



Determinants of Flash Flood Evacuation Choices and Assessment of Preferences for Flash Flood Warning Channels The Case Study of Thailand

Kannika Thampanishvong



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for Flash Flood Warning Channels:
The Case of Thailand**

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March, 2013

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DETERMINANTS OF FLASH FLOOD EVACUATION CHOICES AND ASSESSMENT OF PREFERENCES FOR FLASH FLOOD WARNING CHANNELS: THE CASE STUDY OF THAILAND

Kannika Thampanishvong

EXECUTIVE SUMMARY

The Southern part of Thailand, a region with tropical climate and monsoon, has often been affected by torrential rains caused by tropical storms, depressions, and typhoons. Such heavy rain is often accompanied by flash floods – sometimes occurring so suddenly and with an enormous amount of water – that make them particularly dangerous. Hence, flash flood warnings are important to prevent flash flood hazards from becoming disasters. These warnings can give individuals the much needed information that can help them decide whether to evacuate or not, thus reducing casualties and losses.

This research examined the factors that affected the individuals' and households' decisions to evacuate in case of a flash flood. Results showed that individuals with higher probability of evacuation prior or during a flash flood had received flash flood warning; had information about the meeting places in the villages; had higher income; and were female. At the household level, the probability of both male and female members agreeing not to evacuate decreased with the proportion of young children in the household and if the head of the household was female. Also at the household level, the probability of both male and female members agreeing to evacuate increased with the proportion of young children in the household.

These findings give rise to some policy implications. First, because people at risk from flash floods are concerned about their evacuation destination, the government should provide emergency public shelters before, during, and after a flash flood. As women and families with young children are more likely to evacuate, the emergency shelters should cater to their needs. To assist vulnerable groups such as females, young children, the elderly, and disabled, authorized personnel should be stationed along main evacuation routes during evacuations to direct the residents away from the emergency areas.

Residents in the flash flood hazard areas in Nakhon Si Thammarat preferred two-way radio, but very few of them have access to this channel or type of warning channel. The government could step in to ensure that these areas have access to two-way radio sets as well as conventional warning receivers, such as mobile phone, television, and radio.

1.0 INTRODUCTION

Flash floods are short-term events, occurring within a few minutes or hours of excessive and high intensity rainfall (United States Search and Rescue Task Force and Federal Emergency Management Agency, 2012). Most flash floods occur when there is a heavy amount of precipitation falling in an area and that water is channeled through streams or narrow gullies, taking minutes or hours to develop (NOAA, 2012). Factors that could contribute to flash flooding include topography, soil conditions, ground cover, rainfall intensity, and duration (United States Search and Rescue Task Force, 2012).

Recently, vast deforestation in upstream areas has made many areas in Thailand become susceptible to flash floods (Forsyth, 2001). Forest cover provides a good cover for subsurface formations underneath and protects the subsurface through the anchorage of dense root systems. Hence, in the absence of forest cover and vegetation with deep root systems, the possibility of slope destabilization increases (Asian Disaster Preparedness Center, 2006). Recently, the destabilized slopes have been covered with inappropriate types of vegetation, particularly rubber, which are grown for commercial purposes. People should be made aware of the negative effects of disturbances on slopes and vegetation. Moreover,

land use policies should place restrictions on the use of slopes within a catchment to reduce the risk to communities living in flood plains.

The suddenness of a flash flood and the enormous amount of water it brings with it is particularly dangerous. On several occasions, inhabitants of flash flood hazard areas underestimate the dangers associated with a flash flood. They believe that their shelters and vehicles could protect them from being swept away. Such beliefs have been proven wrong, resulting to many fatalities. Aside from death, a flash flood also wreaks substantial damages on residential buildings, commercial establishments, and critical public utilities.

The increased frequency of flash floods and their damages make the occurrence of flash floods an important national issue. To prevent flash flood hazards from becoming disasters, flash flood warnings are critical. Flash flood warnings deliver precise, timely, and accessible information to people residing in the hazardous areas in advance of (alert) or during (notification) a flash flood. Hence, the affected people who have been forewarned may be motivated to respond by evacuating to a safe place. While warnings may not be able to prevent a flash flood, these could prepare the residents better so that they could take appropriate actions, thus minimizing the impacts of flash flood on their lives such as casualties and losses.

This report is divided into three main parts. The first part identifies the factors that affected the residents' decision to evacuate during a flash flood. In particular, it examined whether the specific characteristics of the flash floods and of the 'warned' residents had impacts on the latter's evacuation choices. As the data were at the individual level and both male and female members from each household were interviewed separately, this study can compare the evacuation choices of two members (man and woman) in the household. The second part presents the assessment of the individual's preferences for flood warning channels. Two approaches – direct ranking and pair wise comparison approaches – were used to obtain preference order among different types of flash flood warning channels. Data were split by gender or educational background and assessed for consistent rankings. The third part forwards policy recommendations to improve disaster preparedness or to facilitate the evacuation of affected individuals.

2.0 STATEMENT OF THE PROBLEM

Between the end of March and the beginning of April 2011, a prolonged heavy rainfall caused flash floods in many provinces in Southern Thailand. The flash flood that struck 10 provinces¹ from March to April 2011 affected over two million people from 600,000 households (DDPM, 2011).² The total death toll stood at 64 people, while over 40,000 people evacuated. In addition, the flash floods also created a heavy financial burden on the Thai economy from substantial damages on residential buildings, commercial establishments, and critical public utilities (e.g., schools, bridges, roads). The total financial loss was over 4 billion THB excluding indirect losses from lost production, the costs for economic recovery, or the deprivation of national resources, which could have been used for social and economic development. Figure 1 shows the damages inflicted by the flash flood.

This research project focuses on the province of Nakhon Si Thammarat in Southern Thailand (Figure 2). The flash flood and landslide that struck the province during March and April 2011 affected 1,551 villages in 23 districts. A total of 25 people died and 909,500 others from 312,500 households were affected (Thaiflood.com, 2012). It was also reported that 22,261 people evacuated from the flooded areas. The flash floods also inflicted substantial damages on public infrastructures (e.g., bridge, dam, drainage system) including residential and commercial buildings.

¹ The 10 provinces affected by the recent flash flood during March-April 2011 were Nakhon Si Thammarat, Krabi, SuratThani, Phatthalung, Songkhla, Chumporn, Phang-nga, Narathiwat, Trang and Satul (Department of Disaster Prevention and Mitigation, 2011).

² These flash floods, which struck 10 Southern provinces in Thailand, were different from the flooding during October to November 2011 that affected the provinces of Northern and Central Thailand along the Chao Phraya River basins.



Figure 1. Damages from flash flood during March-April 2011 (Nakhon Si Thammarat)



Source: en.wikipedia.org

Figure 2. Map of Nakhon Si Thammarat

These significant damages brought by flash floods have raised some important policy questions. Before the flash flood struck these areas, did the residents receive any form of flash flood warning? Which flash flood warning channels did they prefer or feel they would likely to respond to because it would reach them and/or their family members in terms of evacuating to a safe place? What were the factors that determined these individuals' evacuation decisions? These questions formed the bases of this study.

It is important to understand what flood warning channels people prefer and to determine what channel generated the appropriate or desirable response in the form of evacuating to safe places. This way, the Thai government could invest in channels that could effectively inform affected people of the risk they face as well as to educate them on what to do during a flash flood to reduce casualties and losses.

3.0 RESEARCH OBJECTIVES

The objectives of this research project are as follows:

1. To identify the factors that determine individuals' and households' evacuation decision;
2. To examine the differences in the evacuation decision of males and females upon receiving the flash flood warning to find out any gender issue and household dynamics;
3. To determine the people's preferences for flash flood warning channels or the warning schemes they would be more likely to respond to by choosing to evacuate; and
4. To summarize the factors that may help improve disaster preparedness or ease the evacuation process in flash flood-prone areas.

4.0 LITERATURE REVIEW

This section presents the review of literature on disaster warnings, behavioral responses to warnings, and preferences for warning channels.

4.1 Disaster Warning

According to the report prepared by Partnership for Public Warning (2002), the warning process consists of people with information communicating with people at risk in advance of or during a hazardous event, with the intent that those at risk will take appropriate action to reduce casualties and losses. With information or knowledge about what is likely to happen and advice through a disaster warning about how to respond, people can then make the appropriate action and get out of harm's way. The success of a warning is measured by what actions people take after receiving it.

To generate the appropriate action, different segments of the population must be identified. For warnings to be broadly effective, we must consider the differences in people's abilities to receive warnings, to attend to them, to comprehend their content, and to personalize the threats. Moreover, warnings must consider the many languages, cultural differences, and needs of people with a wide variety of disabilities³ (Partnership for Public Warning, 2002). For warnings to be functional, these must also reach people no matter where they are or what they are doing - whether they are awake or asleep. The residents (or recipients of the warning) should be immediately available and not required to perform any specific action to enable them to act during a threat.

The literature on what make hazard warnings effective form the bases for the two main analyses in this study, namely: disaster evacuation decisions and preferences for disaster warning channels or warning receivers.

4.2 Behavioral Responses

Related studies focus on the factors and determinants of individuals' evacuation behavior in response to a hurricane. Baker (1991) covers decisions to evacuate during a hurricane in the 1960s and the 1980s, while Dash and Galdwin (2007) provide up-to-date review of literature on the same area.

Different approaches have been used to understand why some people choose to evacuate while others choose not to. The first approach requires researchers to conduct an interview with the victims of disasters. This approach was found to be good because it gave the researchers some useful insights and a good starting point (Baker, 1991). Many decision studies, particularly those on hurricane evacuation, had

³ The warning should be designed for handicapped individuals, including those with hearing, sight, mobility, or literacy limitation. Access to warning for the elderly and children is imperative (Partnership for Public Warning, 2002).

embraced this approach to explain individuals' and households' evacuation behaviors. Nevertheless, the main shortcoming of this approach is that people often lacked the ability to articulate thoroughly their method of decision making.

The second approach requires researchers to conduct empirical analysis on the factors that influence the individuals' evacuation choice, which is a dichotomous decision – staying at home or evacuating to a safe area. Solis et al. (2009) provide an empirical framework that can be used to investigate the impacts of these factors on the individuals' decision to evacuate during a hurricane. This method is based on the theory proposed by Burton et al. (1993) and Viscusi (1995).⁴ According to Baker (1991), Dash and Galdwin (2007), and Solis et al. (2009), factors that affect individuals' decision to evacuate could be grouped into the following categories: characteristics of the disaster, characteristics of the disaster warnings, and demographic and socio-economic characteristics of the disaster victims.⁵

Characteristics of disaster refer to timing of disaster, intensity of disaster, etc. Characteristics of disaster warnings are the type of warning messages and their consistency, clarity, accuracy, language used, source, sufficiency of information, amount of guidance provided, the number of time the warning message is delivered, as well as the location identified to be affected by the disaster (Mileti, 1995; Sorensen, 2000).⁶ The demographic and socio-economic characteristics of the disaster victims refer to people's cognitive abilities, their attitude, their previous experience with disaster, age, gender, status, and educational background.

The evacuation destination and expected expenses associated with evacuation can play an influential role on individuals' evacuation behavior. In the studies conducted by Whitehead et al. (2000) and Smith (1999), evacuation pattern (i.e., individuals' preference to evacuate to a shelter or a friend's house) and expected expenses involved in the evacuation may account for unobserved information affecting their evacuation choice.

The effect of demographic characteristics on evacuation choices is mixed: while Dow and Cutter (1998) and Baker (1991) found that these characteristics do not significantly affect evacuation choice, Dash and Galdwin (2007), Whitehead et al. (2000) and Smith (1999) found that these characteristics influence evacuation choices. One important characteristic that influences individuals' evacuation decisions is wealth; however, the effect of wealth and income on evacuation choice is mixed. Though it might be reasonable to hypothesize that high-income individuals will be more willing to evacuate because they are well equipped with necessary means, the results from previous studies show that high-income individuals were less likely to evacuate. One possible explanation for their decision not to evacuate is the fear of post-disaster theft: wealthy individuals might prefer to stay at their own homes to protect their belongings and properties during and after the disasters.

Literature on disaster evacuation and gender variations and literature on intrahousehold resource allocation were also reviewed. These were used as bases to answer one of the research objectives, that is, to see the difference in the evacuation decisions of males and females upon being warned of a flash flood.

Studies in hurricanes showed that women were more likely to evacuate than men⁷. Yet few researchers such as Bateman and Edwards (2002) have examined these differences closely to explain them. Both researchers undertook a series of bivariate and multivariate analyses to examine the relationship between evacuation and gender variations. They analyzed a cross-sectional survey of 1,050 coastal North Carolina households affected by Hurricane Bonnie. They found that women were more likely to evacuate

⁴ Our empirical investigation on the individuals' evacuation decision before and during the flash flood is based on the framework used by Solis et al. (2009). Details of this empirical framework can be found in Section 6.

⁵ The three groups of factors cited here have not yet taken into account the role played by social interactions. Smith (1999) and Lindell et al. (2005) found that social interactions could help individuals digest the available information better, thus social interactions could be more important than the disaster warning.

⁶ Dash and Galdwin (2007) argued that disaster warning itself has no value since its effect on individuals' evacuation decisions hinges upon an individual's aversion to risk, interpretation, and belief in the warning's credibility.

⁷ In their work on the role of mangroves in reducing death toll during an Indian cyclone and tsunamis, Das and Vincent (2009) did not include gender as the control variable in their regression; instead, they included the following socio-economic characteristics: literacy rates, population shares in scheduled castes, and population shares in five occupations.

than men because of socially constructed gender differences in care-giving roles, access to evacuation incentives, exposure to risk, and perceived risk. Compared to men, women were more likely to evacuate because they lived at greater exposure to risk and had a heightened perception of risk.

The literature on intrahousehold resource allocation is relevant in assessing gender effects, i.e., differences in the evacuation responses between male and female household members. According to this literature, interviewing only a single respondent within the household implies that researchers assume that households adopt the common preference model of intrahousehold resource allocation, where the common preference model is based on restrictive assumptions – either the interviewed respondent is a dictatorial decision-maker in the household or the household members have similar preferences (Prabhu, 2010). However, some researchers found that some level of intrahousehold bargaining takes place, thus the use of alternative models of intrahousehold resource allocation should be explored.

Prabhu (2010) who compared husbands' and wives' willingness to pay (WTP) for malaria vaccines in Navi-Mumbai, India, found that husbands' and wives' demand differed significantly when they were interviewed separately but not when they were interviewed jointly. Hence, he rejected the common preference model and unified bargaining model of intrahousehold resource allocation. Whittington et al. (2008) examined whether spouses in the same household would purchase the same number of HIV/AIDS vaccines for household members and have the same demand function. They also tried to determine whether spouses would allocate vaccines to the same household members. Their results showed that spouses reported that they would purchase the same total number of vaccines, thus they had essentially the same demand function. However, at lower vaccine prices, wives were significantly more likely than husbands to allocate vaccines for their daughters than to sons.⁸

4.3 Preferences for Warning Channels

Some literature related to disaster warning channels were also reviewed to subsequently understand why people preferred one warning channel over the others. Wattegama (2007) argued that Information and Communications Technology (ICT) had played an important role in disaster prevention, mitigation, and management. ICT encompasses both traditional channels used for disaster warning (e.g., radio and television) as well as new channels (cell broadcasting, Internet, satellite radio), all of which can play a major role in informing the people at risk of a potential or impending disaster. Before disasters strike, ICTs are used as a conduit for disseminating information on an impending danger, thereby making it possible to take the necessary precautions to mitigate the impact of these disasters.

In his study, Wattegama (2007) provided quite a detailed discussion on each channel used for disaster warning. He found that some channels may be more effective than the rest, depending on the nature of the disaster, the regions affected, the socio-economic status of the affected communities, and the respondents' political orientation.

This study did not examine or compare the effectiveness of different warning channels just like Wattegama did. Instead, it focuses on people's preferences for flash flood warning channels or the warning schemes that people felt they more likely respond to, and so choose to evacuate. In addition, this study related these preferences with some socio-economic characteristics such as gender and levels of education.

⁸ This literature actually could provide some useful insights, for instance, if an increase in income generated different investments in flash flood risk reduction depending on whether it was given to men or women. However, given our dataset, we do not have sufficient information to infer along these lines.

5.0 SAMPLE CHARACTERISTICS AND SURVEY METHODS

5.1 Location and Date of the Study

Of the 10 Southern provinces affected by flash flood in March to April 2011, Nakhon Si Thammarat was a natural choice for the study. First, its topography makes it highly exposed to heavy precipitation events, hence flash flooding. This province is located on the shore of the Gulf of Thailand, and its terrain is mostly rugged, hilly forest areas. It has high plateau and mountains in the west then sloping down towards the east and becoming a basin along the coastline of the Gulf of Thailand. Second, as Nakhon Si Thammarat is located in the realm of monsoon rains, torrential rains caused by tropical storms, depression, and typhoons are common phenomena especially between the months of October and January. Because of the sudden nature of flash flood and the enormous amount of water it brings, flash flood warnings are particularly necessary to induce those people at risk to take appropriate action to reduce losses.

Between the end of March and the beginning of April 2011, a prolonged heavy rainfall caused flash flooding in many parts of the province. Many areas were considerably affected by the flash flooding. The districts, sub-districts, and villages in Nakhon Si Thammarat selected for this study were recommended by Mr. Uthai Klawkla, the director of Disaster Management Center at Walailuck University.

The villages chosen as study sites (Table 1) were severely affected by the flash flood because they are either located along the foothills near waterways or in the low-lying areas.

Table 1. Study sites and number of respondents per site

Province	Districts	Sub-districts	Villages
Nakhon Si Thammarat (N=332)	Nopbhitam (n=90)	Krungching	Tubnamtao
	Si-chol (n=122)	Thepparat Chalong	Pianbon Wangsarn
	Tha-Sala (n=120)	Talingchan	Tamlord, Natorn, Nakaowat

Figures 3 to 5 are the maps of the study sites drawn by the representatives from these three areas during the focus group discussions (FGDs). For all the three study sites, the respondents' households were not geo-coded because some part of the study sites, especially Nopbhitam, is located in the forest reserve areas where a certain degree of protection was granted.⁹ Though the responsible authorities might have had access to aerial photographs or satellite images of the areas, this information are not available in the public domain. Thus, the geo-coded data were not compared with the actual level of flood water from this recent flood event.

Fieldwork started in July 2011 and ended in September 2011. Interviews for the main survey took place between 26 August and 1 September 2011. The data or information and descriptions about the sites in the subsequent discussions were gathered from the Department of Provincial Administration, Ministry of Interior (2010).

Agriculture has played a key role in the Krungching sub-district. About 85 percent of the people in Krungching are engaged in agricultural production (e.g., rubber plantation, orchard, etc.). As of April 2010, the Krungching sub-district had a population of 9,048 people and 2,838 households.

The total area of Krungching is 227,805 Rai or 364 square kilometers. Krungching sub-district consists of 11 villages, namely: Nop, Huaiparn, Bhitam, Pian, Suanprang, Parklong, Huaitong, Tubnamtao, Huaihaeng, Songpraek and Waisor. Tubnamtao Village, the study site, has 226 households and a population of 603.

⁹ At present, geocoding has proven to be useful in many Geographic Information Systems (GIS) analysis. Geo-coding is the process of finding associated geographic coordinates (often expressed as latitude and longitude) from other geographic data or postal codes. With geographic coordinates, the features can be mapped and entered into the GIS.

The topography of Krungching is hilly to mountainous, with thick virgin forests. After a heavy precipitation event such as a storm or an extensive rainfall, an enormous amount of water can be released in a very short time. When these precipitations or rains fall on poorly-absorbent soil, runoff towards rivers and other water channels increases, thus such runoff rapidly flows downhill. As the Tubnamtao Village is located along the foothills, this village was hard hit by the flash flood.

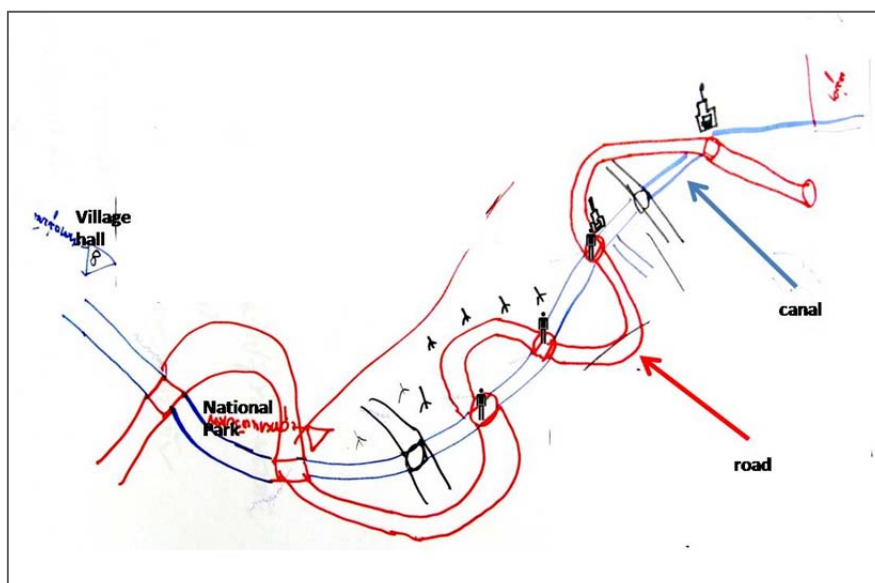


Figure 3. Map of Tubnamtao Village, Nopbhitam

Sichol district is located in the northern part of Nakhon Si Thammarat, with Tha-Sala, Nopbhitam, Kanchanadit, Donsak and Khanom as neighboring districts. To the east of this district is the Gulf of Thailand. Sichol district is divided into nine sub-districts. The two adjacent sub-districts included in this study were Theppharat and Chalong.

Theppharat sub-district covers an area of 50,748 Rai and consists of 15 villages, namely Thorua, Thepparat, Tonniang, Kaoyuantao, Pianlungwaen, Sai-oi, Saipae, Namcha, Kaoka, Pianbon, Srayoong, Suanhua, Klongkood, Wayo, and Sarmthep. The two villages in Thepparat sub-districts included in this study were Pianbon and Sarmthep. Pianbon has 138 households and a population of 297. Sarmthep, on the other hand, has 127 households and a population of 266.

The Chalong sub-district covers 48 square kilometers. There are 11 villages in Chalong sub-district, namely: Thakwai, Klongsai, Toongchaochai, Dornmuang, Naidorn, Toongnork, Phosadet, Huaisam, Pangkam, Wangsarn, and Kaokiw. The village of Wangsarn, which was included in this study, has 95 households and a population of 220.

Similar to the Krungching sub-district in Nopbhitam, agriculture plays an important role in the Thepparat and Chalong sub-districts. These two sub-districts, which are plateaus, have rubber plantations and orchards.

The three villages in this study – Pianbon, Sarmthep and Wangsarn – are located along the foothills near waterways, thus they are exposed to the risk of flash flooding.

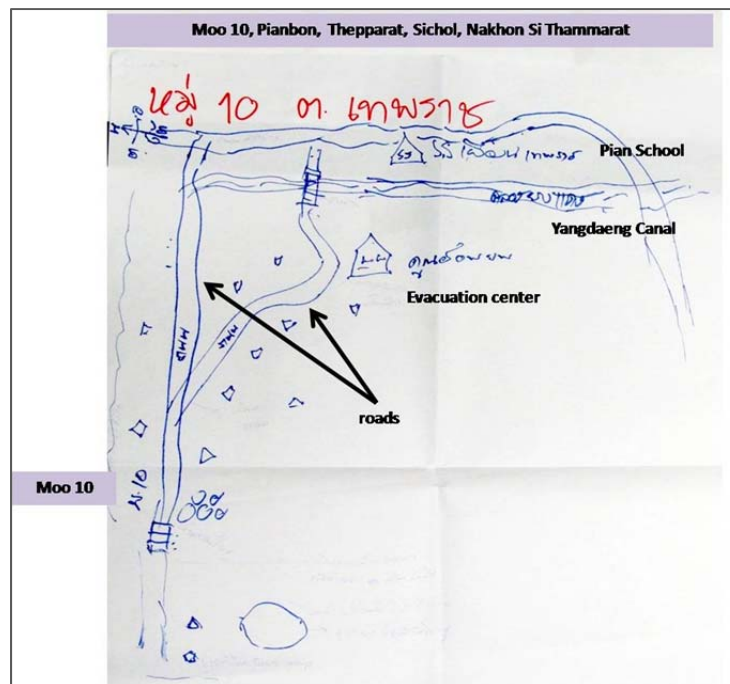


Figure 4. Map of Pianbon Village, Si-chol

Tha-Sala district is sub-divided into 10 sub-districts, with Talingchan as the sub-district of interest in this study. The neighboring districts of Tha-Sala include Mueang Nakhon Si Thammarat, Phrom Khiri, Nopbhitam, and Sichol as well as the Gulf of Thailand, which is located to the east of the district.

Talingchan covers 60 square kilometers or 38 Rai. The main source of income for its residents comes from the rubber plantation and orchard. The Talingchan sub-district can be sub-divided into nine villages, namely: Cha-om, Plakpla, Namyao, Nongwa, Suanchan, Nakaowat, Natorn, Pakchao, and Tamlord. The survey took place in three of these villages, i.e. Nakaowat, Natorn, and Tamlord. Nakaowat has 220 households and a population of 814; Natorn has 248 households and a population of 919; and Tamlord has 230 households and a population of 906. Again, these three villages are located in the low-lying areas along the foothills; hence they were hard hit by the flash flooding in March to April 2011.

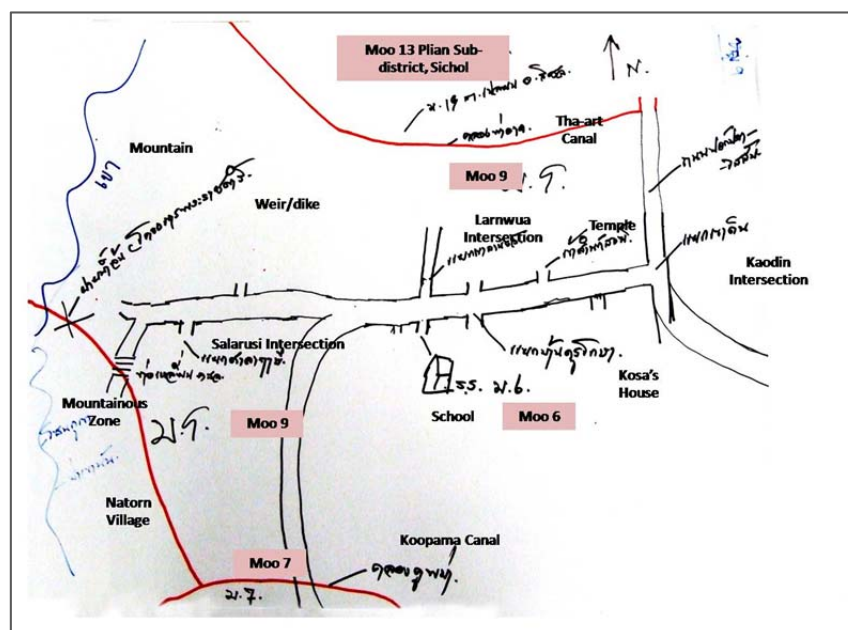


Figure 5. Map of Baantamlord and Natorn, Tha-Sala

5.2 Sample and Sampling Strategy

Two field supervisors and three teams composed of two enumerators for each team gathered data from the sites. They usually started the survey at 9 am to ensure that people who would take part in the interview have already returned home. Most of the interviewees were rubber tappers and were usually available for an interview after they have finished tapping the rubber latex¹⁰.

The dwellings in these villages were mostly in sequential order. The enumerators began recruiting respondents by going to the first house in the village. They also checked for the presence of both male and female members in the household. This was to meet one of the objectives of the study which was to examine the differences in the evacuation decision of both male and female upon receiving a flash flood warning as well as their preferred channels for receiving the warnings. Hence, in most cases, couples (i.e., husbands and wives) were interviewed. Only the households with the presence of both male and female members were included in the face-to-face interview. If only one member – either male or female – was present, the team moved on to the next dwelling.

A helper or a local person in the village assigned to each team assisted the enumerators in recruiting couples for the interview. To maintain confidentiality of responses, the husband and wife were interviewed separately. If the situation allowed, the separate interviews were conducted in different rooms. A team of two enumerators was used for each household interviewed – one for the husband and the other for the wife.

Fieldwork started in July 2011 and ended in September 2011. Interviews for the main survey took place between 26 August and 1 September 2011.

Figure 6 illustrates how the participants were selected in the face-to-face interviews. Table 1 also shows the number of respondents for each study site.

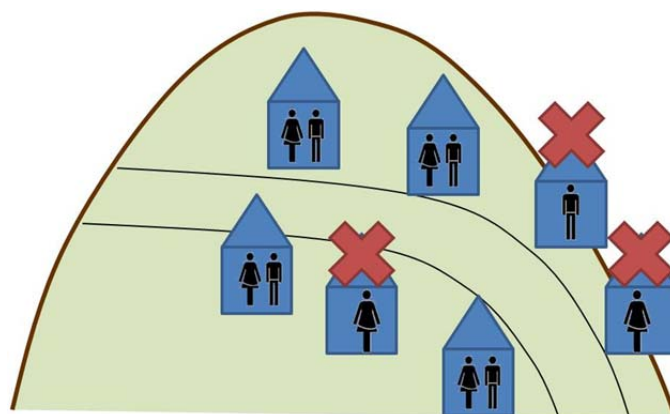


Figure 6. Selection of participants in the face-to-face interview

In the sampling method used, some members of the population were less likely to be included than others, resulting in a biased sample. Households that did not have the presence of both male and female members were excluded.¹¹ Hence, the statistical analysis could potentially be subjected to a selection bias or distortion. If the selection bias is accounted for, then certain conclusions drawn may be accurate.¹²

¹⁰ Usually, latex is tapped from the rubber tree early in the morning when the internal pressure of the rubber tree is highest. After tapping, the rubber trees will drip latex for a few hours, stopping as latex coagulates naturally on the tapping cut, thus blocking the latex tubes in the bark. Rubber tappers usually have time to rest after finishing their tapping work, then start collecting the latex at about midday.

¹¹ It is also important to note that some of these villagers have two jobs, with rubber tapping as the main job and freelancing as the secondary job.

¹² Even if all households in the village had both men and women, not all of them would have been sampled. The target number of questionnaire to be collected in each study site was set ex ante according to the population size. Thus, even if the sampling was sequential, the survey teams knew when to stop.

5.3 Descriptive Statistics and Basic Information

Table 2 contains the profile or description of the characteristics of the sample respondents. The sample had an equal gender split to enable the researchers to compare the evacuation decisions and preferences for flash flood warning channels between male and female respondents.¹³

The average age of the respondents was 44 years, with Nopbhitam comprising relatively young respondents. Majority (95%) of the respondents were married¹⁴ and received at least primary education (66%), with an average of six years of education. Observations during the field survey showed that most of the respondents had a fair level of literacy as they were able to understand the basic Thai language used throughout the interview sessions.

A large proportion of the respondents (88%) were farmers or rubber tappers in the rubber plantations. Hence, their main source of income comes from the plantation. A few respondents had freelance jobs or small grocery stores in the villages. The average household size was around four persons.

The average personal income was 9,485 Thai baht, and the average household income was 14,109 Thai baht. As for wealth or possession, most of the respondents (99%) lived in their own house or in the house owned by their family members. As they worked in the rubber plantations, pick-up trucks were quite widespread. Nevertheless, motorcycles were still the most common means of transport in these villages; in fact, 324 out of 332 respondents reported that they owned motorcycles.

When it comes to ownership of warning receivers, television, mobile phone, and radio were among the top receivers. Ownership of two-way radio was still not extensive. It was mostly clustered among a group of people who were trained on its operation and who obtained license from the concerned authority.

Table 2. Profile of the sample respondents

	All areas (n = 332)	Tha-Sala (n = 120)	Sichol (n = 122)	Nopbhitam (n = 90)
Gender				
Male	166 (50%)	60 (50%)	61 (50%)	45 (50%)
Female	166 (50%)	60 (50%)	61 (50%)	45 (50%)
Age				
≤ 30	55 (16.57%)	12 (10.00%)	18 (14.75%)	25 (27.78%)
31-40	91 (27.41%)	29 (24.17%)	31 (25.41%)	31 (34.44%)
41-50	91 (27.41%)	39 (32.50%)	28 (22.95%)	24 (26.67%)
51-60	50 (15.06%)	19 (15.83%)	26 (21.31%)	5 (5.56%)
61-70	33 (9.94%)	15 (12.50%)	15 (12.30%)	3 (3.33%)
≥ 71	12 (3.61%)	6 (5.00%)	4 (3.28%)	2 (2.22%)
Average Age (years)	44.08	46.91	45.59	38.28
SD Age	13.68	13.53	13.67	12.23
Min Age (years)	14	14	19	14
Max Age (years)	82	82	79	75
Status				
Single	12 (3.61%)	4 (3.33%)	2 (1.64%)	6 (6.67%)
Married	316 (95.18%)	113 (94.17%)	119 (97.54%)	84 (93.33%)
Separated/divorce	4 (1.20%)	3 (2.50%)	1 (0.82%)	0 (0.00%)

¹³ Having an equal gender split is good for examining gender and intra-household issues. However, this sampling strategy has weaknesses: it misses out households that may only have one parent or other atypical household compositions. There appears to be few single-person households though.

¹⁴ If the situation allowed, husband and wife were interviewed in each household; otherwise, one male and one female member of the household was interviewed. In case of the latter, individuals with single and separated/divorce status were in the sample.

Table 2 continued

	All areas (n = 332)	Tha-Sala (n = 120)	Sichol (n = 122)	Nobphitam (n = 90)
Education				
No schooling	9 (2.71%)	6 (5.00%)	3 (2.46%)	0 (0.00%)
Primary	220 (66.27%)	86 (71.67%)	84 (68.85%)	50 (55.56%)
Lower secondary	41 (12.35%)	15 (12.50%)	14 (11.48%)	12 (13.33%)
Upper secondary	42 (12.65%)	10 (8.33%)	12 (9.84%)	20 (22.22%)
Vocational	9 (2.71%)	1 (0.83%)	5 (4.10%)	3 (3.33%)
Undergraduate	11 (3.31%)	2 (1.67%)	4 (3.28%)	5 (5.56%)
Postgraduate	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
Years of Education (average)	6.79	6.03	6.60	8.06
Years of Education (SD)	3.56	3.18	3.52	3.76
Occupation				
Self-employed	1 (0.30%)	0 (0.00%)	0 (0.00%)	1 (1.11%)
Farmer	293 (88.25%)	108 (90%)	110 (90.16%)	75 (83.33%)
Unskilled labor	8 (2.41%)	2 (1.67%)	2 (1.64%)	4 (4.44%)
Civil servant	1 (0.30%)	1 (0.83%)	0 (0.00%)	0 (0.00%)
Business owner	5 (1.51%)	1 (0.83%)	0 (0.00%)	4 (4.44%)
Skilled labor	2 (0.60%)	1 (0.83%)	1 (0.82%)	0 (0.00%)
Private employee	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
Unemployed	18 (5.42%)	7 (5.83%)	6 (4.92%)	5 (5.56%)
Maid	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
Housewife/househusband	4 (1.20%)	0 (0.00%)	3 (2.46%)	1 (1.11%)
Income				
Personal income (average)	9485.15	10438.08	8760.25	9197.21
Household income (average)	14109.04	18005.83	10856.56	13322.22
Personal income (SD)	7800.25	9578.60	6892.01	6082.88
Household income (SD)	10764.67	13642.74	6502.85	9434.37
Wealth possession	<i>out of 332</i>	<i>out of 120</i>	<i>out of 122</i>	<i>out of 90</i>
House	99%	99%	100%	99%
Automobile	55%	56%	48%	62%
Mobile phone	87%	96%	89%	72%
Radio	49%	38%	59%	50%
Two-way radio	16%	8%	22%	19%
Television	97%	100%	93%	97%
Motorcycle	98%	98%	97%	98%
Household Size				
All members (average)	3.96	3.96	3.83	4.16
Children/youth (average)	1.27	0.80	1.75	1.22
Elderly (average)	0.66	0.47	1.21	0.18

Note: Percentages are shown in parentheses

6.0 ANALYSIS OF FLASH FLOOD EVACUATION

6.1 Modeling Framework

This study approached the flash flood evacuation choices in two ways. First, it examined the factors that affected evacuation decisions. Second, it analyzed the differences in the evacuation decisions of males and females upon receiving a flash flood warning.

The factors affecting individuals' evacuation choices were based on the empirical methodology used by Solis et al. (2009), which was originally proposed by Burton et al. (1993) and Viscusi (1995). This empirical model can be summarized as follows:

$$evac_i = g(R_i, D_i, S_i), \quad (\text{Equation 1})$$

where the dependent variable, $evac_i$ is a dummy variable which equals 1 if individual i decides to evacuate and 0 otherwise; R_i is a vector of variables associated with flash flood-related information that an individual i has, such as whether the individual i thinks he or she lives in the flash flood hazard area, whether he or she knows about the meeting place during evacuation; whether the individual i received flash flood warning and whether the individual i knows about neighbor's evacuation decision; D_i is a vector consisting of demographic variables, such as age, gender, level of education, income, and wealth; and S_i consists of house-specific factors, such as whether the house is one- or two-story house.

The logit model was used in conducting the empirical estimate of equation (1). This model relates the probability of evacuation, $Pr(evac = 1|x)$, to a set of explanatory variables, x . The probability of evacuation was estimated as follows:

$$Pr(evac = 1|x) = F(x\beta), \quad (\text{Equation 2})$$

where F is the cumulative distribution function, x is the vector of explanatory variables β and is the vector of estimated coefficients.

Next, to analyze differences in evacuation decisions between males and females upon the receipt of flash flood warning, the study followed the research design used in intra-household resource allocation as discussed in literature. As the spouses were interviewed separately, the study examined the extent of agreement between the husbands and wives (i.e., whether both reached an agreement on the evacuation decisions), and this was done by comparing their responses. In addition, the factors that determined the households' evacuation decision were also examined.

6.2 Survey Instruments

Using the logit models to understand the factors affecting individuals' evacuation choices, the respondents were asked a series of questions regarding their perception of risk, demographic characteristics, previous experience with a flash flood, flash flood warnings, perception of the credibility of the warnings delivered through different warning channels, and their evacuation experiences.

The final questionnaire contained in Appendix 1 comprised three main parts. Part 1 obtained information about the individuals' flash flood experience. Part 2 gathered data to assess the individuals' preferences for flash flood warning channels. Part 3 elicited the individuals' personal information or demographic characteristics. Information from Part 1 and 3 of the questionnaire were used in the empirical analysis on evacuation choices.

6.3 Results

Evacuation Patterns

According to the Partnership for Public Warning (2002), as the success of a warning is measured by what actions people take, the pattern of evacuation choices must be considered.

Out of 332 individuals who participated in the survey, 144 respondents (43.4%) chose to evacuate, which was less than the 188 respondents (56.6%) who chose not to evacuate.¹⁵ Among the 144 respondents who evacuated, 61 of them are male (42.4%) and 83 of them are female (57.6%). Among the 188 respondents who did not evacuate, 105 of them are male (55.9%) and 83 of them are female (44.1%).

Table 3. Evacuation patterns according to gender

Pattern	N=332	Percent (%)
Evacuated	144	43.4
Male	61	42.4
Female	83	57.6
Did not evacuate	188	56.6
Male	105	55.9
Female	83	44.1

Why did some of the respondents choose not to evacuate? Information on the reasons for not evacuating shown in the questionnaire were collected from the focus group discussions. In question 20 of the questionnaire, the respondents were asked to choose the reasons (multiple reasons were acceptable) behind their decision not to evacuate.

Figure 7 shows that the top reason for not evacuating were the respondents' perception or belief that they were safer (from flash flood and other unforeseeable threats) inside their own houses, which were in a safe location, rather than outside. The other important reason was that some residents in the villages were cut off by damaged roads, preventing them from evacuating to the meeting places.¹⁶ Lastly, some respondents wanted to protect their belongings and properties both during and after the disaster events. This fear of theft is similar to the finding of Dash and Galdwin (2007), Whitehead et al. (2000), and Smith (1999).

The factor or reason with the highest impact on the respondents' decision not to evacuate was asked in Question 20 of the questionnaire. Figure 8 confirms the previous finding that majority of the respondents perceived that they were safer (from flash flood and other unforeseeable threats) by staying inside their own houses than going outside.

Moreover, the roads destroyed because of a flash flood posed a heavy barrier during the emergency evacuation. Hence, the authority concerned could possibly assist the victims of disaster during evacuation, perhaps by supplying the latter with ropes and by improving the transport system during the time of emergency.

¹⁵ It is important to note that it is just by chance that about half of the respondents evacuated, while the other half did not. This was not purposive.

¹⁶ Interpreting the reasons for not evacuating must be treated with caution. It is possible that some of the respondents who said they decided not to evacuate might actually have wanted to evacuate, but they could not because the roads in their evacuation routes have been cut off by the flash flood. However, the study does not have sufficient information to prove such surmising.

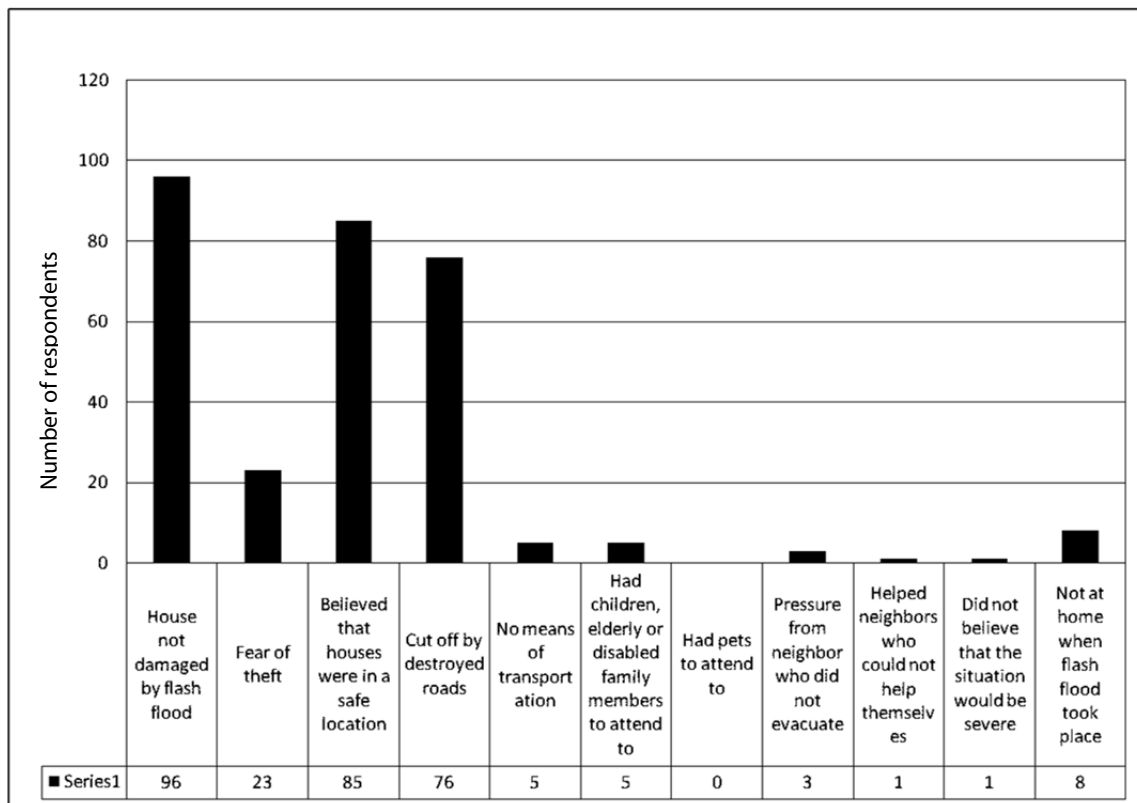


Figure 7. Reasons for not evacuating

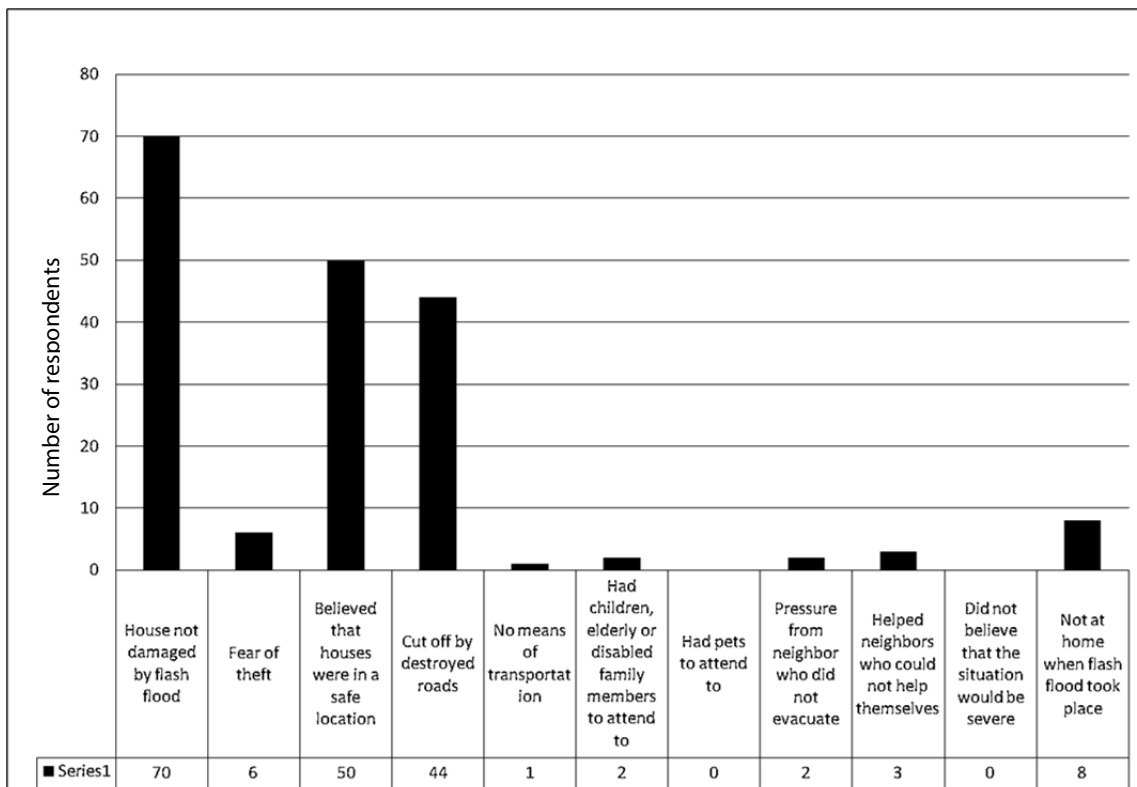


Figure 8. Factors with the highest impact on the decision not to evacuate

To examine the factors that affected the individuals' evacuation choices, the study estimated three specifications for the logit model. The first model specification is

$$evac_i = f(exper_i, hazard_i, warn_i, meet_i, disab_i, gender_i, age_i, pchil_i, peld_i, income_i, pet_i, house_i, neigh_i)$$

where

exper_i is a dummy variable, which indicates whether an individual *i* was affected by the flash flooding in the past. This variable equals 1 if an individual *i* reported that he or she had previous experience with flash flooding and equals 0 otherwise.

hazard_i is a dummy variable, which captures an individual *i*'s perception of the safety of his or her house location, i.e., whether he or she thinks it is located in the flash flood hazard. This variable equals 1 if an individual *i* perceives that his or her house is located in flash flood hazard area and equals 0 otherwise.

The variable *warn_i* is a dummy variable, which captures whether an individual *i* received flash flood warning. This variable *warn_i* equals 1 if an individual *i* received flash flood warning and *warn_i* equals 0 otherwise.

The variable *meet_i* is a dummy variable, which captures whether an individual *i* was aware of the existence and location of the meeting place in his or her village. This variable equals 1 if an individual *i* was aware of the existence and location of the meeting place and equals 0 otherwise.

The variable *disab_i* is a dummy variable, which equals 1 if an individual *i* reported that there is a disabled person in his or her household.

The dummy variable *gender_i* equals 1 if an individual *i* is female and 0 otherwise.

The continuous variables *age_i*, *pchil_i*, *peld_i*, and *income_i* capture age, proportion of young children in the household (less than 15 years), proportion of elderly people in the household (over 60 years), and income of an individual *i*, respectively.

The dummy variable *pet_i* equals 1 if an individual *i* owns pet and equals 0 otherwise.

The dummy variable *house_i* equals 1 if an individual *i*'s house is a two-story house and equals 0 if his or her house is a one-story house.

The dummy variable *neigh_i* equals 1 if an individual *i* knows that his or her neighbor evacuated and equals 0 if he or she knows that his or her neighbor did not evacuate.

The second specification for the logit model is given by

$$evac_i = f(warn_i, meet_i, disab_i, gender_i, age_i, pchil_i, peld_i, income_i, house_i),$$

and the third specification for the logit model is given by

$$evac_i = f(warn_i, meet_i, gender_i, income_i)$$

To assess the robustness of the results, we also estimated separate models for men and women, using the three model specifications described above (with the variable *gender* being removed).

Before proceeding to the logit model estimation, the summary statistics are presented in Table 4. The correlation between the variables that were included in the regression analysis was checked because

the correlation and/or endogeneity problems could affect the results.¹⁷ Table 5 presents the correlations between different pairs of variables in the evacuation logit model.

Table 4. Summary statistics – full sample

Variable	Number of observations	Mean	Standard deviation	Min	Max
evac	332	0.4337	0.4963	0	1
exper	332	0.0241	0.1536	0	1
hazard	332	0.5873	0.4931	0	1
warn	332	0.4608	0.4992	0	1
meet	332	0.6988	0.4595	0	1
disab	332	0.0843	0.2783	0	1
gender	332	0.5	0.5008	0	1
age	332	44.0843	13.6822	14	82
pchil	332	0.2196	0.2003	0	0.6667
peld	332	0.1011	0.2180	0	1
income	332	9485.148	7800.252	500	60000
house	332	0.1777	0.3828	0	1
pet	332	0.7831	0.4127	0	1
neigh	332	0.7259	0.4467	0	1

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

The correlation matrix of these 14 variables, $X_1, \dots, X_{14}$, is the 14×14 matrix, whose i, j entry is $\text{corr}(X_i, X_j)$. The Pearson correlation is +1.0000 in the case of a perfect positive linear relationship; -1.0000 in the case of a perfect negative linear relationship, and some value between -1.0000 and +1.0000 in all other cases, indicating the degree of linear dependence between the variables. As the Pearson correlation approaches 0, there is less of a relationship or closer to being uncorrelated, while the closer is this correlation coefficient to either -1.0000 or +1.0000, the stronger the correlation between these variables.

The correlation matrix presented in Table 5 shows that the correlations between these different pairs of variables are not strong, suggesting that the problem of correlation does not seem to be an issue here.

Results from the logit model estimations are presented in Table 6. In testing to see whether all the coefficients in the model were different from 0, the study checked $\text{Prob} > \chi^2$. Overall, the estimated logit models performed fairly well as the null hypothesis that all coefficients were simultaneously 0 is rejected at the 1 percent significance level for all three model specifications. For the first (Model 1), second (Model 2), and third (Model 3) models presented in Table 6, $\text{Prob} > \chi^2 = 0$, thus the coefficients in the model are different from 0.

¹⁷ The issue of endogeneity may be a concern with the variables that are related to people's perception, such as the variable, *hazard*.

Table 5. Correlation matrix – full sample

	evac	exper	hazard	warn	meet	disab	gender	age	pchil	peld	income	house	pet	neigh
evac	1.0000													
exper	-0.0583	1.0000												
hazard	0.0793	0.0519	1.0000											
warn	0.1419	0.0912	-0.1088	1.0000										
meet	0.5481	-0.1109	0.2365	0.0538	1.0000									
disab	0.1062	-0.0477	0.0122	-0.0849	0.1520	1.0000								
gender	0.1337	-0.0393	0.0428	0.0544	0.0657	0.0217	1.0000							
age	-0.0588	0.0867	-0.0136	-0.0756	-0.0368	0.1624	-0.1195	1.0000						
pchil	0.1170	0.0297	0.0103	0.0355	0.1339	-0.0378	0.0273	-0.4270	1.0000					
peld	-0.0144	0.0182	-0.0725	0.0303	-0.0467	0.0642	-0.0062	0.5778	-0.2800	1.0000				
income	-0.1215	-0.0602	0.1079	-0.1338	0.0147	-0.0815	-0.1583	-0.1092	-0.0788	-0.2155	1.0000			
house	-0.0412	0.0811	-0.0745	0.0760	-0.0383	-0.0277	-0.0079	0.1713	-0.1461	0.0875	0.0363	1.0000		
pet	0.0476	-0.1080	-0.0402	0.0026	0.0687	0.0019	0.0146	0.0921	0.0214	0.1103	0.0028	0.0343	1.0000	
neigh	0.2108	-0.0355	0.1570	0.0398	0.3325	0.0893	0.0068	0.0033	-0.0363	0.0279	0.0994	-0.0146	0.1354	1.0000

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

The logit coefficients shown in Table 6 can tell the direction and the statistical significance associated with the effect of increasing an explanatory variable. However, these coefficients do not tell us the magnitude of the effect of a change in explanatory variables on the probability that the respondents choose to evacuate, i.e. $evac = 1$. If the goal is to determine the magnitude of the effects on the response probability, $Pr(evac = 1|x)$, resulting from a change in one of the explanatory variables, the marginal effects can be found.

The logit models contain both continuous and discrete explanatory variables. The way the marginal effects are computed for these two types of explanatory variables differ (Söderbom, 2009). When the explanatory variable is a continuous variable, such as *age*, *pchil* and *income* its partial effect on $Pr(evac = 1|x)$ is obtained from the partial derivative:

$$\frac{\partial Pr(evac = 1|x)}{\partial x_j} = \frac{\partial F(\mathbf{x}\boldsymbol{\beta})}{\partial x_j} = f(\mathbf{x}\boldsymbol{\beta})\beta_j,$$

where $F(\mathbf{x}\boldsymbol{\beta})$ is the probability of observing $evac_i = 1$ and $f(z) \equiv \frac{dF(z)}{dz}$ is the probability density function associated with F .

When the explanatory variable is discrete, such as *gender*, *warn* and *meet* then the study should not rely on calculus in evaluating the effect on the response probability. Suppose that x_2 is binary, while other explanatory variables are continuous, the partial effect from changing x_2 from 0 to 1, holding all other variables fixed, is

$$F(\beta_1 + \beta_2 \cdot 1 + \dots + \beta_K x_K) - F(\beta_1 + \beta_2 \cdot 0 + \dots + \beta_K x_K),$$

and this depends on all the values of other explanatory variables and the values of all the other coefficients.

The estimation of marginal effects is presented in Table 7.

Table 6. Evacuation logit model estimations – full sample

	Logit Model Estimation – Full Sample		
	Model 1	Model 2	Model 3
exper	-0.1686 (0.9690)		
hazard	-0.2060 (0.3007)		
warn	0.5317* (0.2980)	0.5700** (0.2868)	0.5683** (0.2770)
meet	4.3190*** (0.7090)	4.3682*** (0.7256)	4.4102*** (0.7228)
disab	0.2565 (0.4784)	0.2787 (0.4896)	
gender	0.4512 (0.2851)	0.4512 (0.2817)	0.4688* (0.2762)
age	-0.0062 (0.0140)	-0.0055 (0.0121)	
pchil	0.3557 (0.7652)	0.2908 (0.7444)	
peld	-0.0299 (0.8367)		
income	-0.00003** (0.00002)	-0.00003** (0.00002)	-0.00003** (0.00002)
house	-0.1016 (0.3715)	-0.1038 (0.3648)	
pet	0.0229 (0.3616)		
neigh	0.3298 (0.3661)		
constant	-3.9679*** (1.1196)	-3.9146*** (1.0049)	-4.1203*** (0.7501)
Prob > χ^2	0.0000	0.0000	0.0000

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

* significant at 10%, ** significant at 5% and *** significant at 1%
Robust standard errors are shown in the parentheses

Table 7. Marginal effects of logit model – full sample

	Marginal Effects – Full Sample		
	Model 1	Model 2	Model 3
Marginal effects after logit $y = \text{Pr}(\text{evac})$ (predict)	0.7192	0.7596	0.7314
	dy/dx	dy/dx	dy/dx
exper	-0.0328 (0.1954)		
hazard	-0.0397 (0.0605)		
warn	0.1184 (0.0799)	0.1184* (0.0620)	0.1247** (0.0598)
meet	0.6862*** (0.1973)	0.7211*** (0.0944)	0.6994*** (0.0500)
disab	0.0546 (0.0982)	0.0545 (0.0899)	
gender	0.0993 (0.0739)	0.0916 (0.0616)	0.1012* (0.0593)
age	-0.0012 (0.0028)	-0.0010 (0.0022)	
pchil	0.0718 (0.1614)	0.0531 (0.1360)	
peld	-0.0060 (0.1690)		
income	-0.000007 (0.00001)	-0.000006* (0.0000)	-0.000007** (0.0000)
house	-0.0201 (0.0752)	-0.0184 (0.0661)	
pet	0.0047 (0.0735)		
neigh	0.0711 (0.0883)		

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

dy/dx is for discrete change of dummy variable from 0 to 1

* significant at 10%, ** significant at 5% and *** significant at 1%

Reference points were specified for the binary variables, *exper* = 1, *hazard* = 1, *warn* = 1, *meet* = 1, *disab* = 1, *gender* = 1, *pet* = 1, *house* = 1 and *neigh* = 1. Means were used as reference points for continuous explanatory variables, *age*, *pchil*, *peld* and *income*.

For Model 1, the predicted probability of evacuation is 0.7192 for female residents at the average age of 44, having average income of 9,485 THB, having average proportion of young children in the household of 0.22, having average proportion of elderly household members of 0.10, having disabled member in the household, having two-story house, having pet, having heard about neighbors' evacuation decision, having previous experience with flash flood, having perception that they are residing in flash flood-hazard areas, having received flash flood warning, and being aware of the meeting place designated for evacuation during disaster. Marginal effects and discrete changes are listed under dy/dx column in Table 7.

In Model 2, the predicted probability of evacuation as shown in Table 7 is 0.7596 for female residents at the average age of 44, having average income of 9,485 THB, having average proportion of young children in the household of 0.22, having disabled member in the household, having two-story house, having received flash flood warning and being aware of the meeting place designated for evacuation during disaster. Marginal effects and discrete changes are listed under dy/dx column in Table 7.

The marginal effects for Model 3 are considered. The predicted probability of evacuation is 0.7314 for female residents who earn an average income of 9,485 THB, who have received flash flood warning, and who were aware of the meeting place designated for evacuation during disaster. Marginal effects and discrete changes are listed under dy/dx column in Table 7.

Based on the results presented in Table 7, the study discusses the direction and statistical significance associated with the effect of increasing each of the regressors of the logit model, holding other independent variables constant. The discussion begins with the simple specification¹⁸, i.e., Model 3. According to Table 7, four variables are statistically significant, namely *warn*, *meet*, *gender*, and *income*.

First, the variable *warn* is positive and statistically significant. Individuals who received flash flood warning were 12.47 percent more likely to evacuate than those who did not receive the warning, holding other explanatory variables constant at the reference points. A flash flood warning provides people at risk with information and motivation for them to take informed actions that reduce losses. As evacuation is one of the informed decision, receiving warning in advance or during the flash flood should increase the chances that individuals would choose to evacuate to get out of harm or to reduce their loss.

The estimated coefficient of the variable *meet* is positive. This suggests that having prior information about the existence of the meeting place for evacuation increases the predicted probability of evacuation by 69.94 percent, holding other explanatory variables constant at the reference points. This finding is consistent with the research by Partnership for Public Warning (2002) that individuals usually require information about means of transportation, route of travel, evacuation destination, and lodging when they make evacuation decision.

The field survey revealed that the meeting places could be public meeting places, such as village hall, school, and temple or they could be houses of relatives or neighbors. For respondents in Sichol, the public meeting places were the Pian School and the evacuation center (see map in Figure 4). In Tha-Sala, the public meeting places included the village hall (for Tamlord Village) and Nakaowat School. In Nopbhitam, before the flash flooding in March-April 2011, the evacuation center did not exist, and the nearest school was very far from Tubnamtao Village. Therefore, most residents in Nopbhitam who evacuated chose private meeting places such as the houses of friends or relatives as the evacuation destinations. These gave rise to one important policy implication. Authorities concerned must provide information to the local residents about the location of public meeting places in the communities. The local residents also need to study different possible routes of travel, which could lead themselves and their family members to those designated meeting places. They need to prepare a contingency plan: how would they travel if some roads were cut off because of flood?

The variable *gender* is positive and statistically significant. This suggests that female residents are 10.12 percent more likely to evacuate than male residents, holding other explanatory variables constant at the reference points. Although there is no study on the relationship between gender and flash flood evacuation, the studies of hurricane evacuation in the U.S. often noted that women were more likely than men to evacuate. Bateman and Edwards (2002) examined this relationship between evacuation and gender variations. They found that women were more likely to evacuate than men because of socially constructed gender differences in care-giving roles, access to evacuation incentives, and exposure to risk and perceived risk. The robustness of this result was checked by the separate estimate logit models for men and women.

Lastly, the variable *income* is negative and statistically significant. Thus, individuals with one baht increase in income are 0.0007 percent less likely to evacuate, holding other explanatory variables constant at their reference points. In other words, individuals with a thousand baht increase in income are 0.7 percent less likely to evacuate. In literature, the effect of income on evacuation choice was mixed. Though high-income individuals should be more likely to evacuate because they have the means, their key reason for not evacuating was the fear of theft during and after the disaster. Wealthy individuals might prefer not to evacuate to protect their belongings and properties (Dash and Galdwin, 2007; Whitehead et al., 2000; Smith, 1999).

¹⁸ The issue of concern for the more sophisticated model specification is that there could be correlations between sets of variables even though, according to the correlation matrix shown in Table 5, the pairwise correlations are low.

Table 7 shows the results of other model specifications – Models 1 and 2 – which control for other variables. Even though the control variables included in Model 1 are not statistically significant, the direction associated with the effect of changing each of these variables will be explained.

First, the variable *exper* is negative. This indicates that residents who had prior experience with a flash flood were less likely to evacuate. Baker's (1991) results showed mixed evidence on the impact of a hurricane experience on evacuation. On one hand, more people residing in communities that have recently experienced major hurricanes would evacuate than people in communities that have not. On the other hand, new residents who have not yet undergone the "false experience" would be more likely to evacuate than the long-time residents.

Second, the variable *hazard* is negative but not statistically significant. Residents who believed that they reside in flash flood hazard areas were less likely to evacuate.

The variable *disab* is positive but not statistically significant. Residents having members with disability in the household were more likely to evacuate than those who did not have disabled household members.

The variable *age* is negative but not statistically significant. Some old respondents said that they suffered from poor mobility problems. Poor mobility during evacuation would place a substantial burden on themselves, their families, and on others (Whelan et al., 2006). The field survey also revealed that old people had strong attachment to their houses, thus they were less likely to leave their houses. Further, the variable, *peld*, is negative but not statistically significant. The increase in proportion of elderly people in the household would reduce the probability of evacuation. Baker (1991) found that the restricted mobility of older people could affect evacuation.

The variable *pet* is positive but not statistically significant. Baker (1991) reported that some people chose not to evacuate because they needed to care and provide for pets, which were not allowed at the evacuation shelters. But this study showed that the presence of pets in the house was not associated with evacuation decisions.

The variable *house* is negative but not statistically significant. Respondents with two-story houses were not likely to evacuate. According to Baker (1991), residents who felt that their house location was safe tended to stay (not evacuate). Moreover, residents in houses with high-rise structures tended not to evacuate. Since flood water could penetrate a one-story house more easily than that of a two-story house, one-story dwellers were more likely to evacuate.

Lastly the variable *neigh* is positive but not statistically significant. Respondents with information about neighbors' evacuation decision were more likely to evacuate. Baker (1991) found that one of the frequently cited reasons why people chose not to evacuate before or during the hurricane was the peer pressure from neighbors, i.e., occasionally those who stayed indicated that pressure from neighbors who did not evacuate prevented their own leaving. Hence, Baker highlighted the existence of a conformity effect, i.e., if most of the neighborhood evacuate, a resident of the neighborhood was more likely to leave than someone in a neighborhood where most people stayed.

Gender differences and evacuation

Results show that 122 out of 166 couples agreed on evacuation decisions with 50 couples deciding to evacuate, while 72 couples decided not to evacuate. However, 44 out of the 166 couples did not agree on evacuation, with 44 individuals deciding to evacuate and 44 individuals choosing not to evacuate.

This study also examined any gender differences when it came to flash flood evacuation by estimating separate models for men and women. Table 8 presents the summary statistics for the male respondents, while Table 9 shows the pairwise correlations between variables.

The correlation matrix presented in Table 9 shows the relatively low correlations between these different pairs of variables. Yet, as there still may be correlations between sets of variables in the logit model estimations, the models with simple specifications were included.

Table 8. Summary statistics – male

Variable	Number of observations	Mean	Standard deviation	Min	Max
evac	166	0.3675	0.4836	0	1
exper	166	0.0301	0.1714	0	1
hazard	166	0.5663	0.4971	0	1
warn	166	0.4337	0.4971	0	1
meet	166	0.6687	0.4721	0	1
disab	166	0.0783	0.2695	0	1
age	166	45.7169	14.2811	16	82
pchil	166	0.2142	0.1993	0	0.6667
peld	166	0.1025	0.2199	0	1
income	166	10718.19	8540.206	500	60000
house	166	0.1807	0.3860	0	1
pet	166	0.7771	0.4174	0	1
neigh	166	0.7229	0.4489	0	1

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

Table 9. Correlation matrix – male

	evac	exper	hazard	warn	meet	disab	age	pchil	peld	income	house	pet	neigh
evac	1.0000												
exper	-0.0612	1.0000											
hazard	0.0620	0.0831	1.0000										
warn	0.2154	0.1302	-0.1415	1.0000									
meet	0.5100	-0.1755	0.2362	0.0479	1.0000								
disab	0.1499	-0.0514	-0.0616	-0.0741	0.1575	1.0000							
age	-0.0006	0.1372	-0.0609	-0.0594	-0.0697	0.1507	1.0000						
pchil	0.1369	0.0216	0.0506	0.1039	0.1232	-0.0095	-0.4172	1.0000					
peld	0.0375	0.0480	-0.0932	0.0398	-0.0856	0.0751	0.6120	-0.3119	1.0000				
income	-0.1347	-0.1101	0.1460	-0.1787	0.0436	-0.1181	-0.1154	-0.1187	-0.1911	1.0000			
house	-0.0982	0.1004	-0.0628	0.0628	-0.1018	0.0379	0.1303	-0.1370	0.0698	-0.0014	1.0000		
pet	0.0479	-0.0750	-0.0306	-0.0570	0.0535	0.0484	0.1235	-0.0037	0.1457	0.0443	0.0258	1.0000	
neigh	0.1648	-0.0484	0.1099	-0.0013	0.2791	0.1304	0.0208	-0.0242	0.0530	0.0867	-0.0240	0.1535	1.0000

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

Results from the logit model estimations are presented in Table 10. $Prob > \chi^2$ was checked first to see whether all the coefficients in the model were different from 0. Overall, the estimated evacuation models performed fairly well. The null hypothesis stating that all coefficients are simultaneously 0 is rejected at the 1 percent significance level for all three model specifications (Models 1, 2 and 3).

Table 10 shows that in all three model specifications (Models 1, 2 and 3) the variables *warn* and *meet* are statistically significant. The variable, *income*, is statistically significant in the third model specification (Model 3). The estimations for marginal effects for male respondents are presented in Table 11.

Results of marginal effects based on Model 3 are presented in Table 11. Models 1 and 2 control for the potential impacts of other variables on the probability of evacuation; hence, some comments on Models 1 and 2 are presented below.

Table 10. Evacuation logit model estimations – male

	Logit Model Estimations – Male Respondents		
	Model 1	Model 2	Model 3
exper	0.3821 (0.9653)		
hazard	-0.0488 (0.4403)		
warn	1.0481** (0.4263)	1.0899** (0.4119)	1.0077** (0.3999)
meet	4.2443*** (1.0910)	4.2703*** (1.0594)	4.3194*** (1.0285)
disab	0.4975 (0.7401)	0.5276 (0.7320)	
age	0.0120 (0.0185)	0.0172 (0.0153)	
pchil	1.0328 (1.1095)	0.9681 (1.0938)	
peld	0.4074 (1.3114)		
income	-0.00003 (0.00002)	-0.00003 (0.00002)	-0.00004* (0.00002)
house	-0.4215 (0.5254)	-0.3997 (0.5246)	
pet	0.1535 (0.5366)		
neigh	0.2406 (0.4914)		
constant	-5.2851*** (1.6823)	-5.2234*** (1.4606)	-4.1516*** (1.0213)
Prob > χ^2	0.0009	0.0001	0.0000

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

* significant at 10%, ** significant at 5% and *** significant at 1%
Robust standard errors are shown in the parentheses

The predicted probability of evacuation is 0.6757 for male residents with an average income of 10,718 THB, who have received flash flood warning, and who were aware of the meeting place designated for evacuation during a disaster. Marginal effects and discrete changes are listed under dy/dx column in Table 11.

Table 11. Marginal effects of logit model - male

	Marginal Effects – Male Respondents		
	Model 1	Model 2	Model 3
Marginal effects after logit y = Pr (evac) (predict)	0.7836	0.7135	0.6757
	dy/dx	dy/dx	dy/dx
exper	0.0717 (0.1705)		
hazard	-0.0082 (0.0739)		
warn	0.2242 (0.1381)	0.2578*** (0.0965)	0.2437*** (0.0922)
meet	0.7342*** (0.1838)	0.6799*** (0.1470)	0.6487*** (0.0672)
disab	0.0959 (0.1381)	0.1185 (0.1539)	
age	0.0020 (0.0037)	0.0035 (0.0035)	
pchil	0.1752 (0.2404)	0.1979 (0.2324)	
peld	0.0691 (0.2271)		
income	-0.000005 (0.00001)	-0.000007 (0.00001)	-0.000009* (0.00001)
house	-0.0630 (0.0939)	-0.0744 (0.1037)	
pet	0.0272 (0.0951)		
neigh	0.0436 (0.0935)		

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

dy/dx is for discrete change of dummy variable from 0 to 1

* significant at 10%, ** significant at 5% and *** significant at 1%

Reference points were specified for the binary variables, *exper* = 1, *hazard* = 1, *warn* = 1, *meet* = 1, *disab* = 1, *pet* = 1, *house* = 1, and *neigh* = 1,. Means were used as reference points for continuous explanatory variables, *pchil*, *peld* and *income*.

First, the variable *warn* is positive and statistically significant at 1 percent level of significance. This result suggests that men who received flash flood warning were 24.37 percent more likely to evacuate than those who did not receive flash flood warning, holding other explanatory variables constant at the reference points.

Next, the estimated coefficient of the variable *meet* is positive and statistically significant at 1 percent level of significance. This result suggests that having prior information about the existence of the meeting place increased the predicted probability of evacuation of male respondents by 64.87 percent, holding other explanatory variables constant at the reference points.

Lastly, the variable *income* is negative and statistically significant at 10 percent level of significance. Thus, holding other explanatory variables constant at their reference points, male individuals with a thousand Thai baht increase in income were 0.9 percent less likely to evacuate. The signs and statistical significance of these three variables are consistent with the results reported in the full sample case (Table 7).

Similar to the case of full sample logit model estimation, in Tables 10 and 11, results of other model specifications – Models 1 and 2 – which control for other variables, are also reported. The control variables included in Models 1 and 2 are not statistically significant. Nevertheless, the signs of the estimated

coefficients for these control variables were checked for the consistency. While the signs of the coefficients for the variables *hazard*, *disab*, *pchil*, *house*, *pet*, and *neigh* are consistent when comparing between Table 7 and Table 11, the signs of the coefficients for the variables *exper*, *age*, and *peld* are not consistent.

For male respondents, holding other explanatory variables constant at their reference points, having prior experience with flash flood was associated with evacuation. More likely to evacuate would be older men and those with a higher proportion of elderly members in the household. But as these variables are not statistically significant, no firm conclusion can be drawn.

The next section discusses the case of women. Table 12 presents the summary statistics for female respondents. Compared to men, the women are relatively younger and have smaller income; they are more aware of the meeting place; and they have less prior experience with flash flood, yet they have a higher perception that they are residing in a flash flood-hazard area.

Table 12. Summary statistics – female

Variable	Number of Observations	Mean	Standard Deviation	Min	Max
evac	166	0.5000	0.5015	0	1
exper	166	0.0181	0.1336	0	1
hazard	166	0.6084	0.4896	0	1
warn	166	0.4880	0.5014	0	1
meet	166	0.7289	0.4459	0	1
disab	166	0.0904	0.2876	0	1
age	166	42.4518	12.8928	14	76
pchil	166	0.2251	0.2018	0	0.6667
peld	166	0.0998	0.2168	0	1
income	166	8252.1020	6786.918	500	40000
house	166	0.1747	0.3809	0	1
pet	166	0.7892	0.4091	0	1
neigh	166	0.7289	0.4459	0	1

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

Table 13 shows the pairwise correlations between variables. The correlations between these different pairs of variables are relatively low, suggesting that the problem of correlation does not seem to be an issue of concern here. Yet, as there still may be correlations between sets of variables in the logit model estimations for female respondents, models with simple specifications were included.

Table 13. Correlation matrix – female

	evac	exper	hazard	warn	meet	disab	age	pchil	peld	income	house	pet	neigh
evac	1.0000												
exper	-0.0452	1.0000											
hazard	0.0864	0.0162	1.0000										
warn	0.0603	0.0485	-0.0811	1.0000									
meet	0.5827	-0.0190	0.2327	0.0531	1.0000								
disab	0.0630	-0.0428	0.0807	-0.0975	0.1449	1.0000							
age	-0.0895	0.0058	0.0503	-0.0812	0.0183	0.1834	1.0000						
pchil	0.0930	0.0430	-0.0324	-0.0341	0.1423	-0.0652	-0.4391	1.0000					
peld	-0.0637	-0.0208	-0.0508	0.0215	-0.0043	0.0542	0.5479	-0.2479	1.0000				
income	-0.0654	0.0016	0.0798	-0.0644	0.0016	-0.0350	-0.1527	-0.0228	-0.2580	1.0000			
house	0.0159	0.0567	-0.0860	0.0904	0.0307	-0.0897	0.2183	-0.1550	0.1057	0.0829	1.0000		
pet	0.0443	-0.1516	-0.0516	0.0614	0.0835	-0.0431	0.0618	0.0459	0.0740	-0.0451	0.0433	1.0000	
neigh	0.2575	-0.0190	0.2049	0.0802	0.3903	0.0504	-0.0144	-0.0487	0.0024	0.1224	-0.0049	0.1167	1.0000

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

Table 14 shows the results from the logit model estimations for female respondents. $Prob > \chi^2$ was checked first to see whether all the coefficients in the model are different from 0. Overall, the estimated evacuation models performed fairly well. The null hypothesis that 'all coefficients are simultaneously 0' is rejected at 1 percent significance level for all three models (Models 1, 2 and 3).

According to Table 14, the variable *meet* is statistically significant in all three model specifications (Model 1, Model 2 and Model 3). The variable *age* is statistically significant in the second model specification (Model 2). The estimations for the marginal effects for female respondents are presented in Table 15.

Results of marginal effects are presented in Table 15 based on Model 2. Model 1 controls for the potential impacts of other variables on the probability of evacuation, so some comments were also given on these two specifications (Models 1 and 2).

The predicted probability of evacuation is 0.6941 for female residents with an average age of 42 and an average income of 8,252 THB; who have received flash flood warning; and were aware of the meeting place designated for evacuation during disaster. Marginal effects and discrete changes are listed under dy/dx column in Table 15.

First, the estimated coefficient of the variable *meet* is positive and statistically significant at 1 percent level. This suggests that having prior information about the existence of the meeting place increases the predicted probability of evacuation of female respondents by 67.04 percent, holding other explanatory variables constant at the reference points. The sign and statistical significance of this variable are consistent with the results reported in the full sample case (Table 7).

Next, the variable *age* is negative and statistically significant at 10 percent level. Thus, holding other explanatory variables constant at their reference points, older female individuals were 0.6 percent less likely to evacuate. Table 15 also presents the results of other model specifications – Models 1 and 3. The control variables included in Model 1 were not statistically significant. Nevertheless, the consistency in the signs of the estimated coefficients for these control variables was checked. While the signs of the coefficients for the variables *exper*, *hazard*, *disab*, *age*, *peld* and *neigh* are consistent with results in Table 7 and Table 15, the signs of the coefficients for the variables *warn*, *pchil*, *house*, *pet* are not consistent.

Table 14. Evacuation logit model estimations – female

	Logit Model Estimations		
	Model 1	Model 2	Model 3
exper	-0.6349 (1.2667)		
hazard	-0.4100 (0.4490)		
warn	-0.0455 (0.4333)	0.0187 (0.4163)	0.1407 (0.3884)
meet	4.6888*** (1.0440)	4.6812*** (1.0571)	4.5361*** (1.0278)
disab	0.0639 (0.6213)	0.0696 (0.6309)	
age	-0.0292 (0.0209)	-0.0343* (0.0185)	
pchil	-0.6252 (1.0645)	-0.7021 (1.0012)	
peld	-0.6287 (1.1188)		
income	-0.00004 (0.00003)	-0.00004 (0.00003)	-0.00002 (0.00003)
house	0.2227 (0.5883)	0.2147 (0.5697)	
pet	-0.1123 (0.5479)		
neigh	0.4699 (0.5378)		
constant	-2.1364 (1.4658)	-2.0281 (1.2956)	-3.6524*** (1.0350)
Prob > χ^2	0.0024	0.0005	0.0000

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

* significant at 10%, ** significant at 5% and *** significant at 1%

Robust standard errors are shown in the parentheses

Table 15. Marginal effects of logit model - female

	Marginal Effects – Female Respondents		
	Model 1	Model 2	Model 3
Marginal effects after logit y = Pr (evac) (predict)	0.5785	0.7385	0.6941
	dy/dx	dy/dx	dy/dx
exper	-0.1429 (0.3135)		
hazard	-0.0956 (0.1082)		
warn	-0.0111 (0.1053)	0.0036 (0.0807)	0.0307 (0.0846)
meet	0.5660 (0.3703)	0.7130*** (0.1452)	0.6704*** (0.0581)
disab	0.0157 (0.1511)	0.0137 (0.1216)	
age	-0.0071 (0.0049)	-0.0066* (0.0037)	
pchil	-0.1525 (0.2592)	-0.1356 (0.2039)	
peld	-0.1533 (0.2784)		
income	-0.00001 (0.00001)	-0.000007 (0.00001)	-0.000005 (0.00001)
house	0.0550 (0.1434)	0.0435 (0.1116)	
pet	-0.0271 (0.1333)		
neigh	0.1167 (0.1337)		

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

dy/dx is for discrete change of dummy variable from 0 to 1

* significant at 10%, ** significant at 5% and *** significant at 1%

Reference points were specified for the binary variables *exper* = 1, *hazard* = 1, *warn* = 1, *meet* = 1, *disab* = 1, *gender* = 1, *pet* = 1, *house* = 1 and *neigh* = 1. Means were used as reference points for continuous explanatory variables, *age*, *pchil*, *peld* and *income*.

Determinants of flash flood evacuation: household panel data

Data on the evacuation responses of both male and female members from each household were collected at the individual level. Thus, the dataset can be presented as a panel with two observations per household – for male and for female. A random effect probit model was then estimated.

A random effect probit model is developed when the outcome of interest is a series of correlated binary responses (Gibbons and Hedeker, 1994). In the analysis, individuals within household were considered to share some common characteristics, thus they could produce similar responses, which lead to potentially correlated binary responses.

Consider the following model:

$$Y_{is}^* = X_{is}\beta + u_{is},$$

where *i* indexes household (*i* = 1, ..., 166) and *s* indexes a member within the household (*s* = 1, 2).

$$Y_{is} = 0 \text{ if } Y_{is}^* \leq 0; \\ Y_{is} = 1 \text{ if } Y_{is}^* > 0$$

The error term can be decomposed into two components:

$$u_{is} = \alpha_i + \eta_{is}$$

where it is assumed that $\eta_{is} \sim N(0,1)$, and that the α 's are independent random draws from a normal distribution, where we assume that $\alpha_i \sim N(0, \sigma_\alpha^2)$. This means that

$$Var(u_{is}) = 1 + \sigma_\alpha^2$$

The common error component, α_i , means that, within units, the u_{is} 's will be correlated. The magnitude of the correlation is given by:

$$Corr(u_{is}, u_{ir}, s \neq r) \equiv \rho = \frac{\sigma_\alpha^2}{1 + \sigma_\alpha^2}$$

Table 16 presents the results of random effect probit model estimations. Three model specifications (Models 1, 2 and 3) are included.

The overall significance of the model was first examined by referring to Wald χ^2 , log likelihood and $Prob > \chi^2$. Overall, the estimated random effect probit Models 2 and 3 performed fairly well as the null hypothesis that 'all coefficients are simultaneously 0' is rejected at 1 percent significance level. Next, was the test of the significance of the random effect term compared with a model fitted without the random effect by referring to likelihood-ratio test of $\rho = 0$: $\bar{\chi}^2$ and $Prob > \bar{\chi}^2$. Results shown in Table 16 indicate that the random effect terms are statistically significant at 1 percent level of significance for all three model specifications (Models 1, 2 and 3).

Before discussing the estimated impacts of each explanatory variables on the probability of evacuation, the marginal effects of the random effect probit models were estimated. The marginal effects estimations for random effect probit model are presented in Table 17.

The third model specification (Model 3) was referred to in interpreting the results from marginal effects estimation. The predicted probability of evacuation is 0.8068 for households that received flash flood warning and were aware of the meeting place designated for evacuation during a disaster. Marginal effects and discrete changes are listed under dy/dx column in Table 17.

First, the estimated coefficient of the variable *meet* is positive and statistically significant at 1 percent level. This suggests that having prior information about the existence of the meeting place designated for evacuation during disaster increases the predicted probability of evacuation of households by 80.67 percent, holding other explanatory variables constant at the reference points.

Next, the variable *warn* is positive and statistically significant at 5 percent level. Thus, holding other explanatory variables constant at their reference points, households that received flash flood warning are 21.16 percent more likely to evacuate. In the first and second model specifications (Models 1 and 2), other variables that might affect evacuation were controlled, but these variables turn out to be not statistically significant.

Table 16. Random effect probit model estimations

	Random Effect Probit Model Estimations		
	Model 1	Model 2	Model 3
exper	0.9220 (1.2233)		
hazard	-0.1847 (0.3583)		
warn	0.5849* (0.3434)	0.6090* (0.3314)	0.6251* (0.3242)
meet	5.2092*** (1.3300)	5.0078*** (1.2298)	4.9355*** (1.1818)
disab	0.5780 (0.6475)	0.5285 (0.6156)	
age	-0.0218 (0.0194)	-0.0149 (0.0160)	
pchil	0.4702 (1.0358)	0.3481 (0.9854)	
peld	0.5468 (1.1405)		
income	-0.00004 (0.00002)	-0.00004 (0.00002)	-0.00003 (0.00002)
house	0.1019 (0.5532)	0.0675 (0.5298)	
pet	-0.0518 (0.5092)		
neigh	0.5668 (0.5291)		
constant	-4.1583*** (1.5148)	-3.9087*** (1.3626)	-4.3734*** (1.1499)
Wald chi2	18.06	19.17	19.77
Log likelihood	-142.6210	-143.7699	-144.8170
Prob > χ^2	0.1138	0.0077	0.0002
rho	0.7701 (0.0902)	0.7515 (0.0933)	0.7413 (0.0944)
Likelihood-ratio test of rho=0: chibar2	29.43	28.43	27.86
Prob>=chibar2	0.0000	0.0000	0.0000

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

* significant at 10%, ** significant at 5% and *** significant at 1%
Robust standard errors are shown in the parentheses.

Table 17. Marginal effects of random effect probit model

	Marginal Effects – Random Effect Probit Model		
	Model 1	Model 2	Model 3
Marginal effects after logit y = Pr (evac) (predict)	0.9922	0.9178	0.8068
	dy/dx	dy/dx	dy/dx
exper	0.0593 (0.0963)		
hazard	-0.0032 (0.0134)		
warn	0.0255 (0.0818)	0.1351 (0.1274)	0.2116** (0.1061)
meet	0.9896*** (0.0268)	0.9177*** (0.1227)	0.8067*** (0.0793)
disab	0.0250 (0.0713)	0.1122 (0.1142)	
age	-0.0005 (0.0017)	-0.0023 (0.0031)	
pchil	0.0100 (0.0440)	0.0528 (0.1575)	
peld	0.0117 (0.0483)		
income	-0.0000008 (0.0000)	-0.000005 (0.00001)	-0.000009 (0.00001)
house	0.0025 (0.0149)	0.0107 (0.0817)	
pet	-0.0010 (0.0108)		
neigh	0.0242 (0.0823)		

Legend: evac (evacuation decision); exper (experience of flash flood in the past); hazard (perception of the hazardous location of house); warn (receipt of flash flood warning); meet (awareness of existence of meeting place in case of flash flood); disab (presence of disabled members); gender (gender); age (age); pchild (proportion of young children below 15 years); peld (proportion of elderly above 60 years); income (income); pet (ownership of pet/s); neigh (knowing that neighbor evacuated); house (one or two-story house)

dy/dx is for discrete change of dummy variable from 0 to 1

* significant at 10%, ** significant at 5% and *** significant at 1%

Reference points were specified for the binary variables *exper* = 1, *hazard* = 1, *warn* = 1, *meet* = 1, *disab* = 1, *gender* = 1, *pet* = 1, *house* = 1 and *neigh* = 1. Means were used as reference points for continuous explanatory variables, *age*, *pchil*, *peld* and *income*.

7.0 PREFERENCES FOR FLASH FLOOD WARNING CHANNELS

7.1 Modeling Framework

To assess the individuals' preferences for flash flood warning channels, two approaches were applied, namely: the direct ranking approach and the pairwise comparison approach.¹⁹

Suppose there are *J* alternatives that needed to be ranked by the respondents, they were asked to directly rank all the *J* alternatives under the direct ranking approach. Under the pairwise comparison

¹⁹ Brown et al. (2002) argued that the most direct way to obtain a ranking of the values of a set of resource would be to ask people to make comparative judgments. If each individual in a sample drawn from the relevant population were asked about the full set of resource changes, a ranking could be generated for a respondent.

method, each respondent was presented the elements in pairs and asked to choose the preferred element in each pair. In the pairwise comparison approach, the following questions were asked: "Which of these two flash flood warning channels do you prefer?" The respondents clearly explained that their preferred flash flood warning channel referred to the one that they felt they would be more likely to respond to, perhaps because the warning would reach them and/or their family members.

A set of J flash flood warning channels was presented to the respondents during the field survey. Under the pairwise comparison method, these warning channels were presented in pairs to the respondents. With a set of J flash flood warning channels, $\left(\frac{J}{2}\right) (J - 1)$, obtained were discrete binary choices. For instance, if the choice set consisted of five flash flood warning channels, i.e., $J = 5$, there would be 10 discrete binary choices that needed to be presented to each respondent. When the number of elements in the choice set is large, Green and Srinivasan (1978) suggested that one could apply the conjoint analysis to reduce the number of discrete binary choices. It is very important to make sure that the pairs of flash flood warning channels be randomly ordered for each respondent to control for the order effects.

The way in which the respondent made a choice in the paired comparison was formally examined. $U(Q)$ denoted the respondent's utility given his or her current endowment, Q . The paired comparison was essentially $U(Q, x_i) > U(Q, x_j)$, where x_i and x_j were two flash flood warning channels in the choice set. Each respondent chose the preferred channel in each pair. It is important to emphasize that even if the respondent was indifferent between the two flash flood warning channels in a pair, he or she must still make a choice.²⁰

When the pairwise comparison method is applied to a set of goods only, it allows the test for the transitivity axiom under the neoclassical consumer theory (Peterson and Brown, 1998).²¹ It also yields the individual respondent's preference order among elements of a choice set. The preference order is generated from the preference score, a method that is commonly used to summarize the preference information contained in the pairwise comparison data. The preference score for each item is the number of times the respondent prefers that item over other items in the set. A higher preference score indicates more preferred item.²² The aggregate preference scores for the sample were obtained by finding the column sums of the preference scores reported in the response matrices for all respondents in the sample. These scores specified the number of times each item was chosen across all paired comparisons made by the respondents, indicating the ordinal position of the items.²³

For analysis, these steps were followed. First, to determine the overall ranking of J flood warning schemes, a score was assigned for each rank. Table 18 shows how the scores were assigned. After the scores of individual respondents have been calculated, the sum of the scores for each flood warning channel was computed. The flood warning channel, which obtained the highest scores, received the first ranking.

For the pairwise comparison data, as long as the respondents entered choices for all pairs of items (i.e., the preference scores for 332 individuals in the sample), reliability could be assessed individually for each respondent. One interesting extension was to calculate the coefficient of consistency. The process in which the coefficient of consistency could be calculated is described below.

²⁰ Although not giving the respondents an indifference option may force the respondents to make what seems like unwarranted distinctions, Brown and Peterson (1998) argued that this is not worrisome because across many comparisons, indifference between two items will be revealed in the data as an equality of preference scores.

²¹ In the consumer theory, the transitivity axiom is violated when pairwise comparison of elements of a choice set reveals inconsistent choices or circular triads, i.e. $A < B < C < A$, where A , B and C are elements of a choice set. The intransitivity of preference could be caused by a number of factors, such as systematic intransitive preference, random choice in cases too close to call, and incompetence of the respondents or simple mistakes (Peterson and Brown, 1998).

²² Brown and Peterson (1998) suggest that the preference scores can be calculated by creating a $J \times J$ matrix and entering "1" in each cell, where the column item was preferred to the row items, and entering "0" otherwise.

²³ According to Dunn-Rankin (1983), the scale values represent the conversion of aggregate preference scores into percentage. They are linear transformations of the aggregate preference scores and express the number of times that an item was chosen.

Table 18. Scoring scheme

Outcome from direct ranking of alternatives	Assigned scores
1 st	J
2 nd	$J-1$
$\vdots$	$\vdots$
$(J-1)^{th}$	2
J^{th}	1

Step 1: Calculate the maximum number of circular triads, m . According to Kendall and Smith (1940) and David (1988), the maximum number possible is $m = \left(\frac{J}{24}\right)(J^2 - 1)$, when J is an odd number or $m = \left(\frac{J}{24}\right)(J^2 - 4)$ when J is an even number, where J denotes the number of items in the set.

Step 2: Calculate the number of circular triads for an individual respondent, c :

$$c = \left(\frac{J}{24}\right)(J^2 - 1) - \frac{1}{2}\sum(a_i - b)^2,$$

where a_i denotes preference score of item i and b denotes the average preference score, i.e. $b = \frac{J-1}{2}$.

Step 3: Calculate $\vartheta = 1 - \frac{c}{m}$, where ϑ denotes the coefficient of consistency.

The coefficient of consistency, ϑ , takes the values between 0 and 1 (inclusive). According to Iida (2009), when $\vartheta = 1$, there is no circular triad, and as ϑ decreases to 0, the inconsistency increases, where inconsistency is measured by the number of circular triads. The coefficient, ϑ , can be used as measure of consistency in a preference. When ϑ is not unity, Kendall and Smith (1940) suggested that the following possibilities are possible: (i) the respondent may be a bad judge; (ii) some of the objects may differ by amounts which fall below the threshold of distinguishability for the respondent; (iii) the flood warning channel under judgment may not be a linear variate at all; or (iv) several of the effects may be operating simultaneously (Iida, 2009).

7.2 Survey Instruments

Part 2 of the final questionnaire contained in Appendix 1 gathered data on the individuals' preferences for the flash flood warning channels. It was divided into two parts. Question 37 in the questionnaire required the respondents to rank all the six flash flood warning channels, by filling in number 1 to 6 in the boxes provided. 1 represented the most preferred flash flood warning channel and 6 represented the least preferred flash flood warning channel.²⁴ It was clearly explained to the respondents that "prefer" meant that the respondent felt that he or she would be more likely to respond to the warning message. They were also given an instruction that ties were not allowed.

Question 38 in the questionnaire contains the pairwise comparison tasks. Under this pairwise comparison approach, the flash flood warning channels were presented to the respondents in pairs. Given a set of six flash flood warning channels, each respondent needed to make 15 discrete binary choices. To control for the order effects, five versions for the pairwise comparisons were created, which differed in only one respect: order or sequence in which pairs were presented to the respondents.

²⁴ Focus group discussion was done with 10 to 15 representatives in each area to find out the flash flood warning channels that were available in the three study sites. Of the many channels, six flood warning channels were shortlisted and included in the final questionnaire.

7.3 Results

Results from direct ranking of flash flood warning channels

Table 19 shows the ranking for the full sample and the individual ranking for each of the three study sites. To facilitate understanding of the underlying reasons behind this ranking result, simple analysis of the pros and cons of the typical disaster warning channels, namely: mobile phone, television, radio and two-way radio were included.

Table 19. Results from direct ranking of flash flood warning channels

Flash flood warning channel	Full sample	Tha-Sala	Sichol	Nopbhitam
Mobile phone	5 th	3 rd	5 th	6 th
Television	2 nd	2 nd	3 rd	3 rd
Radio	3 rd	5 th	2 nd	2 nd
Neighbor	4 th	4 th	4 th	4 th
Family member	6 th	6 th	6 th	5 th
Two-way radio	1 st	1 st	1 st	1 st

Remark: Neighbor and family member are intermediate warning channels. The warning is delivered to recipients in person, in contrast to the other four warning channels.

Although there are some variations in the ranking, results across the three study sites showed common trends. The two-way radio was the most preferred flash flood warning channel. The pros and cons of the intermediate warning channels, i.e., neighbor and family member, were based on the information obtained from the respondents during the field survey. Table 20 provides a summary of the pros and cons of different channels used for disaster warning.

Interviews with the respondents revealed why the two-way radio was very well received by the respondents. It had two key advantages: its functionality or ability to deliver warning in circumstances with no electric supply and in remote rural areas.

Television and radio were considered effective sources of information when flash flooding were days or weeks away. However, power often fails immediately before or during flash flooding, hence rendering these channels ineffective during these times. Moreover, the respondents felt that the warnings disseminated through television or radio often did not specify very specific locations, which were more prone to flash flooding. It also required the respondents to stay tuned to the specific channels for them not to miss the warnings being issued.

During the recent flash flooding in March to April, 2011, many respondents acknowledged the role played by their neighbors in the delivery of warning messages. Some households that lived in very remote areas (especially those without access to traditional warning channels such as television, radio, mobile phone, etc.) were warned of the flash flood by their neighbors. However, some respondents had concerns about the authenticity of the warning messages delivered by their neighbors.

As the villages included in the study were located either along the foothills or near forest areas, the telephone signal penetration in many areas was still not satisfactory even during normal, calm days. This problem of poor signal was very severe in Tubnamtao Village, Nopbhitam as majority of the respondents complained that they usually could not use their mobile phone for day-to-day communication. Tubnamtao Village is located in the forest reserve areas, hence network providers were not permitted to install the cell site antenna there.

Table 20. Channels used for disaster warning: pros and cons

Channel	Pros	Cons	Availability in the areas
Mobile phone (including SMS)	Quick delivery of warning	• This is not functional when phone lines are congested, a situation which usually occurs immediately before or during a disaster. • It does not reach non-users. • Local language can be a problem. • Users often do not read text messages they receive. • There is a problem of authenticity. • Telephone penetration in many areas is still not satisfactory.	✓
Television	Quick dissemination of warning to a broad population	• It has limited use at night when television is switched off. • It does not work in case of power failure.	✓
Radio	Quick, widespread warning to a broad population Operation using batteries (not necessarily relying on electricity supply) Portable	• It has limited use at night (when the device is switched off). • It does not work in case of power failure.	✓
Neighbor	Acts as intermediary; delivers warnings to other people who do not have warning receivers; deals with local language issues	There is a problem of authenticity.	✓
Family member	Acts as intermediary; delivers warnings to other people who do not have warning receivers; deals with local language issues; recipients usually trust their family members for authenticity of the warning messages.	Recipients believe that their family members should have fairly equal information as themselves, so warning messages might not cause them to personalize the threat and choose protective action.	✓
Two-way radio	Can be used even at night; good in remote rural area; functional in the circumstance without power supply (except to recharge batteries); quick delivery of warning message	• It is not widespread. • People might lose interest if it is used only in case of disaster.	✓
Outdoor sirens	Can be used even at night; good in rural areas	• The alarm system must be maintained. • A detailed information cannot be disseminated. • False alarm can result in the 'crying wolf' problem. • It does not work in case of power failure. • Some people in remote areas might not be able to access the warning channel.	×

Source: Adapted from Wattegama (2007)

Flash flood can strike the neighborhood quickly. Family members might not be together when a flash flood occurs. Some members of the households reported that they received the flash flood warning through radio and television before the event. However, the warning did not directly reach other members in the same households, probably because they were out at work. Before the flash flood took place, the family members who had access to warning acted as the intermediary or intermediate warning channels for the rest of the family members.

The respondents' perceptions toward having family members as the intermediate warning channel were mixed. Some respondents felt that people in their families were reliable and trustworthy sources of warning information, hence they were ranked quite highly. However, other respondents felt that their family members could not have better information than themselves, thus the warning conveyed by the latter did not carry much impact on their evacuation choices.

Out of the six villages that served as study sites, only Pianbon village had access to the sirens warning of a flash flood. However, according to the interviewed respondents, the sirens have been switched off because of the blunder of a few false alarms in the past. Therefore, when the flash flood occurred in March to April 2011, the sirens were unable to prompt people in Pianbon village to evacuate to safer areas to reduce their losses.

The ranking of preferred warning channels was related to demographic characteristics of the respondents, specifically gender and level of education. Table 21 reports the outcome of the ranking when the data was split by gender.

Table 21. Direct ranking of flash flood warning channels – by gender

Channel	Gender	
	Male	Female
Mobile phone	5 th	6 th
Television	2 nd	2 nd
Radio	3 rd	3 rd
Neighbor	4 th	4 th
Family member	6 th	5 th
Two-way radio	1 st	1 st

The rankings for flash flood warning channel were consistent for male and female respondents: both preferred most the two-way radio. The traditional warning media – television and radio – came second and third, respectively. In the interviews, the respondents said that radio and television were effective sources of information when flash flooding was days or weeks away. However, immediately before or during the flash flood, they preferred the two-way radio because it was able to disseminate warning quickly and even when there was power failure.

Both male and female respondents who did not have access to traditional warning channels reported receiving flash flood warning from their neighbors (ranked 4th). Family members and mobile phones (ranked 6th and 5th or vice-versa for the genders) were at the bottom of the rankings for both male and female respondents. The main criticism for mobile phone as a warning channel was the congestion of phone signals, poor reception, and unreliable communication network, especially immediately before or during the flash flood. The functional value of family members as warning channel was not high, primarily because some male and female respondents felt that their family members did not have 'better' information. Hence, the warning conveyed through someone in their families did not have much impact on their evacuation choices.

Table 22 shows the outcome of the ranking with data split by level of education.

Table 22. Direct ranking of flash flood warning channels – by level of education

Channel	Level of Education			
	No schooling	Primary education	Secondary education	Tertiary education
Mobile phone	6 th	5 th	6 th	6 th
Television	2 nd	2 nd	3 rd	2 nd
Radio	5 th	3 rd	2 nd	1 st
Neighbor	1 st	4 th	5 th	5 th
Family member	4 th	6 th	4 th	3 rd
Two-way radio	3 rd	1 st	1 st	4 th

The rankings seemed to be inconsistent across respondents with different educational backgrounds. Hence, analysis was based on observations and information obtained during the field survey.

First, the respondents who did not receive formal education preferred their neighbor (or interpersonal communication) as the warning channel for flash flood. Without schooling, the respondents felt that their neighbors, who acted as intermediaries, had already determined whether the warning message was relevant, accurate, and internally consistent before transmitting the warning information to them. Moreover, they did not have to worry about understanding the content of the warnings because their neighbors passed on the warnings in a form that was easily accessible and understandable to them.

Second, the respondents with primary or secondary education seemed to prefer the two-way radio as flash flood warning channel, followed by television and radio. Many of the respondents obtained weather forecasts and weather warning information from television and radio even in calmer weather conditions.²⁵

Respondents who received undergraduate education seemed to prefer radio as the flash flood warning channel.²⁶ They felt that radio, particularly their community radio, provided reliable and easily accessible warning information.

Results from pairwise comparison of flash flood warning channels

From the pairwise comparison data, the preference scores for each respondent were calculated. The preference score for each flash flood warning channel is the number of times the respondent preferred that item over other items in the set. A higher preference score indicated a more preferred item (Table 23).

Table 23. Computation of preference scores

	Mobile	TV	Radio	Neighbor	Family	Two-way radio
Mobile		1	1	1	1	1
TV	0		1	1	1	1
Radio	0	0		1	0	0
Neighbor	0	0	0		0	1
Family	0	0	1	1		1
Two-way radio	0	0	1	0	0	
Preference Score	0	1	4	4	2	4

²⁵ A major factor that lowers the income levels of rubber tappers (latex harvesters) is the interference of rain on tapping. Rain hinders the tapping of rubber and harvesting of latex. If a wet rubber tree is tapped, it leads to panel diseases (Nugawela, 2008).

²⁶ The respondents with tertiary level of education constitute a small group (11 out of 332 respondents).

After the preference scores for all respondents were obtained, the coefficient of consistency, ϑ , for each respondent was computed. Figure 9 shows the distribution of coefficients of consistency, and Figure 10 shows the proportion of respondents at each value of coefficient of consistency.

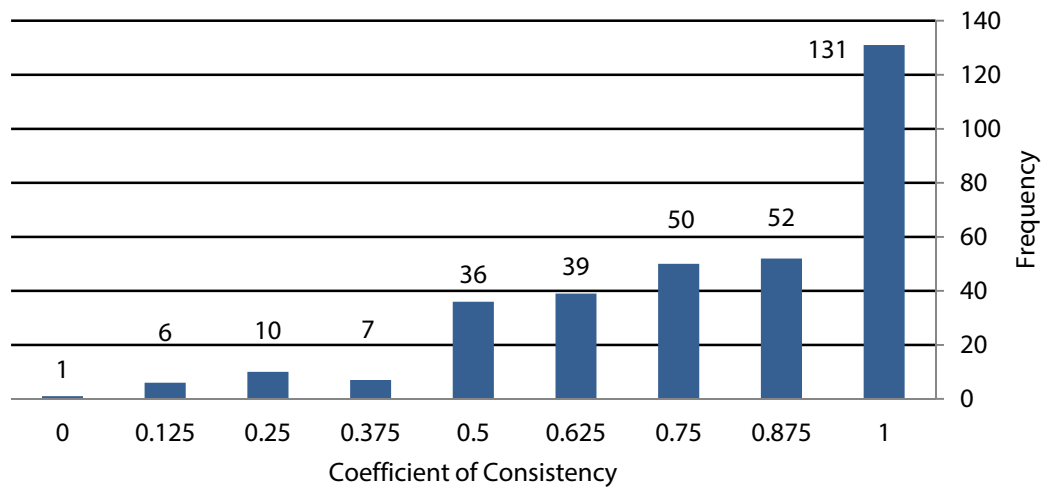


Figure 9. Coefficient of consistency distribution

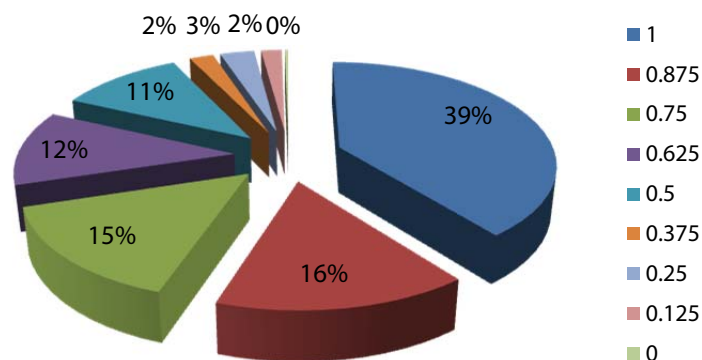


Figure 10. Proportion of respondents at each value of coefficient of consistency

Figures 9 and 10 confirm that $0 \leq \vartheta \leq 1$, where $\vartheta = 1$ indicates that there is no circular triad, and as ϑ decreases to 0, the inconsistency increases. Of the 332 respondents who were surveyed, 39 percent of them had consistency of preference, i.e., no circular triad. However, for the rest of the respondents, the degree of inconsistency in preference varied.

In Figure 10, as the coefficient of consistency decreased to 0 (i.e., more inconsistency in preference), the proportion of respondents associated with those values of coefficients declined. This suggests that only a few respondents in the sample had significant inconsistency in preference.

The next sub-section discusses the results from the pairwise comparisons that are parallel to the direct rankings. Table 24 shows the ranking of data obtained from pairwise comparisons of flash flood warning channels under full sample and in each of the three study sites.

Although the pairwise ranking results varied across the three study sites and in the full sample, there was a trend. Overall, the two-way radio was the most preferred flash flood warning channel (ranked 1st). However, in contrast to the results from the direct ranking, pairwise ranking showed that the family member was the second most preferred warning channel for a flash flood. This highlights the role played by

intermediate warning channel. Television ranked from 3rd and 4th. Mobile phone, which is a relatively low cost warning channel, appeared to be the least preferred in the full sample, in Sichol and in Nopbhitam. Part of the reason is the issue of authenticity of information and the inability to use the gadget immediately before or during disaster events.

Table 24. Pairwise ranking of flash flood warning channels

Channel	Full sample	Tha-Sala	Sichol	Nopbhitam
Mobile phone	6 th	4 th	6 th	6 th
Television	3 rd	3 rd	4 th	4 th
Radio	4 th	6 th	5 th	3 rd
Neighbor	5 th	5 th	3 rd	5 th
Family member	2 nd	2 nd	2 nd	2 nd
Two-way radio	1 st	1 st	1 st	1 st

Remark: Neighbor and family member are intermediate warning channels. The warning is delivered to recipients in person, contrasting to the other four warning channels.

The preferences of the respondents for flash flood warning channels (as reflected through the ranking results) were related to their demographic characteristics. The ranking data obtained from the pairwise comparisons were split according to some selected demographic characteristics, namely: gender and level of education. Table 25 shows the outcomes of ranking when the data was split by gender.

The preferences for flash flood warning channels were quite similar. For both male and female, the two-way radio was the most preferred channel, followed by the family member; the mobile phone was the least preferred. Both genders differed in their preferences for neighbor, television, and radio as warning channels (Table 25).

Table 25. Pairwise ranking of flash flood warning channels – by gender

Channel	Male	Female
Mobile phone	6 th	6 th
Television	5 th	3 rd
Radio	3 rd	4 th
Neighbor	4 th	5 th
Family member	2 nd	2 nd
Two-way radio	1 st	1 st

Table 26 shows the outcome of the ranking when the data was split by levels of education. The rankings seem to be inconsistent across respondents with different levels of education. First, the two-way radio was the most preferred warning channel for respondents with primary and secondary education, which constituted majority of the sample (312 out of 332 respondents or 94%).

Second, respondents who did not receive formal schooling preferred family member the most as a warning channel. This is a small group consisting of nine out of 332 respondents or 2.7 percent. This highlights the role played by the intermediate warning channel as the family member could convey the warning messages in more easily understandable forms. Respondents with tertiary education preferred family members and two-way radio most. But again, the higher educated group is quite small (11 out of 332 respondents or 3.3%).

Table 26. Pairwise ranking of flash flood warning channels – by level of education

Channel	No schooling	Primary education	Secondary education	Tertiary education
Mobile phone	3 rd	6 th	6 th	6 th
Television	6 th	3 rd	4 th	5 th
Radio	5 th	4 th	3 rd	3 rd
Neighbor	2 nd	5 th	5 th	4 th
Family member	1 st	2 nd	2 nd	1 st
Two-way radio	4 th	1 st	1 st	2 nd

To control for the order effects in the pairwise comparisons, five versions of the pairwise comparison section (which differed only in the sequence by which pairs of warning channels were presented) were used. The preferences of the respondents for flash flood warning channels (as reflected through the ranking results) were related with the order in which pairwise comparisons were presented to the respondents during the interview. Table 27 shows the ranking outcomes.

The ranking results showed relative consistency. The two-way radio was the most preferred warning channel (with exception to version 5). Again, the mobile phone was the least preferred warning channel across the five versions. However, the rankings for the other four warning channels varied across the five versions.

Table 27. Pairwise ranking of flash flood warning channels – by versions of questionnaire

Channel	Version 1	Version 2	Version 3	Version 4	Version 5
Mobile phone	6 th	6 th	6 th	6 th	6 th
Television	4 th	2 nd	4 th	3 rd	5 th
Radio	3 rd	4 th	5 th	4 th	3 rd
Neighbor	5 th	5 th	3 rd	5 th	4 th
Family member	2 nd	3 rd	2 nd	2 nd	1 st
Two-way radio	1 st	1 st	1 st	1 st	2 nd

There are two issues related to the flash flood warning that need to be addressed. First is the role of community flash flood wardens. These teams of local volunteers can assist the residents who cannot reach or access traditional warning channels, particularly elderly people, young children, and handicapped individuals, including those with limitations in hearing, sight, mobility or literacy. However, the volunteers should receive the necessary training to deal with the problem of authenticity in their information sharing. People in communities should also be made aware that these people are authorized personnel in warning about flash floods.

Second, instead of solely relying on the weather or meteorological forecasts from official sources, the government should train people in the communities at risk how to obtain forecast locally. For example, the community members can be taught how to check the amount of precipitation by reading the rain gauges provided by the Department of Mineral Resources. According to the people interviewed in the villages, rain gauges are available, but people have limited ability to obtain forecast locally using the rain gauge. With information on the amount of rainfall or precipitation, the local residents can better prepare themselves for the flash flood that could strike their communities.

8.0 POLICY IMPLICATIONS

The goal of a warning is to prevent hazards from becoming disasters, and the success of flash flood warnings should be measured by what actions people take. A warning should prompt people at risk to take immediate and appropriate actions to reduce casualties and losses. In this report, the determinants of both individuals' and households' evacuation choices before or during flash flooding were analyzed.

At the individual level, a flash flood warning was not the only factor that determined the individuals' evacuation choices. Other factors, particularly information about the existence of public shelter or evacuation assembly points, and socio-economic factors, especially gender and income, played a significant role in explaining evacuation decisions of individuals. At the household level, households with young children were more likely to evacuate before or during flash flooding.

The backdrop of these realities should guide policymakers in drafting policies. There are concrete steps that should be considered by the governments, both at national and local levels. The next sub-section discusses these recommendations.

People at risk of flash flood are concerned about their evacuation destination or lodging or the place where they will take refuge after they have left their own houses. Hence, it is important for the government to provide them information about the existence and location of the nearest emergency public shelters before, during, and after a flash flood. The shelters could be schools, temples, or community centers.

Women and families with children are more likely to evacuate. Hence, it is very important that the emergency shelters cater to their needs. These shelters may be inhabited for the entire duration of the post-flash flood reconstruction period; therefore, they need to be planned with respect to sanitation, livelihood, and security.

In addition to providing emergency shelter and informing the residents at risk about the existence of these shelters, responsible government agencies should provide guidance and advice to residents in preparing evacuation plans for their own communities. There should be an evacuation map, which provides the local residents information about different evacuation routes and the locations of emergency flash flood shelters.

High-income individuals were less likely to evacuate because of the possible burglary once they leave their houses. Based on their own or on others' unpleasant experiences, they knew that the dwellings of wealthy individuals became targets for looting and theft once these were deserted in the wake of a flash flood. Hence, wealthy individuals preferred to stay to protect their belongings and properties during and after the flash flood events. Concerned government agencies should show some degree of reassurance to the local residents about the security of their unoccupied dwellings from theft during evacuation.

Governments and other stakeholders should then consider these gaps to be filled with regard to flash flood warning:

First, the two-way radio was very well received by residents in the flash flood hazard areas in Nakhon Si Thammarat.²⁷ The key advantage of the two-way radio is its functionality, i.e., ability to deliver warning to people living in the remote rural areas and in case of power failure, which usually occurs immediately before or during flash flood.

Despite various benefits associated with the two-way radio, it seems to be a relatively costly warning channel. At present, very few people have access to this type of receiver. Of the 332 respondents, only 54 respondents (16%) reported owning a two-way radio. Battery-powered two-way radios are quite expensive, and many respondents said they could not afford the gadget. The government has an important role to play in terms of investments in these emergency communication devices or in providing subsidy to

²⁷ Based on the impressions from the field survey, the two-way radio was preferred not because the people believed that they would get this from the local government. Even if their family did not have a two-way radio, they would get the warning message as passed on by neighbors or someone else in the community who had a two-way radio.

buy these devices. Moreover, the two-way radio usually requires licensing. Further, to be part of the network, participation in the training is compulsory.

Mobile phones are relatively low-cost warning channels for flash flood, yet, the issues of authenticity and multiplicity of warning sources pose key challenges. The government must develop a unified public warning system and coordinate among responsible government agencies. This way people at risk can be confident in the authenticity and credibility of the warning, prompting them to take informed and immediate actions. According to the survey, the network providers should try to improve the reception of mobile phone, especially in the flash flood hazard areas.

Television and radio are two relatively inexpensive flash flood warning channels because they can disseminate warnings quickly to a broad population. However, these channels have limited use immediately before or during a flash flood. The public should be informed that they cannot solely rely on these channels for disaster warning. Instead, they should use these channels to obtain meteorological information, weather forecast, and warnings about disaster events days or weeks away, but not events seconds, minutes, or hours away.

This section also offers observations based on the field interviews and observations. Information on the length of stay of the residents showed that the communities affected by the flash flood were not new settlements. The people at risk have been living in the same place over a number of generations. Thus, one key issue of concern is the poor practice of settlement. Without stringent enforcement of the Forest Reserve Act and the National Park Act in the past, these early communities have encroached in the forest reserve and the national parks. In many cases, they have set up habitation or constructed their houses on the slopes of the hills, hence exposing their houses to the risk of slope failures, gully erosion, debris flows, and flash flood current. Looking into the future, these settlement practices need to be banned to reduce future losses of life and destruction of personal properties.

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Internet Resources

Federal Emergency Management Agency: www.ready.gov/floods

National Oceanic and Atmospheric Administration (NOAA):
www.nws.noaa.gov/om/brochures/flood/PDF/Flood_p3.pdf

United States Search and Rescue Task Force: <http://www.ussartf.org/flooding.htm>

Questionnaire ID _____ Interviewer _____
 Interview Date _____ Checked by _____

QUESTIONNAIRE

Determinants of Flash Flood Evacuation Choices
 and the Assessment of Preferences for Flash Flood Warning Channels:
 The Case Study of Thailand

Would you be willing to participate in this survey?

☐ Yes ☐ No

Respondent's Contact Details

First Name and Family Name _____
 House Number _____ Village _____ Village Code _____
 Sub-district _____ District _____
 Telephone Number: _____

Part 1. Flash Flooding Experience and Risk Perception**1.1 Flash flooding prior to March-April 2011**

1. In your opinion, do you think your house is located in the flash flood hazard area?
☐ (1) Yes ☐ (2) No
2. Prior to March-April 2011, did you experience flash flood?
☐ (1) Yes (Continue with Q3) ☐ (2) No (Proceed to Q13)
3. When did such flash flood event take place?
 Month.....Year.....
4. Were you affected by such a flash flood event?
☐ (1) Yes (Continue with Q5) ☐ (2) No (Proceed to Q7)
5. What were the sources of damages (hazard agents)?
☐ (1) Flash flood and landslide
☐ (2) Flash flood only
☐ (3) Landslide only
☐ (4) Slow-onset flood
6. What were the damages caused by flash flood?
☐ (1) Damages on personal properties, such as house, furniture, car, etc.
☐ (2) Damages on agricultural products or crops
☐ (3) Damages on public infrastructure such as road, bridge, etc.
☐ (4) Adverse impacts on health or death
☐ (5) Others (Please specify).....
7. Did you evacuate to a safe place?
☐ (1) Yes (Continue with Q8) ☐ (2) No. The reason is.....(Proceed to Q13)
8. What were the key factors behind your decision to evacuate?
☐ (1) Received flash flood warning (Continue with Q9)
☐ (2) Saw flash flood and mudslide approaching (Proceed to Q11)
☐ (3) Water penetrated into the house (Proceed to Q11)
☐ (4) Others (Please specify).....

9. Through which channels did you receive flash flood warning?
- ☐ (1.1) Radio ☐ (1.2) Television
- ☐ (1.3) Two-way radio ☐ (1.4) Friend/neighbor
- ☐ (1.5) Family member ☐ (1.6) Mobile phone
- ☐ (1.7) Others (Please specify)
10. Which flash flood warning channel had the most impact on your evacuation decision?.....
11. Do you feel that evacuating was the correct decision?
- ☐ (1) Yes (Proceed to Q13) ☐ (2) No (Continue with Q12)
12. Why do you think that evacuating was not the correct decision?
- ☐ (1) Flash flood did not actually occur (i.e., crying wolf problem)
- ☐ (2) Personal properties were looted during evacuation
- ☐ (3) Inconvenience incurred during evacuation
- ☐ (4) Discomfort and poor environment of public shelter
- ☐ (5) Others (Please specify).....

1.2 Flash flooding during March-April 2011

13. Did you get affected by the flash flood that took place in March-April 2011?
- ☐ (1) Yes (Continue with Q14) ☐ (2) No (Proceed to Q16)
14. What were the sources of damages (hazard agents)?
- ☐ (1) Flash flood and landslide
- ☐ (2) Flash flood only
- ☐ (3) Landslide only
- ☐ (4) Slow-onset flood
15. What were the damages caused by flash flood?
- ☐ (1) Damages on personal properties, such as house, furniture, car, etc
- ☐ (2) Damages on agricultural products/crops
- ☐ (3) Damages on public infrastructure, such as road, bridge, etc.
- ☐ (4) Adverse impact on health or death of family member
- ☐ (5) Others (Please specify).....
16. Did you receive any flash flood warning?
- ☐ (1) Yes (Continue with Q17) ☐ (2) No (Proceed to Q19)
17. Through which channel(s) did you receive flash flood warning?
- ☐ (1.1) Radio ☐ (1.2) Television
- ☐ (1.3) Two-way radio ☐ (1.4) Friend/neighbor
- ☐ (1.5) Family member ☐ (1.6) Mobile phone
- ☐ (1.7) Others (Please specify)
18. For each channel or each channel that you knew or remember, please tell us how you feel about whether you trust the source of flash flood warning.

Flash flood warning channels	Flash flood in March-April 2011			Future Flash Flood		
	Yes	No	Not applicable	Yes	No	Not applicable
Radio						
Television						
Two-way radio						
Friend/neighbor						
Family member						
Mobile phone						

19. Did you evacuate to safe place during flash flood in March-April 2011?
- ☐ (1) Yes (Proceed to Q21) ☐ (2) No (Continue with Q20)

20. What were the reasons behind your decision not to evacuate?
- ☐ (1) House was not damaged by flash flood
 - ☐ (2) Concerned about properties
 - ☐ (3) Believed that house was located in a safe area
 - ☐ (4) Roads were damaged by flash flood
 - ☐ (5) Had no vehicle to use for evacuation
 - ☐ (6) Had children, elderly or disabled family members to attend to
 - ☐ (7) Had pets to attend to
 - ☐ (8) Pressure from neighbors who did not evacuate
 - ☐ (9) Others (Please specify).....

Which factor had the highest impact on your decision not to evacuate?.....

21. Flood warning channels and flash flood evacuation decision

- 21.1 Does the warning received through the following flash flood warning channels have impact on evacuation decision?

	Flash flood in March-April 2011			Future Flash Flood		
	Yes	No	Not applicable	Yes	No	Not applicable
Radio						
Television						
Two-way radio						
Friend/neighbor						
Family member						
Mobile phone						

21.2 Which flash flood warning channel had the most impact on your evacuation decision in March-April 2011?

21.3 Which flash flood warning channel do you think will have the highest impact on your future evacuation decision?

22. Does your community have a safe assembly point designated for emergency evacuation during flash flood?

- ☐ (1) Yes. Assembly point is located at (Continue with Q23)
- ☐ (2) No (Proceed to Q25)
- ☐ (3) I don't know (Proceed to Q25)

23. Please give us information about the distance and travelling time from your house to the evacuation destination.

- 23.1 Distance.....meters.....kilometers ☐ I don't know
- 23.2 Travelling time.....hours.....minutes ☐ I don't know

24. How was the condition of the flood emergency assembly point/public shelter?

- ☐ (1) Too far
- ☐ (2) Need to live with strangers
- ☐ (3) Congested and caused discomfort
- ☐ (4) Insufficient facilities such as toilet, etc.
- ☐ (5) Others (Please specify).....

1.3 Prevention and Preparedness for Flash Flood

25. Did your household adopt any flood mitigation strategies?

- ☐ (1) Yes (Continue with Q26)
- ☐ (2) No (Proceed to Q28)

26. What were the flash flood mitigation strategies adopted by your household?

- ☐ (1) Purchased flood insurance
- ☐ (2) Constructed flood defense
- ☐ (3) Others (Please specify).....

27. How effective do you think are the flood mitigation strategies adopted by your household?
- ☐ (1) Very effective
☐ (2) Moderately effective
☐ (3) Not very effective
28. Which part of the day did the flash flood strike your community?
- ☐ (1) Daytime ☐ (2) Nighttime
29. Do young children, female members, elderly people or disabled people stay at home during the daytime?
- ☐ (1) Yes ☐ (2) No
30. Was the head of household the only person who could make evacuation decision?
- ☐ (1) Yes ☐ (2) No (please specify who made evacuation decision).....
31. Is there any disabled person in your household?
- ☐ (1) Yes (Continue with Q32) ☐ (2) No (Proceed to Q33)
32. Please describe the nature of disability

List of family member with disability	Nature of disability
1.	
2.	
3.	

33. Did your community have any emergency assistance plan for its members during the time of flash flood?
- ☐ (1) Yes (Continue with Q34)
☐ (2) No (Proceed to Q35)
34. What forms of assistance were provided?
- ☐ (1) Organized team of volunteers designated for rescuing people from their homes
☐ (2) Prepared rescue equipments such as rope, ladder, etc.
☐ (3) Others (Please specify).....
35. What type of assistance did your household provide to its members before the flash flood took place?
- ☐ (1) Notified relatives and neighbors that your family members need assistance during evacuation
☐ (2) Studied alternative evacuation routes
☐ (3) Prepared necessary equipments that are useful during the time of evacuation such as rope and ladder
☐ (4) Others (Please specify).....
36. Did your household prepare for emergency evacuation if your community is struck by flash flood?
- ☐ (1) Yes. How?
- ☐ (1.1) Survival kits ☐ (1.2) Jewelry and important documents
☐ (1.3) Cut off power supply ☐ (1.4) Others (Please specify).....
☐ (2) No

Part 2. Assessment of preference for flash flood warning channel

37. Ranking of flash flood warning channels according to preference
Instruction Please rank each of these flash flood warning channels by filling number 1-6 in the boxes provided (no ties are allowed), where

- 1** represents the most preferred warning channel
6 represents the least preferred warning channel

Remark: "Prefer" means the respondent feels that he/she would be more likely to respond to the warning message received.

Flash flood warning channels	Ranking
Mobile phone	
Television	
Radio	
Friend/neighbor	
Family member	
Two-way radio	

38. Pairwise comparison of flash flood warning channels

Warning Channel 1	Warning Channel 2	Preferred Channel
Family member	Two-way radio	
Friend/neighbor	Mobile phone	
Mobile phone	Television	
Family member	Radio	
Two-way radio	Mobile phone	
Friend/neighbor	Family member	
Television	Friend/neighbor	
Radio	Television	
Mobile phone	Family member	
Radio	Mobile phone	
Two-way radio	Television	
Friend/neighbor	Radio	
Two-way radio	Friend/neighbor	
Radio	Two-way radio	
Family member	Television	

39. In the future, which flood warning channel do you think is the most effective warning channel for your community?.....

Part 3. Personal Information

40. Gender ☐ (1) Male ☐ (2) Female

41. Age

42. Marital status ☐ (1) single ☐ (2) married ☐ (3) widow/divorce/separated

43. Years of education

44. Highest level of educational attainment

- ☐ (1) No formal schooling ☐ (2) Primary education
☐ (3) Lower secondary education ☐ (4) Upper secondary education
☐ (5) Vocational schooling ☐ (6) Undergraduate
☐ (7) Postgraduate ☐ (8) Others (Please specify).....

45. Occupation

- ☐ (1) Self-employed ☐ (2) Farmer
☐ (3) Unskilled labor ☐ (4) Civil servant
☐ (5) Business owner ☐ (6) Skilled labor
☐ (7) Private employee ☐ (8) Unemployed
☐ (9) Maid ☐ (10) Others (Please specify).....

46. Total number of household member.....

Number of working member.....

Number of young member (below 15 years).....

Number of elderly member (above 60 years).....

47. Are you the head of household?

- ☐ (1) Yes (Proceed to Q48) ☐ (2) No (Continue with Q47)

48. Your relationship with the head of household:

- | | |
|---|--|
| ☐ (1) Partner | ☐ (2) Father/mother/father-in-law/mother-in-law |
| ☐ (3) Single son/daughter | ☐ (4) Married son/daughter |
| ☐ (5) Son-in-law/daughter-in-law | ☐ (6) Grandchild |
| ☐ (7) Grandparent | ☐ (8) Others (Please specify)..... |

49. Income

(48.1) Your personal income.....Thai Baht/month

(48.2) Your household's income.....Thai Baht/month

50. Please give us information about your wealth possession

- | | | |
|--------------------------------------|----------------------------------|---------------------------------|
| (49.1) House | ☐ (1) Yes | ☐ (2) No |
| (49.2) Automobile | ☐ (1) Yes | ☐ (2) No |
| (49.3) Motorcycle | ☐ (1) Yes | ☐ (2) No |
| (49.4) Television | ☐ (1) Yes | ☐ (2) No |
| (49.5) Radio | ☐ (1) Yes | ☐ (2) No |
| (49.6) Mobile phone | ☐ (1) Yes | ☐ (2) No |
| (49.7) Two-way radio | ☐ (1) Yes | ☐ (2) No |
| (49.8) Others (Please specify) | | |

51. Type of your house ☐ (1) One-story house ☐ (2) Two-story house

52. Household expenditure

(51.1) Total monthly expenditure.....Thai Baht

(51.2) Rent/mortgage payment..... Thai Baht

(51.3) Electricity bill.....Thai Baht/month

(51.4) Water bill..... Thai Baht/month

(51.5) Mobile phone bill.....Thai Baht/month

53. Your length of residence in the community.....

54. Do you own pets? ☐ (1) Yes ☐ (2) No

55. What type of pets do you own? (Please specify)

56. Did you know whether your neighbors evacuate before or during the flash flood which occurred in March-April 2011?

- ☐ (1) Evacuated ☐ (2) Not Evacuate

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