Determinants of evacuation decision of households at Maypangdan, Borongan City, Eastern Samar, Philippines: A case of Typhoon Hagupit

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ABSTRACT

The Philippines is frequently visited by strong and destructive typhoons, claiming hundreds of lives and extensive damage to the environment, and properties. To minimize negative impacts, understanding evacuee behavior for evacuation planning is essential. Determinants of household evacuation decision were investigated in this study using 164 valid observations obtained through face-to-face interviews with household heads in the affected area of Typhoon Hagupit in Barangay Maypangdan, Borongan City, Eastern Samar, Philippines. Correlation analysis and logistic regression were used to identify significant factors that affect household evacuation decisions. Results showed that the presence of children less than 10 years of age and elderly, house material, and house floor level affect the household evacuation decision. The insights from the results of this study are useful for policymakers and planners in preparing contingency plans for typhoon events at the barangay level. This may include ensuring the welfare of the vulnerable age groups, and strict implementation of building code for structural design and constructions.

Keywords: evacuation behavior, internal validation, LR-based test logistic regression, parameter estimation

INTRODUCTION

The Philippines is located on the western part of the Pacific Ring of Fire where hydro-meteorological hazards such as typhoons, floods, storm surges are prevalent. Over the years, typhoons are becoming more frequent and severe. The tracks and time of occurrences of typhoons are also changing. The impacts of typhoons are becoming more catastrophic posing threats to the physical, physiological, and psychological aspects of human beings, and causing environmental degradation. There are eight to nine typhoons and another ten entering the Philippine area of responsibility (PAR) every year (Brown 2013). Two strong and destructive typhoons hit the Philippines from 2013 to 2014 which were called Haiyan and Hagupit, respectively. In 2013, Typhoon Haiyan with local name "Yolanda", a Category 5 storm, made landfall in the Eastern Visayas region, with a wind speed of more than 241 kph, affecting more than 14 million people in 44 provinces It displaced 4.1 million people, claimed the lives of more than 6,000 people, left 1,800 missing, and caused damage over USD 5.8 billion (Reid 2018).

Typhoon Hagupit succeeded Typhoon Haiyan in 2014. It reached a maximum sustained wind speed of 215 kph near the center, and gustiness of 250 kph, the strongest typhoon recorded that year (APAD 2015). The central and northern parts of the province were heavily affected leaving 2.9 million people (694,300 families) homeless (UNOCHA 2014). According to UNOCHA (2014), there were around 8,700 damaged houses, 39,100 partially damaged houses and 19 reported deaths. Around 3,003 evacuation centers were prepared before the disaster and accommodated 788,500 during the event.

The Philippines adopted and implemented the Sendai Framework for Disaster Risk Reduction in 2015. The main goal of the Sendai Framework is for nations to prevent and reduce disaster risks. This is by integrated and inclusive measures in all dimensions of society that prevent and reduce exposure to hazards and vulnerability and increase preparedness that will eventually strengthen resilience. Evacuation is one of the components that ensure effective preparedness to reduce disaster risks (Lim et al. 2016). It is a process that includes hazard detection and assessment, warning, moving people to identified shelters, and return entry (Lim et al. 2013). Evacuation planning is important for the implementation of the evacuation process (Lumbroso et al. 2011). Assumptions are used to define threats and measures within the evacuation operation (Kolen and Helsloot 2014). However, one needs to understand the behavioral determinants of household or individual evacuation decision whether to evacuate or not. Analyzing and identifying these determinants is crucial in planning and implementation of evacuation, especially in the compliance and allocation of resources (Lim et al. 2016).

Studies in understanding the determinants of evacuation decisions have been done in engineering and social research areas. These determinants are categorized as socio-demographic, economic, environmental, and hazard-specific factors, among others. Specific factors include gender, income, presence of elderly people, vehicle ownership, use of the internet and social media, availability of mobile applications related to evacuation management, presence of younger adult or children, previous trauma associated with evacuation experience, and frequency of receiving warning orders (Lim et al. 2016; Goodie et al. 2019; Ahmed et al. 2020; Buylova et al. 2020; Wang et al. 2021). Household size is also a factor like in the case of wildfire evacuation decisions (Lee et al. 2018; Toledo et al. 2018).

Hazard-related factors such as perceived risk, and initial locations of household members significantly affect decisions (Lim et al. 2016; Meyer et al. 2018; Chen et al. 2021). Experience and knowledge on the strength and wind speed of typhoon in the past is associated to a lower likelihood of evacuation from the area at risk of hazard (Buylova et al. 2020; Meyer et al. 2018). Moreover, recent studies in emergencies indicated that people are more likely to work with others instead of behaving individually (Cuesta et al. 2021; Wang et al. 2021). Housing and employment type, and proximity to high-risk areas where people do not feel safe staying at home more likely contribute to evacuation compliance (Pan 2020).

It was observed in earlier studies that most of these were data-driven, and findings vary across different hazards and intensities. Factors affecting people's decisions are based on their priorities and specific disasters. Despite several studies in the past, investigation of evacuation travel behavior in the onset of typhoons is still inadequate. Thus, this study was conducted to identify and analyze the determinants of the evacuation decision of households affected by Typhoon Hagupit in Borongan City, Eastern Samar.

METHODS

Study Area

On 06 December 2014, Typhoon Hagupit ravaged Northern, Eastern Samar, and Samar provinces in the Eastern Visayas Region among other areas in the Philippines (UNOCHA 2014). Typhoon Hagupit left the Eastern Visayas region with 15 casualties, and 855 people injured (NDRRMC 2014). Among the areas that experience the onslaught of Hagupit in Eastern Samar is Borongan City.

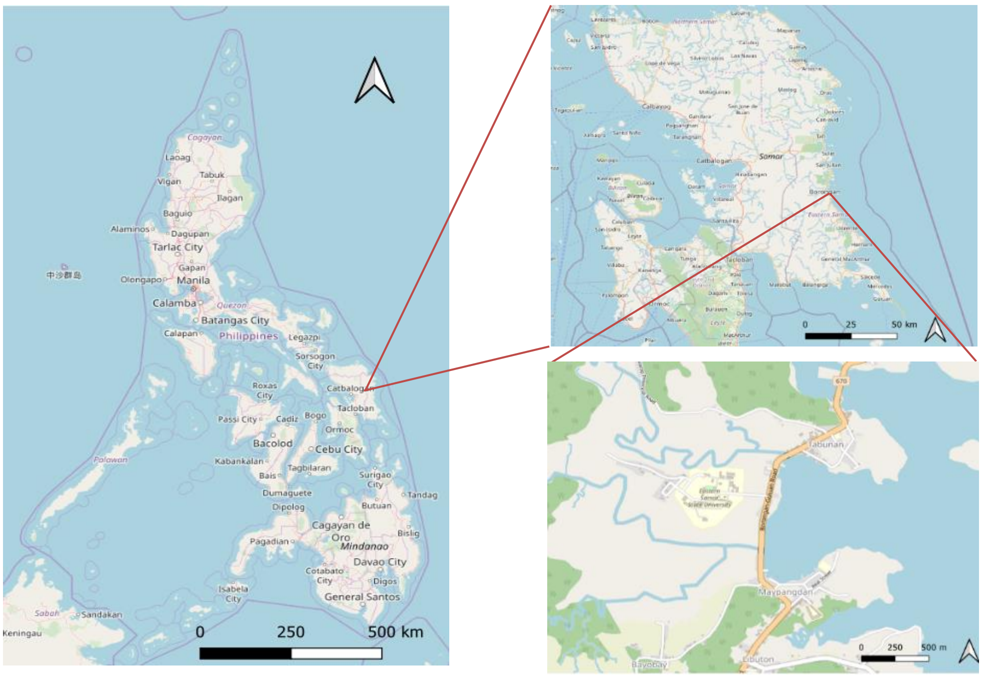

Figure 1. Location map of Maypangdan, Borongan City, Eastern Samar.

Borongan City is the provincial capital of Eastern Samar, Philippines (Figure 1). The center of the city is situated along the northern banks of the Lo-om River, and near the shoreline of Borongan Bay. Borongan City is located along the middle coastal area of Eastern Samar. It faces the Pacific Ocean on the east, the municipality of San Julian on the north, and the municipality of Maydolong on the South. On the west are the municipalities of Hinabangan, Calbiga, Pinabacdao, and Basey. The city of Borongan experiences various natural disasters such as typhoons, earthquakes, flash floods, flooding, landslide, tsunami, and storm surge (Gaillard et al. 2009).

Maypangdan is a barangay in the city of Borongan, Eastern Samar with a population of 2,798 (4.04% of the total population of Borongan) based on the 2015 Census (PhilAtlas 2020). There are about 547 households recorded in Maypangdan (NSO 2012). Considering the most affected area in Borongan City during the onslaught of Typhoon Hagupit, Barangay Maypangdan was specifically selected because it is considered the most vulnerable barangay in the city both geographically and demographically. Maypangdan is where the Eastern Samar State University-Main Campus is located. In the area, there are many transient residential areas and student boarding houses ranging from small temporary cottages to permanent and concrete structures.

Data Collection

For analyzing evacuation decision, data used in this study were collected through face-to-face interviews with household heads in the Barangay Maypangdan. Since there were less than 600 households recorded in Maypangdan, less than half of this was targeted as respondents. The households that were interviewed were selected using purposive sampling technique. The selection of household heads was done by talking to those who were in the areas near the coasts when the survey team went there. Two hundred ten (210) households were approached but only 200 agreed to be fully interviewed. The respondents were first requested to provide their consent for interview after introducing the intention and details of the questionnaire. The survey instrument elicited socio-demographic and capacity-related information. The former included the profile of the head of the household such as age (AGE), gender (GEN), work (WORK), education (EDUC), income (INCOM), marital status (MAR), the presence of children utmost 10 years of age (ACHILD), the number of household members (MEM), and the presence of elderly at least 60 years old (SEN). The capacity-related information elicited includes the house ownership (HOWN), house materials (HMAT), and the number of house floors (FLOOR). The respondents were also asked whether households evacuated or not (EDEC), and evacuated before or during the onslaught of Typhoon Hagupit.

After collection of information from households, the raw data were encoded and cleaned. Then, data were presented, classified based on categories, and summarized data were validated. The observations with invalid and missing data were removed. This resulted to 164 valid observations that were used for analysis. This number of samples covers less than 30% of the sample population considering an analysis at a 95% confidence level.

Parameter Estimation

Before employing logistic regression, the intercorrelation of the variables were analyzed to better understand if there exists a direct relationship between the variables considered for analysis. The correlation coefficients between two variables indicated a significant direct or indirect relationship between variables. The existence of the relationship between variables affected the selection of variables included in the logistic regression model.

After this, logistic regression was used to estimate the parameter of the evacuation decision (EDEC). The utility function for EDEC (EV_{ih}) is given in (Eq. 1). It consists of systematic terms ($\beta' Y_{sih}, \beta' Z_{cih}$) and a random term ($\varepsilon_{ih}$). The vectors Y_{sih} and Z_{cih} represent the household characteristics and capacity-related factors, respectively, that determined the EDEC, i, of a household, h. The ε_{ih} is the error term corresponding the effects of unobserved attributes, differences in preference among others, concerning the choice variable.

$$EV_{ih} = \beta' Y_{ih} + \beta' Z_{ih} + \varepsilon_{ih} \qquad \text{(Eq. 1)}$$

Equation 2 presents the probability of EDEC outcomes being chosen, j, by households, h. The maximum likelihood estimation was used to determine the coefficients, β, in equation (1), and log-likelihood function in (Eq. 3). Stata software version 13.1 was used to estimate the parameters for the choices on evacuation decision. The stepwise backward elimination method was used to select the variables included in the model (Steyerberg et al. 2004).

$$P_{ih} = \frac{e(\beta\prime Y_{sih} + \beta\prime YZc_{ih})}{\sum_i^j e(\beta\prime Y_{sih} + \beta\prime YZ_{cih})} \qquad \text{(Eq.2)}$$

$$LL = \sum_{i=1}^{J} \sum_{h=1}^{H} \log(P_{ih}) \qquad \text{(Eq. 3)}$$

Model specification validation was tested through the LR-based statistical test. The model goodness of fit was evaluated based on McFadden pseudo-R^2. Further, the receiver operating characteristics (ROC) together with the area under the curve (AUC) were used to distinguish and evaluate the outcomes with a 0.5 cut-off point. The AUC indicated the probability of sensitivity (desired outcome) and specificity (base outcome). AUC ranges from 0 to 1. The model can discriminate when it comes closer to 1. Models with AUC from 0.9 to 1, from 0.8 to less than 0.9, and 0.7 to less than 0.8, indicate outstanding, excellent, and acceptable discrimination, respectively (Hosmer and Lemeshow 2000). Moreover, the correct classification rate (CCR), determined as the sum of squares of the probability of the outcomes, was used to evaluate the predictive performance of the model. The base rate of the choices was compared to the predictive ability of the model developed (Liu et al. 2014). The increase in the predictive ability of the model showed the improvement in prediction accuracy brought about by the addition of significant variables.

Model Validation

Internal model validation was used for the assessment of the validation of the model. Likelihood Ratio (LR) test was specifically employed. It assumes a null hypothesis where the parameters of the model estimated using the whole data have no significant difference with that of the two subgroups from the whole data. It then means that the specification of the model is established when the null hypothesis is not rejected (Hasan et al. 2013). Then the LR test is given in (Eq. 4) below.

$$LR = -2[LL(\beta_{whole}) - LL(\beta_{sample1}) - LL(\beta_{sample2})] \quad \text{(Eq. 4)}$$

In this equation, $LL\ (\beta_{whole})$ is the pooled data model log-likelihood; $LL\ (\beta_{sample1})$, is the log-likelihood at the convergence of model 1 using the first group of data randomly selected from the whole data; then $LL\ (\beta_{sample2})$ is the loglikelihood at the convergence of the model of sample group 2 from the whole data.

RESULTS

Descriptive Statistics

Table 1 presents the distribution of the 164 observations by household characteristics and capacity-related variables. The variable categories and the mean of selected variables such as AGE, INCOME, MEM and ACHILD are also indicated. It should be noted that the variables in the data are categorized as shown in the second column in Table 1. Accordingly, most of the respondents (76.83%) disclosed that they evacuated during Typhoon Hagupit while 23.17% of the respondents did not. Almost half of the respondents (46.34%) were 51 years old and above. More than half of the respondents (57.32%) are male. Married status had the largest distribution among the respondents (81.10%). In terms of EDUC, 48.78% of them finished high school level. In terms of their occupation, 43.29% were self-employed, 26.83% were unemployed, and 15.24% were employed in the private sector. Most of the respondents (87.20%) reported that the household earned a monthly income of less than PHP 10,000.

Moreover, 45.73% of the respondents divulged that the household had less than four members. Also, 62.80% of the respondents do not have children who were 10 years old and younger. Absence of senior in the household comprised 68.29%. Further, most of the respondents (89.63%) revealed that they do not own their house. This can be attributed to the result where most of the respondents reported to have low household income. Hence, are unable to own a house. In terms of HMAT, most of the respondents (65.24%) were living in a house made of wood and/or light materials. With FLOOR identified, 82.32% and 17.68% of the respondents live in one-floor and two-floor houses, respectively.

Variable Correlation

The correlation analysis of EDEC and the other independent variables (Table 2) indicate that ACHILD (r = 0.273) positively correlated with EDEC. Conversely, AGE (r = -0.206), SEN (r = -0.247), HMAT (made of concrete materials) (r = -0.258), and the more than one-floor level (r = -0.162) were negatively correlated to EDEC. Furthermore, these correlation values were significant (P < 0.05). The summary of correlation coefficient results, however, gave information on the effect of each variable individually against EDEC. This indicates, a logit model was estimated to evaluate the relationship of EDEC to the other variables in a single model (Table 3).

Model estimation

The resulting logistic regression model estimate (Table 3) is statistically significant (P < 0.01). This means that the relationship of the dependent variable, EDEC, and independent variables such as ACHILD, SEN, MAT, and FLOOR collectively exist. Additionally, the estimation resulted in a McFadden R^2 of 0.146. Further, the AUC of the model in this study is 0.775 which is an acceptable level of discrimination of the EDEC choices. Notice that AGE was not mentioned as a significant factor, but it was correlated with other significantly correlated variables like the ACHILD, SEN, and HMAT (Table 2). This explains the significant direct relationship among these variables that also led to the selection of variables included in the model.

Table 1. Socio-demographic profile and capacity-related information of all respondents with valid data from Maypangdan, Borongan City, Eastern Samar (n = 164).

Variable	Category	Number	Mean	Percentage
Evacuation Decision (EDEC)	Did evacuate	126		76.83
	Did not evacuate	38		23.17
Age of the head of the household (AGE)	< 30	18	50.35	10.98
	31–50	70		42.68
	> 51	76		46.34
Gender of the household head (GEN)	Male	94		57.32
	Female	70		42.68
Civil status of the head of the household (MAR)	Single	13		7.93
	Married	133		81.10
	Widow	18		10.98
Educational attainment of the household head (EDUC)	Elementary	39		23.78
	Highschool	80		48.78
	College	45		27.44
Work of the head of the household (WORK)	Government employee	19		11.59
	Self-employed	71		43.29
	Unemployed	44		26.83
	Private employee	25		15.24
	Others (retired, etc.)	5		3.05
Monthly income of the household (INCOM)	≤ 10,000	143	4,746.22	87.20
	10,001–20,000	14		8.54
	20,001–30,000	7		4.27
Number of household members (MEM)	≤ 4	75	5.16	45.73
	> 4	89		54.27
Number of children utmost 10 years of age (ACHILD)	None	103	0.71	62.80
	Have child ≤ 10 years old	61		37.20
Presence of senior (i.e. > 60 years of age) (SEN)	No senior member	112		68.29
	Have senior member	52		31.71
House ownership type (HOWN)	Not owned	147		89.63
	Owned	17		10.37
House material (MAT)	Wood/ light materials	107		65.24
	Concrete	38		23.17
	Half-concrete	19		11.59
Number of floors (FLOOR)	One	135		82.32
	Two	29		17.68

For household characteristics ACHILD and SEN appears to be significant factors to the decision. The coefficient of variable ACHILD (β = 1.234) is positive. This means that a household that has children who are 10 years old or younger will more likely evacuate compared to those that do not have such children. The odds of a household that has children 10 years of age or younger deciding to evacuate is 3.434 times higher than those households that have no children of this age. Further, SEN showed a negative coefficient (β = -0.786), yet it is significant at a 90% level of confidence. This means that a household that has a senior member is less likely to evacuate. Also, the odds of households that have senior members and not evacuating is 0.455 times that of those households that have no senior members. These households find it difficult to evacuate because senior members prefer to stay at home than move, maybe due to their health conditions.

For capacity-related factors, HMAT and FLOOR had shown to be significant factors at a confidence level of 95% and 90%, respectively. HMAT has a negative coefficient (β = -0.603) which means that those with houses built with concrete materials are less likely to evacuate than those whose houses are built with wood or light materials. Moreover, FLOOR shows a negative coefficient (β = -0.803) which means that households that have two floors are less likely to decide to evacuate than those households that have one house floor level. The odds of households with a house of two-floor levels not evacuating is 0.448 times higher than households with one-floor houses. Households whose house is built with concrete materials and has two floors provide a sense of safety and security against the impacts of the hazard.

Table 2. Intercorrelation of the variables used for evacuation decision analysis (n = 164). *Significant at 0.05 level

Variables	Evacuation decision	Age	Gender	Household head work	Educational level	Income	Marital status	No. of Children	No. of Members	Presence of senior	House ownership	House materials	No. of house floors
Evacuation decision	1.000												
Age	-0.206*	1.000											
Gender		-0.143	1.000										
Household head work		-0.139		1.000									
Educational level		-0.142			1.000								
Income					0.286*	1.000							
Marital status		-0.218*	-0.152*	0.261*			1.000						
No. of Children	0.273*	-0.539*		0.243*			0.255*	1.000					
No. of Members							0.217*	0.175*	1.000				
Presence of senior	-0.247*	0.403*		-0.249*			-0.309*	-0.362*		1.000			
House ownership		-0.150								-0.146*	1.000		
House material	-0.258*	0.278*		-0.199*	0.212*	0.167*		-0.205*		0.225*		1.000	
No. of house floors	-0.162*						0.138						1.000

Table 3. Model estimation results for evacuation decisions for households that evacuated. *0.05 level of significance; **0.01 level of significance. CCR – correct classification rate; AUC – area under the curve.

Variable	Coefficient (β)	Odds Ratio	SE	Z	$P > \|z\|$	95% Confident Interval	
Constant	1.694	5.440	0.379	4.47	0.000	0.951	2.436
Household characteristics							
Indicator variable for ACHILD (1 for households with children aged ≤ 10, 0 otherwise)	1.234*	3.434	0.545	2.26	0.024	0.166	0.476
Indicator variable for SEN (1 for those with senior citizen, 0 otherwise)	-0.786**	0.455	0.426	-1.85	0.065	-1.620	0.476
Capacity-related factors							
Indicator variable for MAT (1 for house material with concrete, 0 otherwise)	-0.603*	0.547	0.271	-2.22	0.026	-1.134	-0.071
Indicator variable for FLOOR (1 for more than 1 floor, 0 otherwise)	-0.803**	0.448	0.482	-1.67	0.095	-1.747	0.141
Number of observations		164					
LR chi^2 (4)		25.92					
Prob > Chi^2		0.0000					
Log-likelihood convergence		-75.82					
Log-likelihood at 0		-88.78					
McFadden R^2		0.1460					
CCR		75.61%					
CCR base rate		64.40%					
AUC		0.7750					

Model Validation

The LR calculated for model validation is 3.292 with a DF of 4. At 0.05 level of significance, and DF of 4, the critical value of $\chi^2_{0.05, 4}$, is equal to 9.488. Since the LR value is less than the critical value, this indicates that the model result is established.

DISCUSSION

Findings in this study show that the variables determining evacuation decision include the presence of children 10 years of age and below, the presence of elderly of at least 60 years of age, a household with concrete houses, and the number of house floors. Although the presence of household members aged 60 years and above and the number of house floors appears to be significant at 90% confidence level, the variables are still included due to its significant correlation to evacuation decision as presented in Table 2.

Some of the findings correspond with previous studies where households with younger children are more likely to evacuate (Lim et al. 2013, 2016; Toledo et al. 2018). Goodie et al. (2019) stated that younger children in a household will have a high possibility to evacuate compared to the adults. This is because younger children were instructed several times as shown in Goodie et al. (2019) studies. Results on house materials is supported by Lim et al. (2016) who found out that households with a house built with concrete materials are less likely to evacuate than those made of wood. Moreover, results on the number of house floors are consistent with that of Lim et al. (2016, 2019) in the case of a typhoon-induced flood in other areas. This may have indications of the possibility of model transferability for typhoon-induced flooding cases, in different areas.

The result of this study provides insights regarding the evacuation behavior of households. Government services can be improved to increase the compliance of households by catering to their needs during an evacuation. This is true especially to households with children aged utmost 10 years of age and elderly people. Government leaders may develop an emergency preparedness plan for this type of household with the help of other government agencies. Learnings from the successful implementation of measures such as the flood early warning system in the Philippines (GIZ 2012) can be adopted. The program helped increase the capacity of local communities towards decrease in flood risks. Moreover, researchers can expand this research to other areas and identify more factors such as hazard-related factors. Furthermore, determining evacuee's departure timing, destination choice, and mode choice can be investigated.

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