Journal of
Flood Risk Management

The impact of income disparity on vulnerability and information collection: an analysis of the 2011 Thai Flood

M. Henry[1], A. Kawasaki[2], I. Takigawa[3] and K. Meguro[4]

1 Division of Field Engineering for the Environment, Faculty of Engineering, Hokkaido University, Sapporo, Japan
2 Department of Civil Engineering, School of Engineering, The University of Tokyo, Tokyo, Japan
3 Division of Computer Science and Information Technology, Graduate School of Information Science and Technology, Hokkaido University, Sapporo, Japan
4 International Center for Urban Safety Engineering (ICUS), Institute of Industrial Science, The University of Tokyo, Tokyo, Japan

Correspondence
Michael Henry, Division of Field Engineering for the Environment, Faculty of Engineering, Hokkaido University, Kita-ku North 13 West 8, Sapporo, Hokkaido 060-8628, Japan
Tel: +81 011 706 6180
Email: mwhenry@eng.hokudai.ac.jp

DOI: 10.1111/jfr3.12144

Key words
Age; education; evacuation; flooding; income; information dissemination; media use.

Abstract

The impact of income disparity on vulnerability and information collection during the 2011 Thai Flood was examined through a survey investigation. Lower-income respondents were found to have been more likely to be inundated by the flood than higher-income respondents because of the location of their residences, and lower-income respondents whose residences flooded were also less likely to have evacuated. Television was widely used, regardless of income level, but lower-income respondents tended to also utilise lower-technology modes, such as radios and loudspeakers, in contrast to the Internet-based modes used by higher-income respondents. Lower-income respondents also tended to be less aware of the government hotline; however, those that were aware of it were more likely to find it useful. Overall, while income was a good predictor of people's flood vulnerability, it was not the best predictor for media usage; other demographic characteristics, such as education level and age, should also be considered.

Introduction

The Chao Phraya River Flood (hereafter, the 2011 Thai Flood) was a massive flood event that occurred during the second half of 2011 (Figure 1) and led to extensive and long-term social and economic damages (World Bank, 2011; Komori *et al.*, 2012). The primary cause of the flood was record rainfall over the Indochina Peninsula from June to September 2011. However, other factors contributed to the flood progress and socio-economic damages, such as incomplete flood control facilities, poor rainfall estimation, lack of flood control measures, and inappropriate land use. These were aggravated by a lack of communication between the Thai national government and the Bangkok metropolitan government, inappropriate disaster countermeasures, and insufficient information dissemination to the general population (Bangkok Post, 2011; MCOT, 2011; The Guardian, 2011; The New York Times, 2011). More than 800 people died or went missing because of the flood [Department of Disaster Prevention and Mitigation (DDPM), 2011], and The World Bank estimated that total losses would reach 1.36 trillion Thai baht (approximately 42 billion US dollars) (World Bank, 2011). The 2011 Thai Flood thus became the fourth largest natural disaster ever, in terms of economic damages, following the 2011 Great East Japan Earthquake, the 2005 Hurricane Katrina in the United States, and the 1995 Great Hanshin-Awaji Earthquake in Japan (UNISDR, 2009; Iwaki *et al.*, 2011).

Although the flood inundated an enormous area of Thailand, its effects may not have been felt equally across Thai society. This supposition arises from the definition of vulnerability given by the Organization for Economic Co-operation and Development (OECD), which states that 'the extent to which a community . . . is likely to be damaged or disrupted' by a disaster depends, in part, on the nature of that community (OECD, 2001). Previous investigations strongly support this theory in demonstrating that as socio-economic status decreases, vulnerability to the impacts of a disaster increases (Morrow, 1999; Boyce, 2000; Chou *et al.*, 2004). Furthermore, the reduction of disaster vulnerability has been strongly linked to poverty reduction, particularly in Asia (UNISDR, 2008; UNESCAP and UNISDR, 2010). In the case of Thailand, wealth distribution is skewed towards a small percentage of the population, with a GINI index of 53.6 as of 2009 (Central Intelligence Agency 2014), and geographically concentrated in the metropolitan area, with the

Figure 1 Progression of the 2011 Thai flood.

average monthly income in Greater Bangkok twice that of most other regions as of 2011 (National Statistical Office, 2011). Therefore, the unequal distribution of economic resources across Thai society may lead to unequal exposure to disaster risk as well.

Proper provision of information during disaster events can contribute to reducing vulnerability, but access to such information may be similarly affected by socio-economic status. Previous studies that examined the disaster information collection behaviour of disabled people and foreigners unskilled in the local language found that greater attention should be given to populations with unique needs in times of disaster (Spence *et al.*, 2007; Kawasaki *et al.*, 2012b). However, there is little information on the effect of income disparity on disaster information collection. The gathering of relevant and up-to-date information is essential for decision making in response to a developing disaster situation, and the vulnerability of people with lower socio-economic status may be exacerbated by a lack of timely and proper information. Conversely, appropriate disaster information dissemination may increase the resilience of such disadvantaged groups.

This paper describes and explains the relationship between income disparity and disaster information collection, and the resulting impacts on peoples' vulnerability, using the results of a questionnaire survey conducted after the 2011 Thai Flood. From the analysis results, key points are extracted for understanding how disaster information systems should take socio-economic differences into account, as well as how vulnerability could be reduced through the effective dissemination of disaster information. As income disparity is an issue not only in Thailand, but also in many other countries around the world, the results of this paper may be valuable and applicable beyond the borders of Thailand.

Information dissemination during the flood

A wide variety of government- and citizen-driven activities were carried out for disseminating information during the 2001 Thai Flood. To respond to the intense and extensive damage caused by the flooding, the Flood Relief Operation Center (FROC) was established by the Thai government's DDPM. FROC carried out various emergency response activities, including disseminating flood hazard alerts via television, the radio, and the Internet. FROC also set up a 24-h call centre (hotline) to serve as a connection between the government and the general public. While this hotline provided an opportunity for residents to share their ideas and for the government to clearly communicate its plans, it is unclear whether this service was effective (Kawasaki *et al.*, 2012a).

Social media and crowd-sourced crisis Web maps linked with social networking services were also utilised during the 2011 Thai Flood. A number of services worked with Twitter and Facebook to enable citizens to input disaster information that they observed, and some government organisations also utilised mashed up web mapping services to provide information through their official websites, as well as creating Twitter feeds and Facebook pages to increase the opportunities for citizens to access information (Kawasaki *et al.*, 2012a; Kodaka *et al.*, 2012). As a result of the contributions from both government agencies as well as normal citizens, the volume of disaster information available was enormous, but this information may not have been accessible by everyone.

Survey methodology and sample characteristics

Survey design and distribution

Data on the vulnerability and information collection of Thai residents during the flood were collected using a questionnaire survey. The survey was designed to clarify respondents' vulnerability, information collection behaviour, and demographics (Table 1).

The details of the survey and its distribution are summarised in Table 2. To ensure the quality of the Thai-language survey, a three-step process was carried out. First, an English

Journal of Flood Risk Management published by Chartered Institution of Water and Environmental Management and John Wiley & Sons Ltd.

Table 1 Survey questionnaire items

Theme	Questionnaire items
Vulnerability	Situation of flooding and evacuation
Disaster information collection	Media modes utilised for information gathering
	Awareness and usefulness of government call centre
Demographics	Annual income, occupation, location of residence, age, gender, education

Table 2 Survey details

Method	Anonymous Internet-based survey	Field survey
Period	12 March to 23 July, 2012	9–20 May 2012
Target	Thai people residing in Thailand during the 2011 Thai Flood	
Distribution method	Forwarding of URL through social and professional contacts and through direct requests to organisations	Direct request to residents to fill out paper survey in various areas
Responses	162 people Total 764 people	602 people

Table 3 Categorisation of respondents by income level

Annual income	Frequency	Valid %	Classification	Frequency	%
Less than 50 000 Baht (less than 1600 USD)	67	9.6	Very low	178	25.5
50 000–100 000 Baht (1600–3200 USD)	111	15.9			
100 000–150 000 Baht (3200–4800 USD)	160	22.9	Low	160	22.9
150 000–500 000 Baht (4800–16 000 USD)	269	38.5	Middle	269	38.5
500 000–1 000 000 Baht (16 000–32 000 USD)	68	9.7	High	91	13.0
1 000 000–2 000 000 Baht (32 000–64 000 USD)	13	1.9			
2 000 000–4 000 000 Baht (64 000–130 000 USD)	7	1.0			
More than 4 000 000 Baht (more than 130 000 USD)	3	0.4			
Valid total	698	100.0	Total	698	100.0
Prefer not to answer	66				
Total	764				

survey form was created by authors fluent in English. Then, based on the English form, a native Thai speaker fluent in English translated the form into Thai. Finally, a second native Thai speaker checked the initial Thai translation, compared it with the original English form, and revised it appropriately.

Categorisation by annual income and sample characteristics

Respondents were categorised based on their reported annual income, which was collected using eight brackets following the Thai income tax system, with modifications. To analyse the disaster information collection considering the income disparity in Thailand, the eight brackets were grouped into the four levels of 'very low', 'low', 'middle', and 'high' income. Using this categorisation, 698 valid respondents were extracted, with the breakdowns by annual income bracket and grouped income level shown in Table 3.

While higher income generally corresponds to a higher level of education, there exists a distinct group for whom this trend does not hold: the higher-education (college, university, or graduate) student. Therefore, their vulnerability and disaster information collection behaviour may differ from other respondents with similarly low economic resources. Considering this exception, respondents who identified themselves as students (with at least a high school degree) were removed from the categorised income groups and placed in a separate group. The resulting five categories (four by income, and one for students) are summarised in Table 4, and the sample demographics are summarised in Table 5.

Table 4 Group sizes after extraction of students

Group	Change after extracting students	Freq.	%
Very low	−58	120	17.2
Low	−17	143	20.5
Middle	−10	259	37.1
High	No change	91	13.0
Students	+85	85	12.2
Total		698	100.0

Table 5 Demographics of extracted respondents by group

	Group (N = 698)				
	Very low (n = 120) (%)	Low (n = 143) (%)	Middle (n = 259) (%)	High (n = 91) (%)	Students (n = 85) (%)
Education					
Junior high or lower	58.3	19.6	1.9	3.3	0.0
High school	15.0	24.5	8.5	5.5	12.9
2- or 4-year college	19.2	49.0	67.6	36.3	64.7
Graduate school	4.2	4.2	21.6	54.9	21.2
Prefer not to answer	3.3	2.8	0.4	0.0	1.2
Age					
20–29	24.2	28.0	27.4	4.4	88.2
30–39	15.8	39.2	35.1	37.4	2.4
40–59	40.8	30.8	34.0	52.7	2.4
60 or older	17.5	2.1	3.5	4.4	0.0
10–19, prefer not to answer	1.7	0.0	0.0	1.1	7.1
Gender					
Male	32.5	49.0	41.3	59.3	31.8
Female	66.7	50.3	58.3	39.6	68.2
Prefer not to answer	0.8	0.7	0.4	1.1	0.0
Area of residence					
Bangkok	13.3	20.3	48.6	58.2	29.4
Greater Bangkok region	50.8	65.0	38.6	27.5	36.5
Subcentral region	33.3	7.7	6.6	5.5	14.1
Other	2.5	7.0	6.2	8.8	20.0
Survey type					
Field	93.3	95.8	79.5	53.8	67.1
Internet-based	6.7	4.2%	20.5	46.2	32.9

List of provinces included in each region.
Greater Bangkok region: Nakhon Pathom, Nonthaburi, Pathum Thani, Samut Prakan, Samut Sakhon.
Subcentral region: Ang Thong, Ayutthaya, Chai Nat, Lop Buri, Nakhon Nayok, Saraburi, Sing Buri.

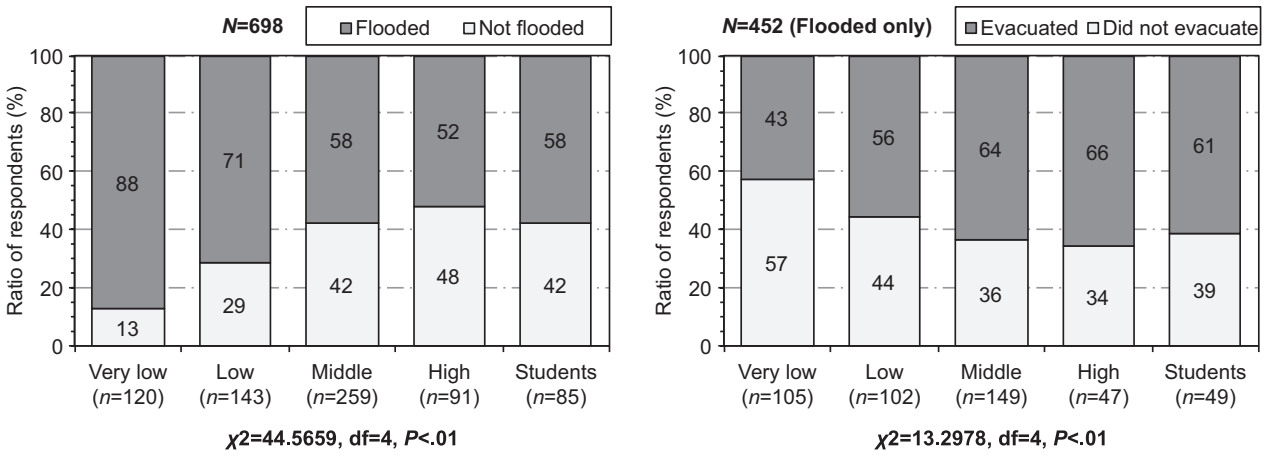

Figure 2 Relationship between income level and flooding of residence (left) and decision whether to evacuate (right, for flooded respondents only).

Results and discussion

Flooding and post-flooding evacuation

To understand the vulnerability of the respondents considering income disparity, two factors were examined: first, whether they were affected by the flood, and second, whether they chose to evacuate. The results are shown in Figure 2. It can be seen that the percentage of respondents whose residences flooded tended to increase with a decrease in income. Furthermore, the tendency to not evacuate also increased as income decreased. The greatest difference for

Journal of Flood Risk Management published by Chartered Institution of Water and Environmental Management and John Wiley & Sons Ltd.

flooding and evacuation behaviour occurred between the 'very low' and 'middle' respondents, as the results of 'middle', 'high', and 'student' respondents were similar. Finally, the chi-square test confirmed that, in both cases, there is a very high likelihood that the examined variables are dependent ($P < 0.01$ when testing the null hypothesis that the variables are independent).

These results showed that lower-income respondents appeared more likely to have been affected by the flood than higher-income respondents. One primary reason why people with lower socio-economic status have higher flood vulnerability may be due to the location of their residences, as these groups must often live in more hazardous areas (Morrow, 1999). Therefore, as shown in Figure 3, the relationship between demographic characteristics and location of residence was examined. In this case, multinomial regression was used to evaluate the predictive power of five demographic characteristics (income, education, age, gender, and student) in determining the location of residence. It should also be noted that, for this analysis, only the regions surrounding Bangkok (as well as Bangkok itself) were focused on. The analysis results are given in Table 6. It can be seen that the lower-income, lower-education, and student respondents were more likely to be living in the Greater Bangkok area than in Bangkok itself; furthermore, lower-income and lower-education respondents were more likely to be living in the subcentral region than in Bangkok.

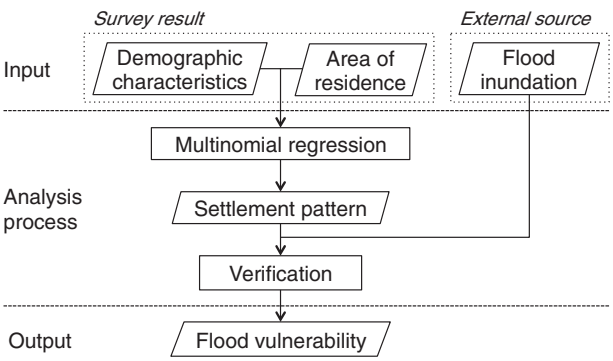

Figure 3 Method for analysing the relationship between demographic characteristics and people's flood vulnerability.

Table 6 Multinomial regression analysis of demographics as predictors of residence location

Demographic characteristics	Greater Bangkok/Bangkok		Subcentral region/Bangkok	
	z	Significance	z	Significance
Intercept	6.331	0.000***	2.983	0.003**
Income	–4.649	0.000***	–3.815	0.000***
Age	–0.839	0.402	1.718	0.086
Education	–2.145	0.032*	–4.585	0.000***
Gender	–1.869	0.062	–0.534	0.593
Student	–2.078	0.038*	0.994	0.320

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05.

Next, it is necessary to confirm whether these areas were actually inundated. Table 7 summarises the ratio of the flood-inundated area to the total regional area for the three selected regions. Although some flooding occurred in the Bangkok Metropolitan area, it can be seen that there was a higher ratio of inundation in the area immediately surrounding the city and that the ratio was slightly lower for the subcentral region. Combining the multiple regression analysis with the data on the actual flood inundation confirmed that respondents of lower socio-economic status were more likely to be living in areas with higher flood inundation.

Among those respondents affected by the flood, it could be seen that lower-income respondents had a higher tendency not to evacuate their homes. Logistic regression analysis was thus carried out to examine the predictive power of income as well as that of the other demographic attributes for the decision to evacuate. Income was found to be the strongest factor and the only highly significant one (Table 8). To understand this behaviour, it is necessary to consider three key words: recovery, security, and mobility. Because of their limited economic resources, it is more difficult for lower-income people to recover from flood damage. Therefore, they stand to lose more if they leave their residences, as they cannot easily purchase replacement materials or living supplies once the disaster has abated (Morrow, 1999). Furthermore, remaining at home is one way of ensuring the

Table 7 Ratio of flood-inundated area for selected regions

Region	Ratio of flood-inundated area (%)
Bangkok	26.4
Greater Bangkok region	47.1
Sub-central region	38.3

Data on flood area from (Hydro and Agro Informatics Institute and Ministry of Science and Technology Thailand, 2011).

Table 8 Logistic regression analysis of demographics as predictors of decision to evacuate

Demographic characteristics	Chose to evacuate	
	z	Significance
Intercept	0.393	0.694
Income	2.889	0.004**
Age	–0.958	0.338
Education	–0.373	0.709
Gender	–0.923	0.356
Student	1.208	0.227

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05.

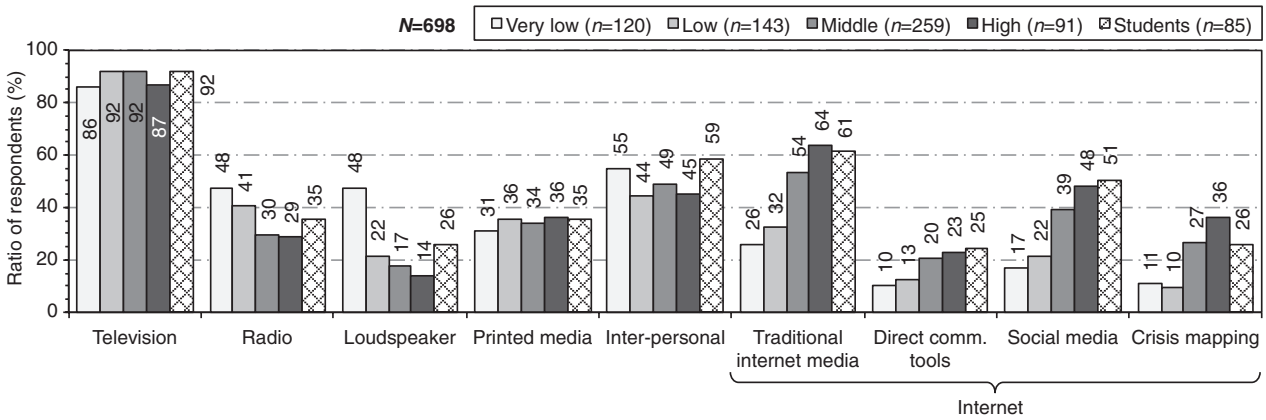

Figure 4 Relationship between income level and media usage.

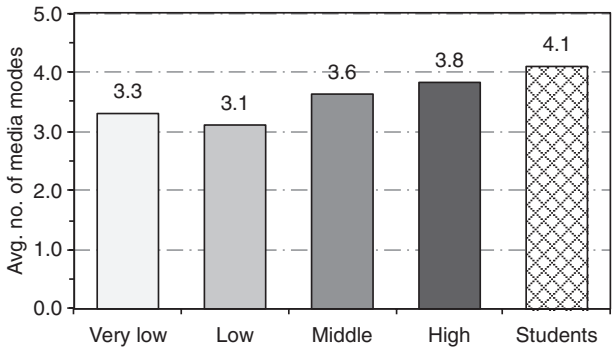

Figure 5 Average number of utilised media modes.

security of their possessions by preventing thievery or looting. Finally, lower-income people may have less access to transportation.

Utilised media modes for information collection

To understand how income disparity may have affected information collection behaviour, the media modes utilised by the respondents were examined by income level. As shown in Figure 4, 'television' was the most-used media mode across all income levels. For 'very low'-income respondents, the second most-used mode after 'television' was 'interpersonal (face-to-face, hotline, etc.)', followed by 'radio' and 'loudspeaker'. However, for 'high'-income respondents, the second most-used media mode was 'traditional Internet media (websites, information portals, etc.)' followed by 'social media (social networking sites, blogs, etc.)'. In general, a decrease in income level was associated with a decrease in the usage of Internet-based media modes but an increase in the usage of 'loudspeakers' and 'radio'. The average number of utilised modes also decreased with a decrease in income (Figure 5).

Logistic regression was carried out to examine the suitability of the demographic characteristics for predicting media usage. The results are summarised in Table 9 by media mode. For 'television', the logistic regression model suggests that usage decreases primarily with age and among male respondents. Males are less likely to use 'radio', and a decrease in income and age corresponds to an increase in the usage of 'loudspeakers'. Among the Internet-based media modes, however, both age and education were strong and highly significant predictors for all modes except 'crisis mapping'. For these modes, the logistic regression models predict that usage decreases with an increase in age and decrease in education.

These analyses revealed marked differences in the utilisation of media modes depending somewhat on income level but more so on other demographic characteristics. First and foremost, television was highly utilised regardless of income level. Investigations after other recent disasters, such as the 2005 Hurricane Katrina and the 2011 Great East Japan Earthquake, have also shown that television remains a critical means for information collection in disaster situations, despite the emergence of online technology (Spence *et al.*, 2007; Kawasaki *et al.*, 2012b). While the usage of online or 'high' technology was observed to increase as income increased, decreasing age and increasing education were generally found to be better indicators of increased online media usage. Considering that television is limited in its ability to provide detailed and localised information, especially in the case of an extensive disaster such as the 2011 Thai Flood, the results found here suggest that people of higher socioeconomic status were receiving general information via television and turning to the Internet to retrieve more detailed information, such as that specific to their situation or area (Figure 6).

Conversely, it was found that respondents of lower socioeconomic status had a lower tendency to utilise online

Journal of Flood Risk Management published by Chartered Institution of Water and Environmental Management and John Wiley & Sons Ltd.

Table 9 Logistic regression analysis of demographics as predictors of media mode usage

Media modes			Intercept	Income	Age	Education	Gender	Student
Television		z	3.742	–0.032	–0.385	0.081	–0.294	–0.025
		Sig.	0.000***	0.873	0.000***	0.568	0.312	0.968
Radio		z	0.696	–0.204	–0.009	–0.158	–0.414	–0.087
		Sig.	0.077	0.070	0.904	0.051	0.013*	0.771
Loudspeaker		z	–0.552	–0.508	0.210	–0.076	0.190	–0.039
		Sig.	0.205	0.000***	0.008**	0.410	0.323	0.906
Printed media		z	–0.184	0.011	–0.151	–0.002	0.138	–0.205
		Sig.	0.640	0.918	0.038*	0.977	0.402	0.486
Interpersonal		z	0.218	–0.026	0.039	–0.105	0.045	0.507
		Sig.	0.559	0.807	0.562	0.179	0.774	0.076
Internet	Traditional internet media	z	–0.296	0.177	–0.665	0.613	–0.414	–0.116
		Sig.	0.494	0.165	0.000***	0.000***	0.024*	0.708
	Direct comm. tools	z	–1.770	0.128	–0.337	0.292	–0.098	0.252
		Sig.	0.001***	0.371	0.002**	0.008**	0.632	0.448
	Social media	z	–1.636	0.058	–0.477	0.666	–0.074	0.051
		Sig.	0.000***	0.652	0.000***	0.000***	0.683	0.866
	Crisis mapping	z	–2.921	0.326	–0.176	0.381	0.026	0.458
		Sig.	0.000***	0.016*	0.058	0.000***	0.892	0.159

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05.

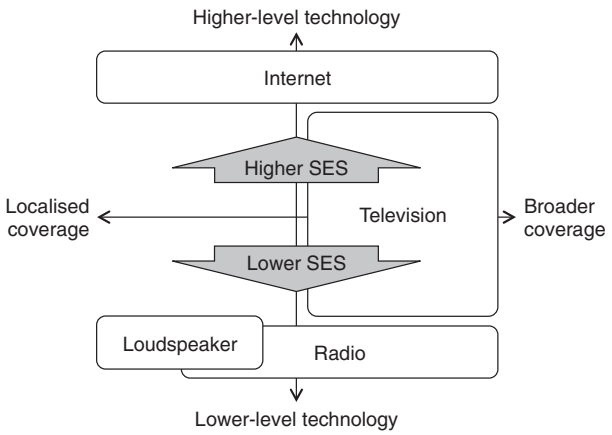

Figure 6 Conceptual illustration of media usage trend considering socio-economic status (SES).

media. This behaviour may be explained in two ways: first, the respondents did not choose to utilise online media even though they had access to it; or second, they did not have access to online media. In contrast, the usage of 'low' technologies such as radio, loudspeaker, and interpersonal communication generally increased as socio-economic status decreased, although highly significant correlations were found in only a few cases. It is possible that respondents of lower socio-economic status were using 'low'-technology media modes to gather localised information to supplement the general information they were receiving from television (Figure 6). The amount of information people can receive from 'low'-technology media modes is still limited, however, whereas Internet-based media can cover the entire spectrum from the national to local scales. Building a connection between 'low' and 'high' technologies and between 'wide'- and 'local'-scale media modes could improve information dissemination and increase the information resources available to people with lower socio-economic status.

Awareness and usefulness of the government hotline

Although the government provided a call centre (hotline) as part of its efforts to interact with and disseminate information to the general public, it is unclear to what extent people were aware of this hotline and whether it was useful for their information-gathering activities. As part of the objective to clarify disaster information collection behaviour, respondent awareness and evaluation of the government's call centre were examined (Figure 7). Awareness of the hotline was lowest among the 'very low'-income respondents, with the level of awareness increasing as income level increased. Among respondents who were aware of the call centre, those of lower income tended to find the hotline more useful; its usefulness decreased as income level increased. The chi-square test result again confirmed that the examined variables were highly likely to be dependent ($P < 0.01$ when testing the null hypothesis that the variables are independent).

As summarised in Tables 10 and 11, logistic regression was carried out to examine the predictive power of income and other demographic characteristics. For hotline awareness, education level was the strongest predictor of awareness, with an increase in education level leading to an increase in awareness. For usefulness, however, the strongest predictor

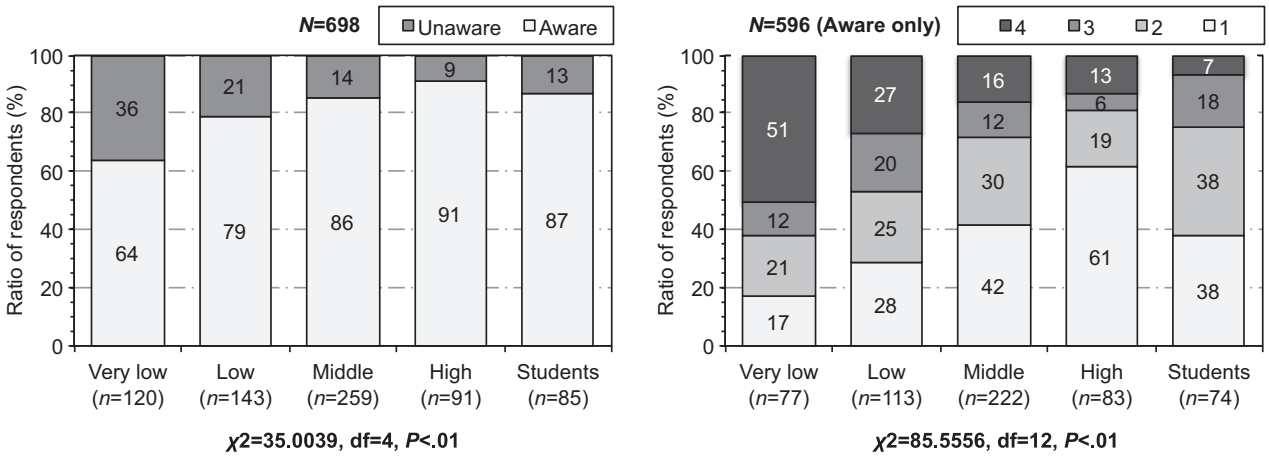

Figure 7 Relationship between income level and awareness of the hotline (left) and usefulness of the hotline (right, for aware respondents only). Note: for usefulness, 4: very useful and 1: not useful.

Table 10 Logistic regression analysis of demographics as predictors of hotline awareness

Demographic characteristics	Aware of hotline	
	z	Significance
Intercept	0.602	0.209
Income	0.104	0.469
Age	–0.139	0.099
Education	0.436	0.000***
Gender	–0.361	0.097
Student	0.021	0.960

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05.

Table 11 Logistic regression analysis of demographics as predictors of hotline usefulness

Demographic characteristics	Usefulness	
	z	Significance
Intercept 1|2	–2.373	0.000***
Intercept 2|3	–1.169	0.004**
Intercept 3|4	–0.392	0.335
Income	–0.518	0.000***
Age	0.145	0.073
Education	–0.254	0.002**
Gender	–0.036	0.823
Student	0.680	0.015*

Significance codes: 0 *** 0.001 ** 0.01 * 0.05.

was being a student, with non-students more likely to find the hotline useful. This was not the most significant predictor, as both income and education were also strong and highly significant predictors.

In summary, people of lower socio-economic status were less likely to be aware of the hotline but more likely to find it useful, and a more effective strategy for increasing awareness of the government hotline (and other future government support systems and programs) among disadvantaged groups is necessary. First, television was the most-utilised media mode across all income levels (Figure 4), so the effectiveness of television as a medium for raising awareness of the government hotline needs to be improved. Furthermore, as previously introduced, people of lower socio-economic status utilised fewer and lower-technology media modes, so they were less likely to discover the hotline, and they also had less access to information, so they subsequently found the hotline more useful. Building a connection between the 'high' and 'low' technologies used for disaster information dissemination, as proposed earlier, may thus be an effective means for increasing awareness of the government's hotline, in addition to increasing access to information.

Connecting vulnerability and information dissemination

People's vulnerability during the 2011 Thai Flood was clearly affected by a combination of geographic location and socio-economic settlement patterns, particularly in Bangkok and its environs. Considering the socio-economic capacity of Thailand, it is difficult to improve the situation of residences located in areas with higher flood hazard. However, the vulnerability of people with lower socio-economic status may be reduced by timely and proper information provision, as the gathering of relevant and up-to-date information is essential for decision making in response to a developing disaster situation.

In that case, what role might effective dissemination of disaster information play in reducing vulnerability? The

Journal of Flood Risk Management published by Chartered Institution of Water and Environmental Management and John Wiley & Sons Ltd.

development of community vulnerability maps that combine flood hazard assessment with patterns of community settlement and development could serve as a first step in understanding how to reduce vulnerability in lower socio-economic areas. Such work was carried out by Cutter *et al.* (2003) for the development of the Social Vulnerability Index, which provided a 'measure of the overall vulnerability' by geographical area in the United States based on 11 distinct factors. A similar approach could be applied in Thailand to connect flood hazard, demographic factors, and vulnerability. By understanding the distribution of socio-economic characteristics in a given area, not only could disaster information be disseminated considering the localised flood hazard of that area, but it could also be tailored considering the media utilisation patterns of the groups in that area. This could assist the implementation of preparatory strategies to increase access to information during flood events by, for example, increasing the number of loudspeakers in lower socio-economic areas. These loudspeakers could then be utilised to provide localised updates about the flood situation, government support such as food and drinking water distribution, and evacuation warnings – the type of information that would have been useful in lower socio-economic areas where many people chose not to evacuate. In addition, during the 2011 Thai Flood, many people died by drowning or electrocution. Providing alerts to raise awareness and prevent such incidents through appropriate information dissemination during the flood might reduce the occurrence of these accidents. The role of appropriate disaster information dissemination could thus be to reduce the vulnerability of lower socio-economic groups by increasing their resilience.

The unique case represented by students

As explained during the sample categorisation, students represent a unique case in that they generally have low economic resources but high education level; thus, for this analysis they were extracted from the categorised income level groups and formed into a separate group. An examination of the preceding analysis clearly shows that students demonstrated behaviour very different than that of other 'very low'- or 'low'-income respondents; in general, the flood vulnerability and information collection behaviour of students were similar to those of the 'middle'- and 'high'-income respondents.

One reason for this observed behaviour may be due to the relationship between income disparity and unequal access to educational opportunities. In countries with a large wealth gap, higher-income families may have better access to educational opportunities (OECD, 2010). As such, higher-education students, while having low income themselves as individuals, are more likely to come from families of a higher economic status, and thus, their vulnerability and information collection behaviour are similar to those of higher-income respondents. On the other hand, regression analysis found that education may be a better predictor of media usage than income for some media types (particularly online media). Therefore, unequal access to education – rather than income disparity – may be a better perspective for understanding disaster information collection behavior.

Conclusion

In this paper, the impact of income disparity on people's flood vulnerability and information collection behaviour was examined for the case of the 2011 Thai Flood. Key results are summarised as follows:

1. Lower-income respondents were more likely to have been affected by the flood than higher-income respondents because of the locations of their residences. Lower-income respondents were also more likely to not have evacuated their homes in the case of flood inundation.
2. Television was the most-used media mode regardless of income level. Lower-income respondents were more likely to use 'low'-technology media modes such as radio or loudspeakers in addition to television, whereas higher-income respondents were more likely to use 'high'-technology (online) media modes. Lower-income respondents also utilised fewer media modes on average.
3. Lower-income respondents tended to be less aware of the government hotline but more likely to find it useful in the event they were aware of it.
4. The vulnerability and information collection behaviour of students was similar to that of higher-income respondents despite students generally belonging to a lower income level.
5. While income was a good predictor for examining people's flood vulnerability and hotline usefulness, it was not the best predictor for most media modes or hotline awareness. It was shown that other demographic characteristics must also be considered when improving disaster information dissemination in the future.

The results presented here provide valuable information about the people's flood vulnerability and the unique information collection needs of disadvantaged populations, while also demonstrating the difficulty of trying to understand said vulnerability and information needs using just a single demographic characteristic (such as income). The examination of flooding confirmed that lower socio-economic status led to higher vulnerability, which supports previous studies on other types of disasters. However, there are few studies on media usage trends in disaster situations that focus on differences due to socio-economic status; thus, this paper presents new findings that may be highly useful for governments and other stakeholders in diverse countries with high exposure to disaster hazards. Finally, while the

connection between proper provision of disaster information and reduction of disaster vulnerability was not fully explored in this investigation, the issues raised in this paper serve as an important starting point for any such future studies.

Acknowledgements

This investigation was partially supported by the Japan Society for the Promotion of Science (Challenging Exploratory Research, project no. 25560161).

The authors would like to express their gratitude to Dr Pakawat Sancharoen (Sirindhorn International Institute of Technology, Thammasat University), Dr Manop Kaewmoracharoen [Natural Disasters Research Unit (CENDRU), Civil Engineering Department, Chiang Mai University], and Ms Aphisorn Suwannasuk [Regional Network Office for Urban Safety (RNUS), Asian Institute of Technology] for their assistance in carrying out the survey investigations.

References

Bangkok Post. More areas at risk due to lack of organization [online]. http://www.bangkokpost.com/news/local/264927/more-areas-at-risk-due-to-lack-of-organisation [accessed 22 July 2014], 2011.

Boyce J.K. Let them eat risk? Wealth, rights, and disaster vulnerability. *Disasters* 2000, **24**, 254–261.

Central Intelligence Agency. The World Factbook [online]. https://www.cia.gov/library/publications/the-world-factbook/rankorder/2172rank.html [accessed 12 March 2014], 2014.

Chou Y.J., Huang N., Lee C.H., Tsai S.L., Chen L.S. & Chang H.J. Who is at risk of death in an earthquake? *Am J Epidemiol* 2004, **160**, 688–695.

Cutter S.L., Boruff B.J. & Shirley W.L. Social vulnerability to environmental hazards. *Soc Sci Q* 2003, **84**, (2), 242–261.

Department of Disaster Prevention and Mitigation (DDPM). 2011 Thai Flood page [online]. http://disaster.go.th/dpm/flood/flood.html [accessed 13 March 2014] (in Thai), 2011.

Hydro and Agro Informatics Institute & Ministry of Science and Technology Thailand. 2011 flood event [online]. http://www.thaiwater.net/current/flood54.html [accessed 13 March 2014] (in Thai), 2011.

Iwaki H., Korekawa Y., Gonda N., Masuda M. & Ito H. Method of damage estimation of stocks by the Great Eastern Japan Earthquake, Economic Research Bureau, Cabinet Office [online]. http://www5.cao.go.jp/keizai3/discussion-paper/dp111.pdf [accessed 13 March 2014] (in Japanese), 2011.

Kawasaki A., Komori D., Nakamura S., Kiguchi M., Nishijima A., Oki K., Oki T. & Meguro K. Emergency response during the 2011 Chao Phraya River flood in Thailand focusing on information sharing and coordination among governmental agencies. *J Soc Saf Sci* 2012a, **17**, 109–117, (in Japanese).

Kawasaki A., Henry M. & Meguro K. Disaster information collection of foreigners after the 2011 Great East Japan Earthquake considering the difference in language ability. *J Soc Saf Sci* 2012b, **18**, 381–390, (in Japanese).

Kodaka A., Sunthararuk A. & Kawasaki A. Preliminary instigation of disaster information dissemination using web mapping during the 2011 Thai Great Flooding. *Seisan Kenkyu* 2012, **64**, (4), 521–525, (in Japanese).

Komori D., Nakamura S., Kiguchi M., Nishijima A., Yamazaki D., Suzuki S., Kawasaki A., Oki K. & Oki T. Characteristics of the 2011 Chao Phraya River flood in Central Thailand. *Hydrological Res Lett* 2012, **6**, 41–46.

MCOT. FROC chief not worried by no confidence motion debate against him [online]. http://www.mcot.net/site/content?id=4ff674950b01dabf3c03b6ac#.U85eLYCSzdY [accessed 22 July 2014], 2011.

Morrow B.H. Identifying and mapping community vulnerability. *Disasters* 1999, **23**, 1–18.

National Statistical Office. *The household socio-economic survey*. Bangkok: Thailand Ministry of Information and Communication Technology, 2011.

OECD. Glossary of statistical terms [online]. https://stats.oecd.org/glossary/detail.asp?ID=2886 [accessed 14 March 2014], 2001.

OECD. PISA 2009 Results: overcoming social background – equity in learning opportunities and outcomes (Volume II) [online]. http://www.oecd.org/pisa/pisaproducts/48852584.pdf [accessed 14 March 2014], 2010.

Spence P.R., Lachlan K., Burke J.M. & Seeger M.W. Media use and information needs of the disabled during a natural disaster. *J Health Care Poor Underserved* 2007, **18**, 394–404.

The Guardian. The politics behind Thailand's floods [online]. http://www.theguardian.com/commentisfree/2011/oct/21/thailand-floods-bangkok [accessed 22 July 2014], 2011.

The New York Times. As Thailand floods spread, experts blame officials, not rains [online]. http://www.nytimes.com/2011/10/14/world/asia/a-natural-disaster-in-thailand-guided-by-human-hand.html?_r=0 [accessed 22 July 2014], 2011.

UNESCAP & UNISDR. *Protecting development gains: reducing disaster vulnerability and building resilience in Asia and the Pacific, The Asia Pacific Disaster Report*. Geneva: United Nations, 2010.

UNISDR. *Linking disaster risk reduction and poverty reduction: good practices and lessons learned*. Geneva: United Nations, 2008.

UNISDR. *Risk and poverty in a climate change: invest today for a safer tomorrow, Global Assessment Report on Disaster Risk Reduction*. Geneva: United Nations, 2009.

World Bank. The World Bank supports Thailand's post-floods recovery effort [online]. http://www.worldbank.org/en/news/feature/2011/12/13/world-bank-supports-thailands-post-floods-recovery-effort [accessed 13 March 2014], 2011.

Journal of Flood Risk Management published by Chartered Institution of Water and Environmental Management and John Wiley & Sons Ltd.