Factors Affecting on "Where do They Go after Flooding Disaster": a Case Study of Thailand Flooding 2011

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Abstract: This paper aims to investigate the evacuee behaviors affecting the shelter choices after flooding disaster. The existing preparation plan is not suitable, thus, there is unable to solve unexpected problems. In order to prepare for handling the next disaster, the socioeconomic factors analysis is needed. Binary Logistic Regression is used for observation of socioeconomic factors and prediction of the probability of public shelter selection. For public shelter selection, there are six factors, which are occupation, family type, children in household, house ownership, flood knowledge, and experience. Whereas, there are four factors affecting on the decision of victim who decide to remain their house, which comprise of gender, occupation, children in household, and house ownership. Also, the models can be used for shelter demand estimation and logistics support plan for emergency materials needed.

Keywords: Natural Disaster, Flooding, Evacuation, Logistics, Shelter, Binary Logistic Regression

1. INTRODUCTION

Natural disasters can have destructive impacts in terms of loss of life, human injury and property damage (Pal et al., 2003). The most common natural disasters are recurrent rather than single events and they strike the same nations repeatedly (Levinson and Granot 2002).

However, experience has shown that failing to draw on lessons learned from previous crises and to adapt to the contexts and circumstances of the local situation (Houghton, 2005). In order to overcome this shortcoming, both typical recurrent nature of disaster and the availability of technological, social, and organizational remedies must be an integral part of a recuperation and pre-disaster planning.

Emergency logistics planning is one of the recuperation planning to support emergency needs i.e. medical needs, shelter, food, cloth and transport in a safe and efficient manner. Logistics planning in emergency situation involves the transport of emergency commodities to distribution centers in the affected areas as soon as possible so that relief operations can be accelerated. Also, the relief demand forecasting is a crucial estimation process before emergency resources can be sent to the affected areas. Subsequently, the evacuee demands in public shelter are reflected the dispatching commodities needs in any emergency situation.

Moreover, the shelter demand estimation does not provide only information for shelter requirement and shelter space, but it can also be used to plan for emergency materials needs. The shelter requirements are a planning goal for evacuation shelter emergency capacity. However, when making the evacuation decision, evacuees are more likely to go someplace safer when given evacuation orders. Objective and subjective risk factors also play an important role when making evacuation decisions. Social and economic factors are the

primary determinants of the destination decision (Whitehead et al., 2000). Severe flooding occurred during the 2011 in Thailand as shown in Figure 1. Beginning at the end of July triggered by the landfall of Tropical Storm Nock-ten, flooding soon spread through the provinces of Northern, Northeastern and Central Thailand along the Mekong and Chao Phraya river basins. In October floodwaters reached the mouth of the Chao Phraya and inundated parts of the capital city of Bangkok. Flooding persisted in some areas until mid-January 2012, and resulted in a total of 815 deaths (with 3 missing) and 13.6 million people affected. Sixty-five of Thailand's 77 provinces were declared flood disaster zones, and over 20,000 square kilometres (7,700 sq mi) of farmland was damaged **(**Flood, Storm and Landslide Situation Report**,** 2012**).** The disaster has been described as "the worst flooding yet in terms of the amount of water and people affected.

This paper intends to investigate the evacuee backgrounds based on different destination choices. Thus the model can be further applied to estimate shelter demand when emergency situation occurs. It employed the binary logistic regression model in estimating the probability of individual choice in selecting evacuation destinations (both public and private shelters). Moreover, the socio-economic factors affecting shelter allocation are also investigated. This paper, consequently, can improve the efficiency and effectiveness of emergency planning and management in the future.

Figure 1. Thailand Flooding 2011

2. DATA COLLECTION

The models are estimated and tested on data collected in one of the most recent flooding experienced areas, Bangkok and suburb areas, Thailand. Respondents are those who are still living in the affected areas during flooding disaster (Laksi district, Bangkok) and also those who are staying in Army Public Shelter, Chulachomklao Royal Military Academy (CRMA). With respect to the survey questionnaires, actual behavior can be investigated and compared to estimate behavioral characteristics for flooding event. Respondents were asked a series of detailed questions about their backgrounds, experiences and opinions.

Questionnaire surveys are conducted during November and December 2011 to obtain the behavioral information of evacuees. For Army Public Shelter, 300 questionnaire forms are distributed, only 122 questionnaires which contain completed information can be used for analysis as shown in Table 1. The return ration is 0.41 for Army Public shelter at CRMA. For private shelter, only 83 questionnaires which contain completed information can be used for analysis since all the questions have been asked one by one during the data collection process. This is the fact that the data collection process during flooding situation was hardly accomplished specially the respondents who living in their houses. The private shelter data

can be divided into two different destinations as living with relatives (49 respondents) and still living in their own houses (34 respondents). The details can be shown in Table 2, and Table 3.

Table 1. Army Public Shelter Information (CRMA)

Item	Factors	Classification	Percent
1	Gender	male	40.2
		female	59.8
2	age	younger than 20 yrs	19.7
		20-29 yrs	22.1
		30-39 yrs	20.5
		40-49 yrs	13.9
		50-59 yrs	12.3
		60 yrs or more	11.5
3	education	Lower than Bachelor	80.3
		Bachelor degree	17.2
		Higher than Bachelor	2.5
4	occupation	No job	21.3
		Business owner and private section	76.2
		Government	2.5

Table 2. Information of respondents who are living with relatives

Item	Factors	Classification	Percent
1	Gender	male	36.7
		female	63.3
2	age	younger than 20 yrs	16.3
		20-29 yrs	28.6
		30-39 yrs	32.7
		40-49 yrs	12.2
		50-59 yrs	6.1
		60 yrs or more	4.1
3	education	Lower than Bachelor	51
		Bachelor degree	38.8
		Higher than Bachelor	10.7
4	occupation	No job	18.4
		Business owner and private section	44.9
		Government	36.7

Table 3. Information of respondents who are living in their own house during flooding

Item	Factors	Classification	Percent
1	Gender	male	73.5
		female	26.5
2	age	younger than 20 yrs	11.8
		20-29 yrs	14.7
		30-39 yrs	20.6
		40-49 yrs	26.5
		50-59 yrs	23.5
		60 yrs or more	2.9
3	education	Lower than Bachelor	82.4
		Bachelor degree	17.6
		Higher than Bachelor	-
4	occupation	No job	58.8
		Business owner and private section	32.2
		Government	8.8

Table 1 shows the respondents staying in Army Shelter (CRMA). The percentage of female (59.8%) is greater than the percentage of male (40.2%), while the majority of evacuees is the evacuees who are less than 30 years old (41.8%). According to education factor, about 80% of respondents are under bachelor degree. The details of respondents living with their relatives can be shown in Table 2. The percentage of female (63.3%) is greater than the percentage of male (36.7%), while the majority of evacuees are the evacuees who are age between 30 and 39 years old (32.7%). Whereas, the respondents graduated bachelor degree and lower are approximately 89.8%. Most of them are business owner or working for private sector. Table 2 demonstrates the basic information of respondents living at their own houses Contradictory to the table 1 and 2, the percentage of male (73.5%) is greater than the percentage of female (26.5%), while the majority of evacuees are the evacuees who are age over 40 years old (52.9%). This may be fact that the male respondents may not afraid of the disaster situation and need to prevent their own properties instead of leaving. According to education factor, about 80% of respondents are under bachelor degree.

3. METHODOLOGY

3.1 Research Model

Logistic regression is a statistical technique that has been developed specifically for analyzing relationships between dichotomous dependent variables (event happened or not) and categorical, interval, or continuous level independent variables (Hosmer and Lemeshow, 2000; Johnson and Bhattacharyya, 2001). The different independent variables are analyzed in associate with the statistical and the goodness-of-fit tests to achieve the most suitable utility function (Ben-Akiva and Lerman, 1985; Horowitz et al., 2000, Malchow and Kanafani, 2004).

The binary logistic regression model for shelter allocation estimates the probability of a respondent selecting any shelter type as a function of a certain set of predictor variables, including the socioeconomic characteristics of the respondents. Each shelter attribute is expected to influence people's perceptions among the two provided shelter types. It is used in this research since the dependent variable Y (shelter type) can only take on two values as public shelter, and private shelter. The probability that a respondent will select the public shelter is determined by Equation (1).

$$\pi_i = \frac{e^{Z_i}}{1+e^{Z_i}} \tag{1}$$

The logit of the logistic regression model (Z_i) is given by Equation (2)

$$Z_i = \ln\left(\frac{\pi_i}{1-\pi_i}\right) = B_0 + B_1 X_1 + B_2 X_2 \ldots + B_N X_N \tag{2}$$

Where; π_i is the likelihood that a respondent who being involved in public shelter. X's are independent predictor variables, which indicate respondent backgrounds. Both main effects and interactions can generally be accommodated. B's are model coefficients which are estimated by using the maximum likelihood method. The advantage of models derived by binary logistic regression, besides the ability to predict the probabilities of respondents being

involved in each shelter for tsunami evacuation, is that the probability of being involved in public shelter increases/decreases for every one unit increment in each predictor variable can be estimated. This increment/reduction is equal to B_i model coefficients and is recognized as log odds. However, the odds of events or odds ratios are more useful to interpret the models rather than the log odds. The odds ratios can be estimated using Equation (3).

$$\text{The odds ratios (O.R.)} = \text{Exp}(B_i) = e^{B_i} \quad ; i = 1, 2, \ldots, N \tag{3}$$

The odds ratios are defined as the probability of the outcome event occurring divided by the probability of the event not occurring. It is the exponential term raised to the power of the coefficients of the predictor variables.

The null hypothesis is that all coefficients in the equation take the value zero. The null hypothesis will be rejected if the relevant predictor variable(s) are statistically different from zero at a level of significance of 0.05. Individual predictor variable is assessed for inclusion using Wald statistic test and test of change in -2-log-likelihood (-2-LL). The Wald statistic is a test for significant of B_i and has a large sample Chi-square distribution. It is obtained by dividing the coefficient by its standard error and squaring the result as show in Equation (4).

$$\text{Wald statistic} = \frac{B^2}{SE_B^2} \tag{4}$$

In logistic regression, there is no true R^2 value as there is in OLS regression. However, because deviance is analogous to MS_{res} (or MSE) in regression analysis, Pseudo R square can approximate an R-squared based on lack of fit indicated by the deviance (-2LL) as shown in Equations (5), and (6). In this study, there are two versions of Pseudo-R^2, one is Cox & Snell Pseudo-$R^2$and the other is Nagelkerke Pseudo-R^2.

$$\text{Cox \& Snell Pseudo-R}^2 = R^2 = 1 - \left[\frac{-2LL_{null}}{-2LL_k} \right]^{2/n} \tag{5}$$

Where the null model is the logistic model with just the constant and the *k* model contains all the predictors in the model. According to Cox & Snell R^2 value cannot reach 1.0, Nagelkerke can be used to modify it.

$$\text{Nagelkerke Pseudo-R}^2 = R^2 = \frac{1 - \left[\frac{-2LL_{null}}{-2LL_k} \right]^{2/n}}{1 - \left(-2LL_{null}\right)^{2/n}} \tag{6}$$

3.2 Socio-economic Factors

All data descriptions and definition of variables used in this study are presented as shown in Table 4. These variables are expected to have significance on the destination selection.

Table 4. demonstrates the definition of independent variables use for model calibration.

Item	Factors	Classification
1	GENDER	GENDER (0,1)
2	AGE	AGE (0,1,2,3,4,5)
3	EDUCATION	EDUCATION (0,1,2)
4	OCCUPATION	OCCUPATION (0,1,2)
5	MARITAL STATUS	MARITAL (0,1,2)
6	FAMILY TYPE	F_TYPE (0,1)
7	NO. OF CHILDREN IN HOUSEHOLD	CHILD (CONTINUOUS VAR)
8	RESIDENT OWNERSHIP	OWNERSHIP (0,1)
9	HOUSEHOLD INCOME	INCOME (0,1,2,3)
10	FLOODING KNOWLEDGE	KNOWLEDGE (0,1)
11	FLOODING EXOERIENCED	EXPERIENCE (0,1)
12	NO. OF PETS	PET (CONTINUOUS VAR)
13	NO. OF VEHICLES	MOTOR (CONTINUOUS VAR)

For Dichotomous Variable (0,1), the model can be divided into two cases as follows;

1) Private shelter (0) and Public Shelter (1);
2) Living with relatives (0) and living in their own house (1)

These two cases are separated since the researcher want to investigate evacuee's backgrounds with different choice destinations. SPSS statistical software is used in this study. A forward stepwise method is used for selection of the best predictor variable(s) to be included in the model.

4. RESULTS AND ANALYSIS

The dependent variable is coded as 1 if respondent selected the public shelter and 0 if respondent selected the private shelter (case 1) and is coded as 1 if respondent living with relatives and 0 if respondent living in their own houses (case 2). Individual predictor variable is assessed for inclusion using stepwise selection method as mentioned earlier. However, even in case of variable is not significant at 0.05 level, it is still selected and included in the model as long as it has a significant change in -2-LL at 0.05 level. Furthermore, the different classification schemes for category variables with more than two categories are tested to find the scheme that produces the best fit of the model.

Limited and comprehensive model inputs are also tested with the purpose of improving the performance of the models. Besides, the test of interaction for logistic analysis is applied and exploring significant interaction among the predictor variables. The advantage of logistic regression is the ability to determine the effect of each predictor variable on the evacuees' chance of being involved in evacuation response patterns by using log odds (sign, magnitude), and odds ratios.

4.1 Case I: Private shelter and Public Shelter

The summary of the case I model is illustrated in Table 5. For those predictor variables which are chosen by forward stepwise method, all coefficients are tested based on the Wald statistic and the change in -2-LL.

It is observed that six predictor variables - OCCUPATION, F_TYPE, CHILD, OWNERSHIP, KNOWLEDGE, and EXPERIENCE - are significant. In the case of the

variables - OCCUPATION(*sig.*=<0.005), F_TYPE (*sig*=0.003), CHILD(*sig.*=0.051), OWNERSHIP(*sig.*=0.003), KNOWLEDGE(*sig.*=0.022), and EXPERIENCE(*sig.*=0.039).
In order to check the linearity of variable- MEMBER, Box-Tidwell transformation term, CHILD *ln(CHILD) is added into the model and tested the fitting again. The coefficient of variable is found to be insignificant at 0.05 level, then the assumption of linearity of the independent variable is justified. It is also found that there is no interaction variable associated with the model. The likelihood ratio index - ρ^2- is used as a goodness of fit in the maximum likelihood estimation. It is found that the model fit the data well since its value is greater than 0.3. The value of the Hosmer and Lemeshow goodness of fit is also tested with the significance level computed from chi-square distribution. The test also indicates that the models fit the data well since the significance value is greater than 0.05 level.

Table 5. Case I: model estimation result

Variables(*X*)	*Bi*	S.E.	Sig.	Exp(*Bi*)
OCCUPATION(1)	-2.835	0.795	<0.005	0.059
OCCUPATION(2)	-3.868	0.757	<0.005	0.021
F_TYPE(1)	1.280	0.434	0.003	3.598
CHILD(1)	0.702	0.361	0.051	2.018
OWNERSHP(1)	-1.038	0.352	0.003	0.354
KNOWLEDGE(1)	0.924	0.404	0.022	2.520
EXPERIENCE(1)	1.055	0.511	0.039	2.873
CONSTANT	0.457	0.821	0.578	1.579

With respect to respondent's background, positive sign of coefficient for the KNOWLEDGE variable of the model indicates that respondents who have disaster knowledge, has an increased chance of being involved in public shelter. Those respondents with disaster knowledge at 0.022 significance level are approximately 2.52 times more likely to being involved in public shelter. Not only disaster knowledge they have but also the shelter information are also included in this variable. This may due to the fact that in the public shelter, there are normally medical service teams providing free medical supports to all needed victims which is more difficult to find such medical service in the flooding area. Also, food and beverage being provided in the public shelter would be enough for temporal living.

The positive sign of an EXPERIENCE's coefficient indicates that the respondents who had experienced the flooding disaster, are more likely to choose public shelter than those who have yet to encounter flooding disaster event. Those with experienced at 0.039 significance level are approximately 2.873 times more likely to being involved in public shelter.

More surprisingly, the sign of coefficient for the OWNERSHIP is negative, this indicates that respondents who have their own houses, are more likely to be involved in private shelter than those who do not have their own place i.e. rental. Comparison between those who have their own house and those who do not have, those who have their own place are, 2.825 times **(**1/0.354), more likely to choose private shelter, at 0.003 level. A positive sign of CHILD's coefficient indicates that having children in their household will increase the probability of living in public shelter by 2 times as they are worry about their children. It is too dangerous to still remain living in flooding areas, even the children are living with their parents.

With respect to respondent's background, positive sign of coefficient for the FAMILY TYPE variable of the model indicates that respondents who living in extended family, has an increased chance of being involved in public shelter. Those respondents with disaster

knowledge at 0.003 significance level are approximately 3.598 times more likely to being involved in public shelter. The negative sign of coefficient for the OCCUPATION reveals that respondents who have their jobs are less likely to be involved in public shelter than those who do not have. At <0.005 level, those who have worked for government are, 0.021 times, less likely to being involved in public shelter as compared with those who don't have. While, those who have worked for private sector or business owner are, 0.059 times, less likely to being involved in public shelter as compared with those who don't have. This may due to the fact that respondents, who do not have job, will possibly perceive that they are safer. Moreover food and beverage are provided in the public shelter with no charge.

4.2 Case II: Living in their own houses during flooding and Living with their relatives

The dependent variable is coded as living in their own houses and living with their relatives. The relatives are defined as cousins, and friends. The summary of the model is illustrated in Table 6 For those predictor variables which are chosen by forward stepwise method, all coefficients are tested based on the Wald statistic and the change in -2-LL.

It is observed that four predictor variables – GENDER, OCCUPATION, CHILD, and OWNERSHIP, - are significant. In the case of the variables – GENDER(*sig.*=<0.005), OCCUPATION(*sig.*=<0.005), CHILD(*sig.*=0.011), OWNERSHIP(*sig.*= <0.005) In order to check the linearity of variable- MEMBER, Box-Tidwell transformation term, CHID *ln(CHILD) is added into the model and tested the fitting again. The coefficient of variable is found to be insignificant at 0.05 level, then the assumption of linearity of the independent variable is justified. It is also found that there is no interaction variable associated with the model. The likelihood ratio index - ρ^2- is used as a goodness of fit in the maximum likelihood estimation. It is found that the model fit the data well since its value is greater than 0.3. The value of the Hosmer and Lemeshow goodness of fit is also tested with the significance level computed from chi-square distribution. The test also indicates that the models fit the data well since the significance value is greater than 0.05 level.

Table 6. Permanent resident model estimation result

Variables	B	S.E.	Sig.	Exp(B)
GENDER(1)	-1.417	0.496	<0.005	0.242
OCCUPATION(1)	-2.103	0.525	<0.005	0.122
OCCUPATION(2)	-1.999	0.790	0.011	0.136
CHILD(1)	-1.318	0.520	0.011	0.268
OWNERSHP(1)	2.431	0.562	<0.005	11.366
CONSTANT	-0.788	0.519	0.129	0.455

For variables - OWNERSHIP, CHILD, OCCUPATION and GENDER, the effect of each predictor variable on the evacuees' chance of being involved in public shelter by using log odds and odds ratios are explained as follows.

More surprisingly, the sign of coefficient for the OWNERSHIP is positive, this indicates that respondents who have their own houses in affected area, are more likely to be living in their own house during flood situation than those who do not have their own place i.e. rental. Comparison between those who have their own house and those who do not have, those who have their own place are, 11.366 times, more likely to stay at their house even though they must being in trouble and inconvenience situation, at <0.005 level. This may be the fact the respondents who have their own house, are worry about their properties.

A negative sign of CHILD's coefficient indicates that having children in their household will decrease the probability of being in a public shelter by 26.8%. Any household

with no children is more likely to be in public shelter as they do not need to worry about their children. The negative sign of coefficient for the OCCUPATION exposes that respondents who have their jobs are less likely to be involved in their house than those who do not have. At <0.005 level, those who have worked for government are, 0.136 times, less likely to being stay at home as compared with those who don't have. While, those who have worked for private sector or business owner are, 0.122 times, less likely to staying at their house. This may due to the fact that respondents, who do not have job, will probably recognize that they need more supports for living during flood situation.

Furthermore, the male respondents are more likely to be living in their own house during flood situation than those who are female by approximately 4 times (1/0.242).

5. CONCLUSION

The behavioral analysis is carried out to provide information on human response to future disaster preparedness. The analysis provides information on hypothetical response to destination choices using binary logistic regression technique. Limited and comprehensive model inputs are tested to improve the performance of the developed models.

It is observed that six predictor variables - occupation, Family type, child in household, ownership of house, disaster knowledge, and experience are significant in selecting public shelter. Whereas, It is observed that four predictor variables – gender, occupation, child in household, and ownership, are significant in selecting to live in their own house.

In summary, this research can be applied to estimate shelter demand when emergency situation occurs but it is needed to be gathering more details on evacuees' backgrounds. In supporting of not only a shelter planning effort i.e. shelter requirement and shelter space, but emergency resource allocation management can be developed as well. However, additional work may be needed to further enhance the ability to examine human behavior and to determine more accurately the most appropriate predictors affecting shelter allocation.

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