey was intended to find out whether people were aware of the coming flood season, their preparations, warnings received, and information on evacuation. Based on the preliminary assessment, it was realised that more specific questions were needed. For example in the pilot study, while respondents were asked whether they
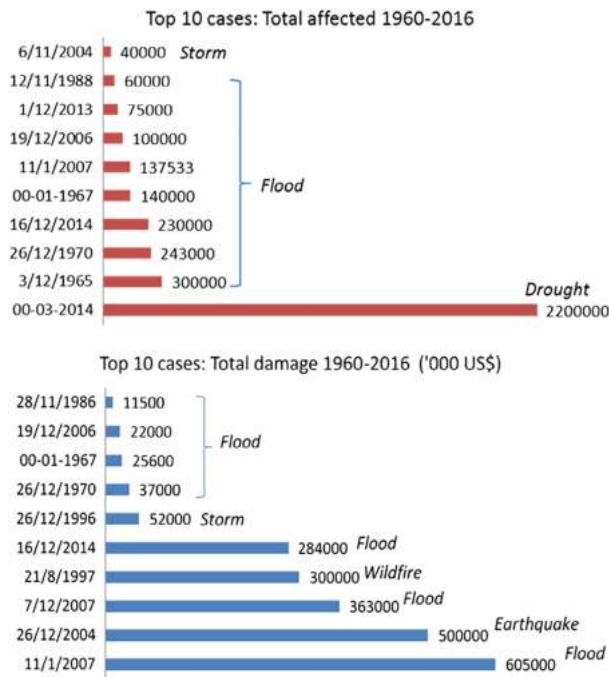
Top 10 cases: Total affected 1960-2016

6/11/2004 — 40000 *Storm*
12/11/1988 — 60000
1/12/2013 — 75000
19/12/2006 — 100000
11/1/2007 — 137533
00-01-1967 — 140000 *Flood*
16/12/2014 — 230000
26/12/1970 — 243000
3/12/1965 — 300000
00-03-2014 — 2200000 *Drought*

Top 10 cases: Total damage 1960-2016 ('000 US$)

28/11/1986 — 11500
19/12/2006 — 22000 *Flood*
00-01-1967 — 25600
26/12/1970 — 37000
26/12/1996 — 52000 *Storm*
16/12/2014 — 284000 *Flood*
21/8/1997 — 300000 *Wildfire*
7/12/2007 — 363000 *Flood*
26/12/2004 — 500000 *Earthquake*
11/1/2007 — 605000 *Flood*

FIGURE 4 Number of affected people (upper) and total cost of damage (lower) due to disasters in Malaysia for the period 1960–2016 (source: Guha-Sapir et al., 2016). Affected people are defined as those who require immediate assistance during a period of emergency

received any warnings, no questions were asked on the medium of the warnings received. At the time of the flood, the available warning system and dissemination methods included river monitoring, sirens near rivers at several locations, the DID flood warning website and Facebook page. Furthermore, some questions were also too difficult for some people to answer and therefore did not provide results that could be analysed to derive useful information.

Consequently, a second, more detailed follow-up questionnaire was developed, predominantly for a larger-scale public survey. It was then re-assessed after a trial using respondents from relevant authorities such as the DID and members of the public in Kelantan. The tests were conducted to screen out difficult and unsuitable technical terms and to make the questionnaire simple to understand by a layman, yet still generate significant and objective answers. The amount of time taken for a respondent to answer the questions was also taken into consideration. This trial ensured that questions were easily understood, covered relevant information to the authorities, and could be answered in an appropriate amount of time. The final set of questionnaires was then developed. As the objective of this paper is to discuss the effectiveness of the dissemination media used and public responses to early flood warnings, only a selection of relevant questions are analysed and discussed here as given in Table 1.

A convenience sampling method was used due to the unpremeditated implementation of the research. Convenience sampling is a non-probability sampling that involves the sample being drawn from that part of the population that is close to hand (Boxill, Chambers, & Wint, 1997). This was a consequence of the 2014 flood being more severe than expected by the authorities; the scale of the flood took many people by surprise, including the National Security Council. In order to immediately assess the dissemination of flood warnings and peoples' perceptions and responses, abrupt planning and initiation of the questionnaires were undertaken.

Distribution and completion of the questionnaires included through conventional mail, online sampling and face-to-face interviews. For the mail samples, more than 20 agencies in Kelantan were contacted via phone-calls and e-mail to inform them of the study. These agencies were considered to represent people working as government employees. Six agencies responded and agreed to take part in the surveys which were distributed through the mail. The participants were the DID, Department of Public Works (JKR), Department of Orang Asli (JAKOA), Kemubu Agricultural Development Authority (KADA), National Security Council (MKN), and Department of Land and Mines (PTG). The others either preferred to be interviewed personally or did not respond. A total of 180 survey documents were delivered to the agencies (30 documents each for distribution to staff throughout the agency) of which 92 were returned (a response rate of 51%).

For the online sampling of the surveys, an access link was made available by e-mail to various agencies' and university addresses in Kelantan from August until November 2015. The link was also shared via social media using Facebook. Only five responses were collected via the online approach indicating a reluctance to use the online survey provided, especially among those in private organisations, with a greater willingness to use a hardcopy of the survey distributed by mail.

The third strategy—using face-to-face interviews for the surveys, produced the most respondents. These were conducted in three phases—in June, August, and October 2015—in an evacuation centre, public schools, Department of Social Welfare, Department of Fisheries Malaysia, Royal Malaysia Police, Universiti Malaysia Kelantan (UMK), and public areas in nine districts in Kelantan. In total, the interviews resulted in 470 respondents to the questionnaire.

From all the above combined sampling strategies a total of 567 respondents were obtained out of 90,721 recorded flood evacuees from various Kelantan districts (Figure 5a). For comparison, Figure 5b shows the inundation area. Based on a normal distribution, 95% confidence level and 567 samples, the sampling margin of error is 4.2%. Since the

TABLE 1 Survey questions related to flood warning dissemination and reaction of the public: Kelantan December 2014 case study

No.	Question	Answers options
Q1	Were you aware of available early warning systems by the Department of Irrigation and Drainage Malaysia	a. Yes b. No
Q2	If you answered yes in Q1, which system do you know?	a. Siren near rivers b. Website (publicinfobanjir.water.gov.my) c. Facebook (www.facebook.com/pages/PublicInfoBanjir) d. Others
Q3	Did any warnings on heavy rainfall or flood reach you?	a. Yes b. No
Q4	Which medium reached you?	a. TV b. Radio c. Newspaper d. SMS e. Rumours from authority by the public f. Others
Q5	From whom was the warning received?	a. Community leaders b. Department of Irrigation and Drainage c. Meteorological Department d. Police e. News from public f. Others
Q6	During the December 2014 Flood, did an evacuation order by the authorities reach you?	a. Yes b. No c. Not sure
Q7	What was your action once you received the evacuation order?	a. Follow orders and be ready to evacuate b. Will evacuate once flood levels reached dangerous level (life threatening to the respondent) c. Will not evacuate d. Not sure
Q8	In your opinion, which medium would be effective in delivering warnings? (May choose more than 1)	a. Television (TV) b. Radio c. Newspaper d. Short massage (SMS) e. E-mail f. Community leaders e. Others

sampling method uses a convenience sample technique, assessment according to location was not conducted. More samples within a particular district should be obtained in order to conduct reliable assessment of the spatial dependence of responses.

Age is hypothesized as a particular factor in determining the effectiveness of an EWS, particularly in terms of the dissemination medium. Therefore, a summary of the socio-demographic characteristic of the Kelantan public sample obtained from the respondents is compared to estimates for the Kelantan state population (Department of Statistics, 2010) in Table 2. This shows slight differences between the sample population and the wider state population data (note however that the population characteristics are based on the 2010 census, while samples were taken in 2015). In general though, Table 2 and Figure 6 indicate broadly similar population distributions in terms of age, with a slight oversampling of older age groups. Comparisons between the gender and monthly income of the sample and population were also performed and indicated that the two statistics for the sample differ from those of the wider population, therefore assessment according to the influence of gender and income were not conducted.

3 | RESULTS AND DISCUSSION

3.1 | Flood early warning system

Two significant questions on the flood EWS were asked in the questionnaire (Table 1). The first (Q1) was on the general awareness of people of the existing warning systems provided by the authorities. The second (Q2) was related to the specific system known to them. In the following two questions respondents were then asked whether they received a warning (Q3) and if so through which medium (Q4).

Analysis of the responses to Q1 shows a majority (67%) were unaware of the system (Figure 7a). Of the 33% of people answering "yes," most knew of it through Facebook (38%), followed by the DID website (34%), and the remainder from the sirens situated near rivers and others (Figure 7b). Exposure to the flood warning system through social media (Facebook) was high for younger age groups (under 26 year of age) as expected, and was even the most familiar medium in the 36 to 49 age group (Figure 7c).

In order to assess how effective available warnings were for the December 2014 flood, the respondents were asked whether they received any warnings (Q3), which medium reached them (Q4) and from whom (Q5). Despite the lack of awareness of available early warning systems, warnings were received by 56% of the people (Figure 8a). Most of
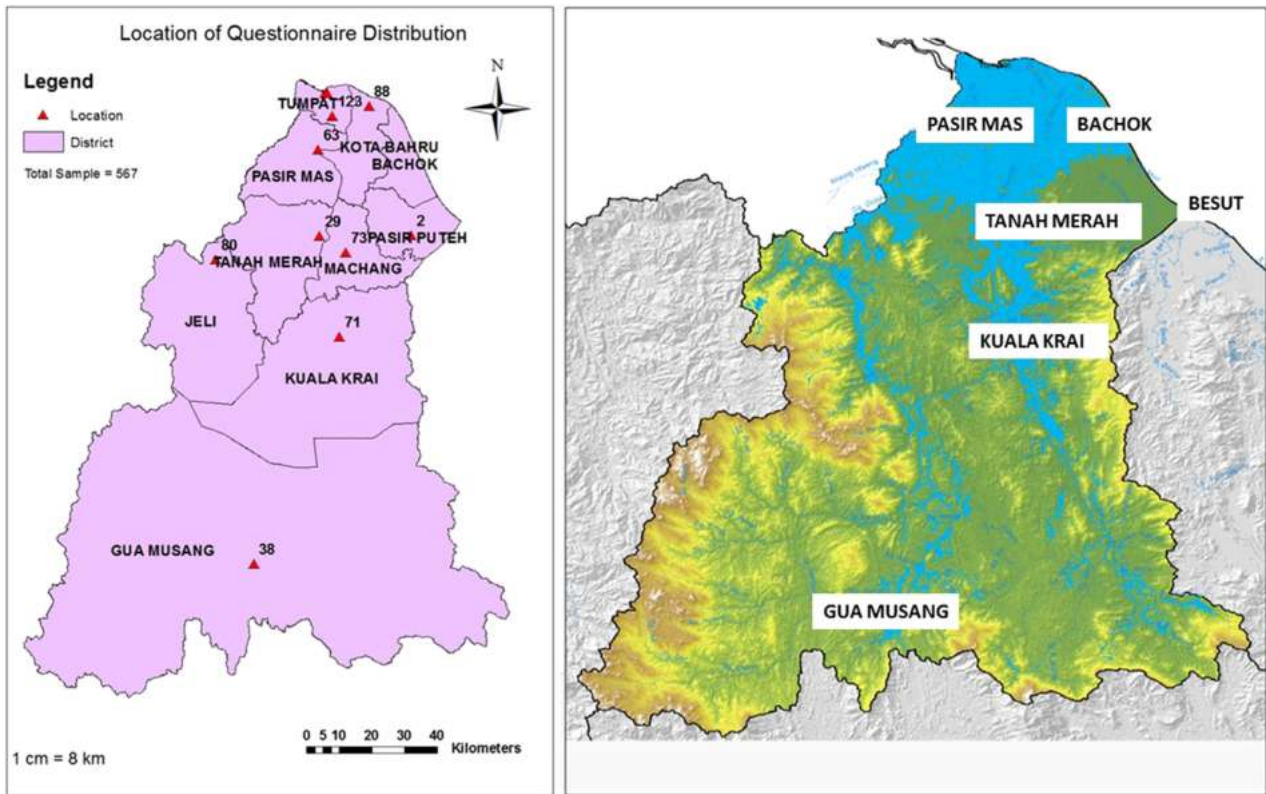
FIGURE 5 (a) Location of the samples across Kelantan (numbers denote number of samples [completed questionnaires] from each district), and (b) flood inundation area in blue (Department of Irrigation and Drainage, DID, 2014)

those who received a warning did so through television (Q4, 52%), (Figure 8b), with the next most frequent medium being by rumour, that is, news circulated among the public themselves (18.6%). This is consistent with the report by

information to the public because they are easily accessible and offer residents a useful way to get an overall picture of the situation. However, this availability and ease of access may be different in other parts of the world. González

TABLE 2 Socio-demographic characteristics of the Kelantan public sample and Kelantan State (estimated based on 2010 census by the Department of Statistics, Malaysia data, Department of Statistics (2010))

Socio-demographic characteristics	Public sample ($N = 567$)	Kelantan State (population = 1,470,696)
Age (median)	26–35 years	25 and lower
Gender (% male)	40.4	50.33
Monthly income (median)	RM1001-2000	RM2716 (year 2014)
Residence length (Medan)	6–10 years	-
Education (diploma or higher)	40.9%	-

Ejupi, Siljanovska, and Iseni (2014), who noted the power of this medium in conveying information to the public and Henry, Kawasaki, Takigawa, and Meguro (2017) who identified the dominant role of television across all income levels during the 2011 Thai Flood. The role of the mass media during large disasters has been stressed in a report by the Foundation of River and Basin Integrated Communications, Japan (FRICS) published by the World Bank (World Bank, 2017). Taken from a case study in Japan, they indicated that the mass media plays an important role in communicating

(2014) also describes the effective role of mass media in disseminating warnings of extreme meteorological events to the public in Cuba where considerable strength is evident through the availability of TV channels, radio stations, and newspapers across the country. However, they also note that messages disseminated by the national media, specifically during the approach of an extreme hydrometeorological event, may overshadow information from local authorities and monitoring institutions. They therefore identify an important gap in defining the content and timing of public
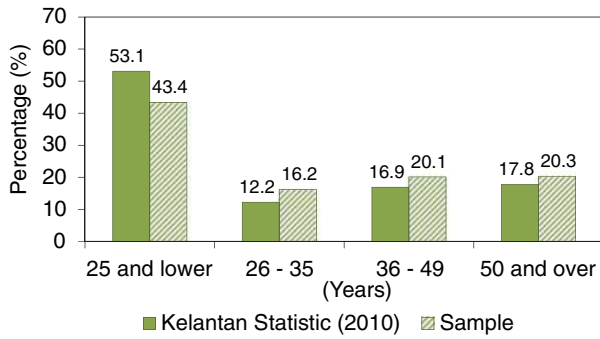
FIGURE 6 Age distribution of the sample and the Kelantan population statistics as at 2010 (Department of Statistics, 2010)

information from authorities and monitoring institutions at local levels.

Further assessment was made of the source of warnings received for example, from a certain organisation or person (Q5, Figure 8c). The highest percentage was from members of the public (34.4%), followed by the meteorological department (MET; 30.3%), community leaders (CLs) (known as JKKK by locals - 21.4%), DID (7.4%), and the police (4.7%). These results generally show that besides the medium of television, important information is being

transferred among people either via local CLs or the public themselves. In this case, reference to the public includes neighbours, relatives, friends, or people living close to the respondents. This shows that at the time of the December 2014 Kelantan flood, the public and local community association was an important source of warnings and demonstrates the importance of giving early warnings to the local village committee which will then further disseminate the information, as the element of "trust" and connectivity is an advantage.

Another interesting outcome relates to SMS as the warning medium. The percentage of people who received a warning through SMS is higher than that from the radio. Most of the respondents identifying SMS as the medium said that they received it from another member of the public, demonstrating the means by which warnings were disseminated among local people rather than directly from the authorities. In Malaysia, this may in part reflect the fact that direct warnings from the authorities via SMS are limited (Figure 8d).
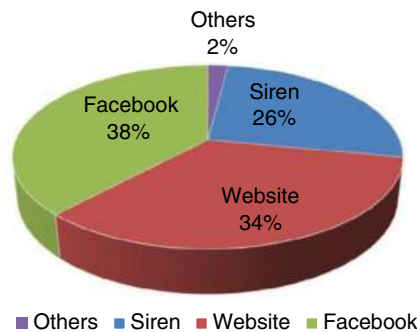
According to the National Disaster Control Center (NDCC) and the National Disaster Management Agency of Malaysia (NADMA), during the December 2014 event, the dissemination of disaster warnings by the authorities was implemented at district level. Once a flood warning was
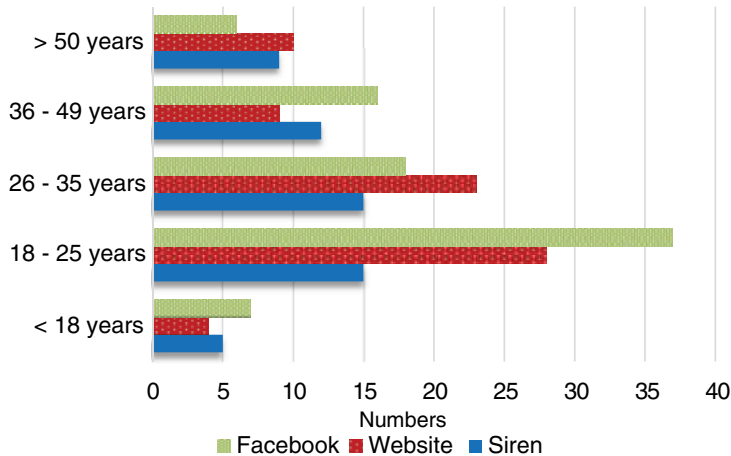
Number of respondents: 567

FIGURE 7 Respondents' knowledge of early warning systems provided by the government: (a) Awareness of existing EWS, (b) types of system known, (c) systems known by age of respondents
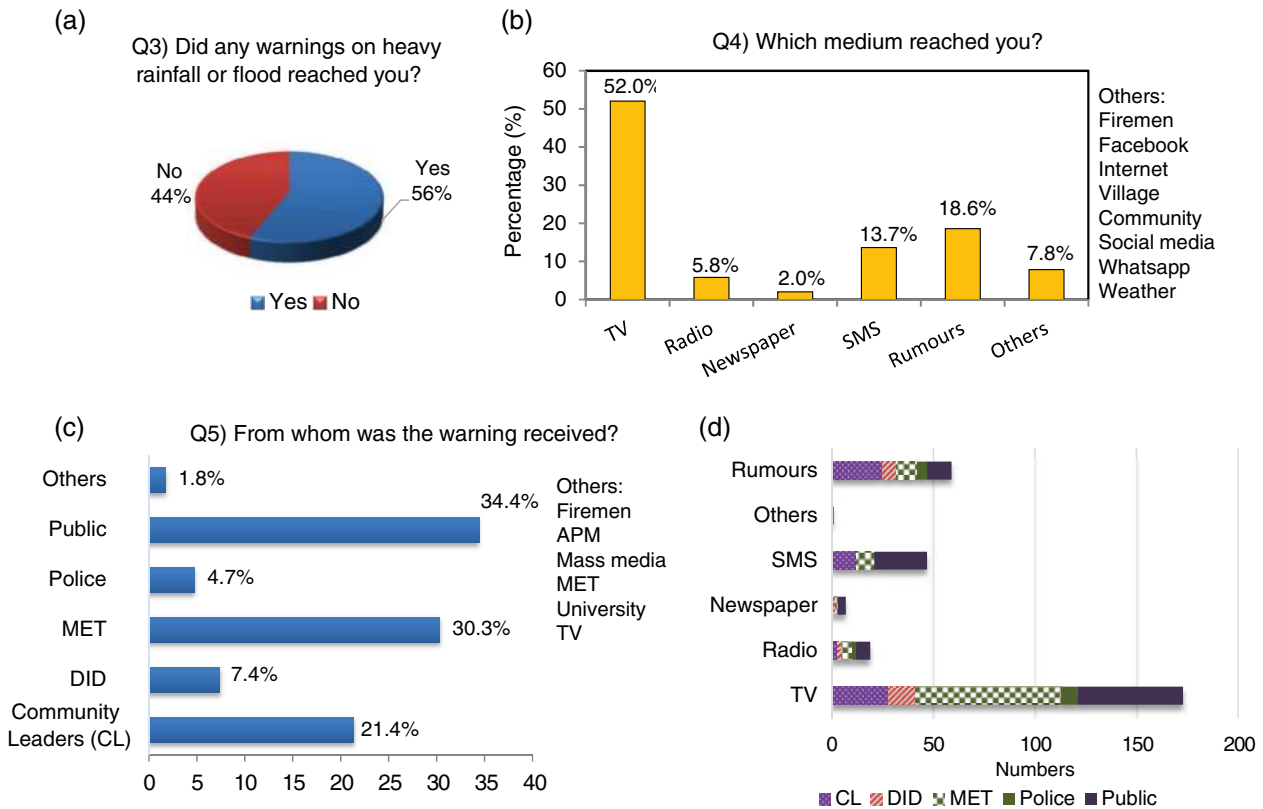
FIGURE 8 Responses to questions relating to the December 2014 flood warning dissemination: (a) receipt of warnings, (b) medium of warnings received, (c) source of warning, and (d) medium received with source

received from the DID at the NDCC, warnings were sent to the state level of the National Security Council. Information was then sent to district levels such as the district operation unit and the district officers. It was then up to the district officer to instigate warnings, emergency evacuations and rescues. Agencies responsible to assist evacuation and rescues are the Malaysia Civil Defence Department (APM), Fire and Rescue Department of Malaysia (JBPM), the military, and the Special Malaysia Disaster Assistance and Rescue Team (SMART). Warnings were then managed by the district authorities. During the 2014 flood, warnings were especially delivered through the village CLs, explaining why a majority of those receiving warnings through rumour stated that village CLs (CL) were their main source of information (Figure 8d).

In order to improve dissemination, the authorities could consider fully utilising SMS as one of their main media to deliver warnings. Research on the usage of cellphones and the internet conducted in 2014 in 32 emerging and developed countries found that 92% of Malaysians owned a cellphone and that 89% used text messaging regularly (Pew Research Center, 2015). Therefore, it may be beneficial that telecommunication companies be involved in policies pertaining to emergency warnings, with a minimal or no-cost service to the authorities providing the warnings.

The sole purpose of flood emergency warnings is to provide sufficient preparation and evacuation time for people. This is vital in order to reduce loss of life and to provide more time to evacuate and secure possessions. Therefore, assessing the responses of people upon receipt of an evacuation order is important. Figure 9 shows the results obtained based on evacuation related questions from the 567 respondents. The first question (Q6) asked whether they received an evacuation order - 48% answering yes (Figure 9a). The others either did not receive one (34%) or were not sure (18%). Among the 48% who received the evacuation order, a majority (72.5%) followed the instruction and were ready to evacuate (Q7; Figure 9b). However, about one fifth of the people receiving an evacuation order waited for the water levels to reach dangerous levels before evacuating. Results were also assessed by age of respondents (Figure 9c). This indicates that with increasing age a lower percentage of people chose to follow orders and be ready to evacuate, preferring instead to evacuate once the water level had become dangerous.

The results of these responses may be assessed in the context of behavioural theory. According to behavioural

theory, people may ignore warnings due to their initial response when a disaster occurs being one of believing that they are safe (Aguirre, 2005). A member of a community will evacuate in response to a (or several) community-wide warnings based on factors that influence certain stages of warning response. These factors include whether a person believes the warning message, whether they feel at risk in the face of the oncoming hazard, and whether they confirm the warning by asking or seeking additional information about what is happening, and thus eventually determine whether the person evacuates their home based on the warning (Kuligowski & Gwynne, 2010). Consistent with behavioural theory, age differences may be considered as one of the factors and as a consequence we may consider that older members of the population may have higher vulnerability to a disaster since they show a less positive response towards evacuation orders. Training and information campaigns might therefore also be conducted at an institutional level, targeting specific participants.

3.2 | Perception

Opinions of the respondents on "*what they think an effective medium of warning dissemination would be?*" were also investigated in the questionnaire (Q8). Figure 10a shows that TV was rated highest - 73.2% of all respondents chose TV as an effective medium, followed by radio, SMS, local leader, newspaper, e-mail and others. In terms of age, there is no clear pattern whether the age affects the perceptions of people on effective dissemination method with TV rated highest across all age groups (Figure 10b). This relates to the earlier response that most people received warnings through TV. Almost one third think SMS would be effective even though less than one fifth received a warning via this medium.

Alternative warning dissemination methods may be derived from the World Bank (2017) which indicates the importance of the public sector in disseminating warnings. Beside the internet, further methods include the use of disaster management radio communications (outdoor loud speakers installed in neighbourhoods) and public relations vehicles. Henry et al. (2017) show the effectiveness of warning dissemination for low-income respondents by utilising lower technology modes such as radios and loudspeakers, in contrast to internet-based modes by higher income respondents. The World Bank (2017) has also highlighted the need for the public sector and mass media to closely cooperate in providing necessary information in order to encourage the public to take proper action for avoiding and reducing disaster damage.
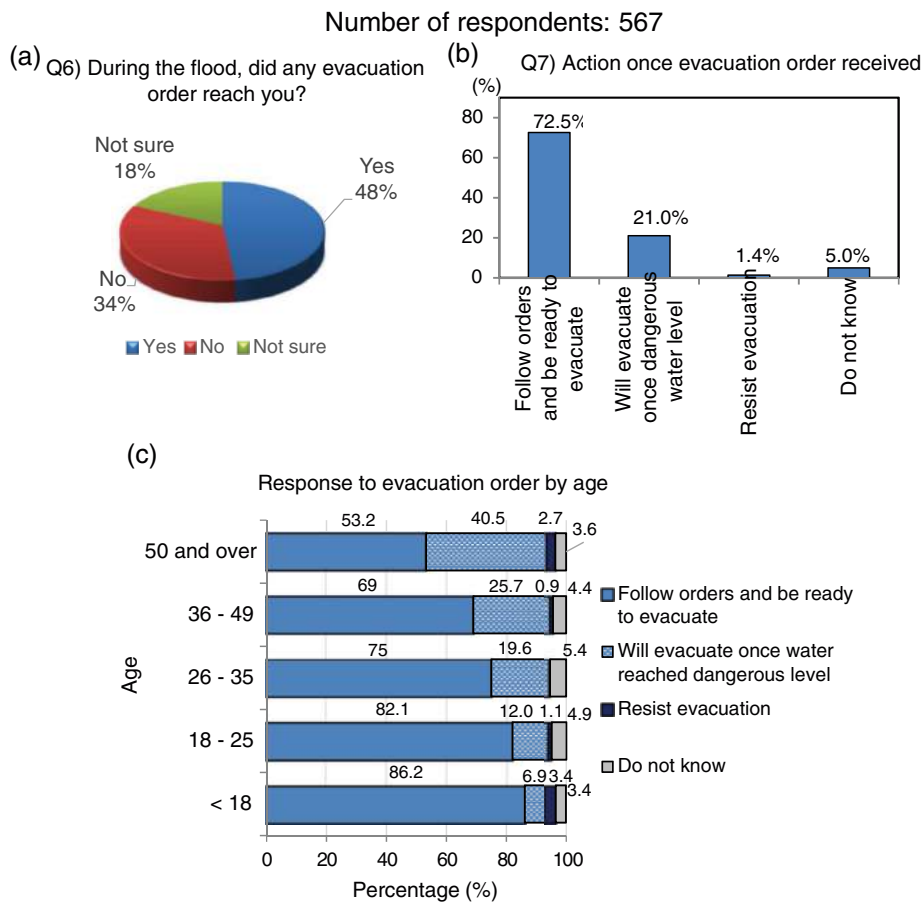

Number of respondents: 567

(a) Q6) During the flood, did any evacuation order reach you?

(b) Q7) Action once evacuation order received

(c) Response to evacuation order by age

FIGURE 9 Responses to the December 2014 flood evacuation order: (a) percentage of evacuation orders received; (b) actions upon receipt of evacuation order; (c) responses to evacuation order by age

FIGURE 10 Responses on warning dissemination method: (a) opinion on effective method; (b) opinion on effective method by age

Number of respondents: 567

(a) Q8) Opinion on effective dissemination method.

(b) Opinion on effective dissemination method by age
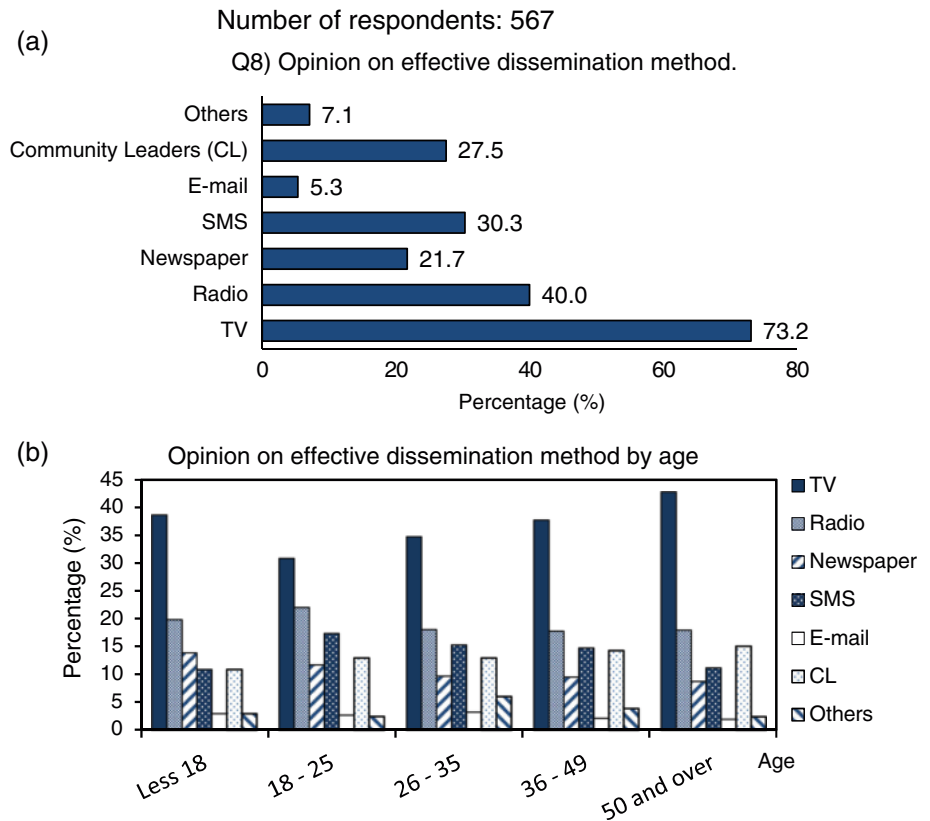
4 | CONCLUSIONS

Improving early warning systems is important to reduce the impact of natural disasters and this process includes improved methods of warning dissemination as well as increased warning time. This paper highlights feedback from the people of Kelantan, Malaysia, subsequent to the extreme December 2014 flood, on the early warnings they received and the potential for improved warnings in the future. The results presented here show that despite the lack of awareness of available flood early warning systems, warnings did reach 56% of the people questioned. However, improvement of the warning system should be undertaken to deliver an effective warning to the remainder of the population. The effectiveness of communicating flood warnings to the public was highly dependent on the dissemination medium used, with large differences in the receipt of warnings via different media. Although TV was shown to have the highest percentage of any medium, most respondents indicated that they received their warnings from the public, whilst one fifth stated CLs. This demonstrates the important role of the community in conveying warnings and signifies the importance of sharing information between people. SMS had the highest percentage for receipt of warnings after TV and rumours, however, warning via SMS directly from the authorities was not widely applied as these are limited to particular receivers. Most people receiving warnings via SMS received

them from other members of the public (e.g., friends, relatives, etc.). Responses upon receiving an evacuation order indicated that with increasing age a lower percentage of people chose to follow orders and be ready to evacuate.

Further research with more structured samples and a larger sample size will benefit from analysing the awareness and perceptions of the population according to their location, socio-economic status, and level of education. This research also suggests that responses to evacuation orders may be lower within elderly, and that younger adults are more prepared to evacuate from their properties. The latter may arise as older adults tend to have more emotional attachment to their homes and belongings, and hence feel uncomfortable with the evacuation orders and very often show resistance to evacuation (Dilmener, 2007; Riad, Waugh, & Norris, 2001). Given the different responses from younger and older members of the population, the application of demographic information may also help in the development of flood evacuation strategies. Focus should also be given on assessing and understanding the psychological aspect of evacuees to improve the mental preparedness of the affected population for evacuation during the flood (Van den Berg et al., 2008). The effectiveness of a flood early warning system in ensuring a smooth evacuation process is dependent on the psychological readiness of the flood victims to evacuate when prompted by the authorities. It is well known that those involved in a flood might encounter psychological

distress during the evacuation process (Paranjothy et al., 2011). This distress may hinder the evacuation despite receipt of an early warning. It is therefore important to understand the psychological aspects of the exposed population as well as the warning systems themselves. Furthermore, evaluating and assessing the effectiveness of an early warning system is not limited to floods but can also be applied to other disasters. Further such studies should be conducted for future improvements and to better understand the community in relation to its early warning system as the development of an effective warning system does not solely depend on advanced technology but needs crucial input derived from feedback from the affected communities. These studies may strengthen the evidence base for a continous cycle of assessment of all components of an early warning system (as proposed in this research and summarised in Figure 1) to be considered essential for such systems to be fully effective.

ACKNOWLEDGEMENTS

ORCID

Nor Eliza Alias https://orcid.org/0000-0002-4174-5637

REFERENCES

Aguirre, B. E. (2005). *Emergency evacuations, panic, and social psychology: Commentary on 'understanding mass panic and other collective responses to threat and disaster*. Newark, DE: University of Delaware, Disaster Research Center.

Ahmad, M. N., Othman, M., Zakaria, N. H., & Mohd Rodzi, M. Z. (2014). Managing information and knowledge in Malaysia's flood management: Towards a new framework. In *New trends in software methodologies, tools and techniques* (Vol. 265, pp. 446–463). Amsterdam: IOS Press. https://doi.org/10.3233/978-1-61499-434-3-446

Akter, T., Quevauviller, P., Eisenreich, S. J., & Vaes, G. (2018). Impacts of climate and land use changes on flood risk management for the Schijn River, Belgium. *Environmental Science & Policy*, *89*, 163–175 ISSN 1462-9011.

AlBattat, A. R., & MatSom, A. P. (2014). Emergency planning and disaster recovery in Malaysian hospitality industry. *Procedia Social and Behavioral Sciences*, *144*, 45–53. https://doi.org/10.1016/j.sbspro.2014.07.272

Alias, N. E., Mohamad, H., Chin, W. Y., & Yusop, Z. (2016). Rainfall analysis of the Kelantan Big Yellow Flood 2014. *Jurnal Teknologi*, *78*(6), 112–120. eISSN 2180–3722.

Baharin, S. S. K., Shibghatullah, A. S., & Othman, Z. (2009). Disaster management in Malaysia: An application framework of integrated routing application for emergency response management system, soft computing and pattern recognition. In *International Conference of Soft Computing and Pattern Recognition, SOCPAR '09* (pp. 716–719). https://doi.org/10.1109/SoCPaR.2009.144

Basher, R. (2006). Global early warning systems for natural hazards: Systematic and people centred. *Philosophical Transactions of the Royal Society A*, *364*, 2167–2182. https://doi.org/10.1098/rsta.2006.1819

Billa, L., Mansor, S., & Mahmud, A. R. (2004). Spatial information technology in flood early warning systems: An overview of theory, application and latest developments in Malaysia. *Disaster Prevention and Management: An International Journal*, *13*(5), 356–363.

Billa, L., Shattri, M., Mahmud, A. R., & Ghazali, A. H. (2006). Comprehensive planning and the role of SDSS in flood disaster management in Malaysia. *Disaster Prevention and Management: An International Journal*, *15*(2), 233–240.

Biniyam, Y., & Kemal, A. (2017). The impacts of climate change on rainfall and flood frequency: The case of Hare Watershed, Southern Rift Valley of Ethiopia. *Journal of Earth Science and Climatic Change*, *8*, 383. https://doi.org/10.4172/2157-7617.1000383

Boxill, I., Chambers, C., & Wint, E. (1997). *Introduction to social research: With applications to the Caribbean*. Jamaica: University of The West Indies Press. Chapter 4, page 36. ISBN 976-8125-22-5

Department of Statistics. (2010). *Population distribution and basic demographic characteristics report 2010*. Kuala Lumpur: Department of Statistics Malaysia.

Department of Irrigation and Drainage, DID. (2014). Laporan Banjir Negeri Kelantan. Report by the Department of Irrigation and Drainage Malaysia.

Didovets, I., Krysanova, V., Bürger, G., Snizhko, S., Balabukh, V., & Bronstert, A. (2019). Climate change impact on regional floods in the Carpathian region. *Journal of Hydrology: Regional Studies*, *22*, 2214–5818.

Dilmener, R. S. (2007). *A Theory of Evacuation as a Coordination Problem*. Durham, NC: Duke University Press.

Ejupi, V., Siljanovska, L., & Iseni, A. (2014). The mass media and persuasion. *European Scientific Journal*, *10*(14), 636–646.

Fakhruddin, S. H. M., Kawasaki, A., & Babel, M. S. (2015). Community responses to flood early warning system: Case study in Kaijuri union, Bangladesh. *International Journal of Disaster Risk Reduction*, *14*, 323–331. https://doi.org/10.1016/j.ijdrr.2015.08.004i

Garcia, C. (2012). Designing and implementing more effective integrated early warning systems in mountain areas: A case study from Northern Italy. *Journal of Alpine Research*, *100*(1), 1–12. https://doi.org/10.4000/rga.1679

Garschagen, M., Hagenlocher, M., Comes, M., Dubbert, M., Sabelfeld, R., Lee, Y. J., … Birkmann, J. (2016). *World risk report 2016. World risk report*. Berlin: Bündnis Entwicklung Hilft and UNU-EHS.

Golnaraghi, M., Douris, J., Luther, J., Maximuk, L., & Aliagha, B. (2015). *Synthesis of status and trends with the development of early warning systems*. Geneva: UNISDR.

González, M. A. P. (2014). *Cuba early warning systems in Eastern Provinces – Facing hydro-meteorological extreme phenomena*. Cuba: UNDP Cuba.

Guha-Sapir, D., Below, R., Hoyois, P. (2016). *EM-DAT: The CRED/-OFDA International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium [online]*. Retrieved from http://www.emdat.be/database

Henry, M., Kawasaki, A., Takigawa, I., & Meguro, K. (2017). The impact of income disparity on vulnerability and information collection. *Journal of Flood Risk Management*, 10, 339–348. https://doi.org/10.1111/jfr3.12144

International Federation of Red Cross and Red Crescent Societies. (2013). *'Community early warning systems: guiding principles', Community Preparedness and Risk Reduction Department Geneva [online]*. Retrieved from http://www.ifrc.org/pageFiles/103323/1227800-IFRC-CEW-Guiding-Principles-EN.pdf

Jeeva, V. R., & Puthiyidam, J. J. (2014). A survey on disaster management systems. *International Journal of Advance Research in Computer Science and Management Studies*, 2(11), 355–360.

Khalid, M. S., Mustaffa, C. S., Marzuki, M. N., Sakdan, M. F., Sipon, S., Ariffin, M. T., & Shafiai S. (2015). Failure to react positively to flood early warning systems: Lessons learned by flood victims from flash flood disasters: The Malaysia experience. *International Journal of Social, Behavioural, Educational, Economic, Business and Industrial Engineering, World Academy of Science and Technology*, 9(5), 1406–1410.

Kuligowski, E. D., & Gwynne, S. M. V. (2010). The need for Behavioral theory in evacuation modeling. In W. Klingsch, C. Rogsch, A. Schadschneider, & M. Schreckenberg (Eds.), *Pedestrian and evacuation dynamics 2008* (pp.721–732). Berlin and Heidelberg, Germany: Springer. https://doi.org/10.1007/978-3-642-04504-2_70.

Lamichhane, R. (2011). *People's perception in early warning system: A case study of Bhandara VDC Padariya-7 in Chitwan district, Nepal*. Dhaka, Bangladesh: BRAC University.

Luo, P., Apip, H. B., Duan, W., Takara, K., & Nover, D. (2018). Impact assessment of rainfall scenarios and land-use change on hydrologic response using synthetic area IDF curves. *Journal of Flood Risk Management*, 11, S84–S97. https://doi.org/10.1111/jfr3.12164

Luo, P., Zhou, M., Deng, H., Lyu, J., Cao, W., Takara, K., … Schladow, S. (2018). Impact of forest maintenance on water shortages: Hydrologic modeling and effects of climate change. *Science of the Total Environment*, 615, 1355–1363. ISSN 0048-9697.

Min Wu, Y., & Kanamori, H. (2005). Experiment on an onsite early warning method for the Taiwan early warning system. *Bulletin of the Seismological Society of America*, 95(1), 347–353. https://doi.org/10.1785/0120040097

Mohd Rodzi, M. Z., Zakaria, N. H., Ahmad, M. N., & Yahya, H. (2014). Towards a knowledge management framework for disaster management in Malaysia. In H. Haron, H. Fujita, & A. Selamat (Eds.), *New Trends in Software Methodologies, Tools and Techniques - Proceedings of the 13th SoMeT 2014* (Frontiers in Artificial Intelligence and Applications; Vol. 265, pp. 417-431). IOS Press. https://doi.org/10.3233/978-1-61499-434-3-417

Paranjothy, S., Gallacher, J., Amlôt, R., Rubin, G. J., Page, L., Baxter, T., … Palmer, S. R. (2011). Psychosocial impact of the summer 2007 floods in England. *BMC Public Health*, 11(1), 145. https://doi.org/10.1186/1471-2458-11-145

Pew Research Center. (2015, March) *Internet seen as positive influence on education but negative influence on morality in emerging and developing nations*. Retrieved from http://assets.pewresearch.org/wp-content/uploads/sites/2/2015/03/Pew-Research-Center-Technology-Report-FINAL-March-19-20151.pdf

Riad, J. K., Waugh, W. L. J., & Norris, F. H. (2001). In A. Farazmand (Ed.), *Handbook of crisis and emergency management The psychology of evacuation and the design of policy* (pp. 309–325). New York: CRC Press.

UN - United Nations. (2006). *Global survey of early warning systems. New York*. Retrieved from http://www.unisdr.org/2006/ppew/info-resources/ewc3/Global-Survey-of-Early-WarningSystems.pdf

UNISDR. (2009). *2009 UNISDR terminology on disaster risk reduction*. Geneva, Switzerland: Author.

Van den Berg, B., Grievink, L., Gutschmidt, K., Lang, T., Palmer, S., Ruijten, M., … Yzermans, J. (2008). The public health dimension of disasters—Health outcome assessment of disasters. *Prehospital and Disaster Medicine*, 23(4), s55–s59.

White, G. F., & Haas, J. E. (1975). *Assessment of research on natural hazards* (p. 487). Cambridge: MIT Press.

World Bank (2017) *Modernization of hydrological services in Japan and lessons for developing countries*. Retrieved from https://doi.org/10.1596/26705