Central Mindanao University
Journal of Science
ISSN Print: 0116-7847 ISSN Online: 2704-3703

Gender-Based Destination Models in Case of A 2013 Flood Evacuation in Quezon City, Metro Manila, Philippines

Ma. Bernadeth B. Lim [a], Hector R. Lim, Jr [b]*
Department of Civil Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, Laguna, Philippines [a]
Agape Rural Program, Puerto Princesa City, Palawan, Philippines[b]

ABSTRACT

Evacuation is a way to reduce disaster risks. Evacuation destination choice is essential in modeling and planning for logistical arrangements in future evacuations. In this study, exogenous variables that determine the destination choice of households were identified. Households in selected areas in Quezon City, Philippines were selected since they are highly vulnerable in the event of urban flooding. Gender-based discrete choice models for the whole evacuating households were developed. The resulting exogenous variables include income, source of warning, distance traveled from their house to their chosen destination, and length of stay in the selected destination. For male evacuees, determinants are the number of house floors, source of warning, and duration of stay in the choice of destination, while for female evacuees, factors are the type of work and house materials. This study provides valuable insights for government to plan for more effective evacuations. At the individual and household level, it gives insights to understand their decisions and increase self or household evacuation compliance. This can be a basis for more effective evacuation logistical arrangements for future flood evacuations.

Keywords: Evacuation behavior, destination type, flood emergency, evacuation planning

INTRODUCTION

Natural and anthropogenic disasters are severe environmental disruptions that cause death, destroy infrastructure, damage ecosystems, weaken the economy, and interrupt human activities (Iheukwumere et al., 2020). Natural disasters range from earthquakes, volcanic eruptions, tsunamis, hurricanes, tornadoes, floods, droughts, landslides, and subsidence to asteroid impacts (Tulane University, 2018). Flood events are the most common disasters. In 2018, were 127 cases of floods recorded with 2879 fatalities (CRED, 2019). On the other hand, 49% of the 396 total natural disasters in 2019 are flood cases (CRED, 2020).

An average of 20 typhoons enter the Philippine area of responsibility every year, of which five are destructive (ADRC, 2019). One of the five destructive typhoons that struck the country in 2009 is Ketsana (locally known as Ondoy). The typhoon left 140 people dead and 450,000 people displaced to shelters (UNOCHA, 2009). Additionally, the typhoon Quinta, super typhoon Rolly, tropical storm Tonyo, and typhoon Ulysses which all arrived in the country in November 2020, left Filipinos in a devastating situation. The continuous rain caused dams all over Luzon to reach their capacity contributing to more floods. The locals compared the disaster brought by Ulysses to worse than Ondoy (Servallos & Cabrera, 2020).

Natural disasters cannot be prevented. However, the potential loss and damage that disaster causes can be mitigated. The ability of humans to cope with the impact of disasters can be increased through capacity building to reduce existing vulnerabilities (Jeronen, 2020). Evacuation can be done by the government before a disaster to reduce bodily injuries and deaths. To prevent losses, modeling household evacuation is either done sequentially or simultaneously. A widely used sequential modeling includes stay/evacuate, followed by departure timing, destination choice, and route choice (Pel et al. 2012). The decisions vary depending on the household socio-demographics and social networks, among others (Abhishek et al., 2019).

One of the decisions that a household make is choosing where they go during an emergency event. Evacuation destination is the location a household will go to when they leave their home due to an impending hazard. Studies in evacuation destination type choice have been increasing recently. However, much of these studies focused on developed countries where culture, capacity, and resources affecting households' response to evacuation orders differ from developing countries. Additionally, there is also a need to further investigate evacuation destinations due to floods as evacuation is considered hazard-specific. Understanding evacuation travel behavior in the context of floods in developing countries, such as the Philippines, is still appropriate and timely.

This study is another effort to examine exogenous variables that contribute to a better understanding of evacuation destination type choice of households.

Corresponding Author:
Ma. Bernadeth B. Lim
Email: mblim4@up.edu.ph
Received: April 20, 2022; Accepted: July 10, 2023

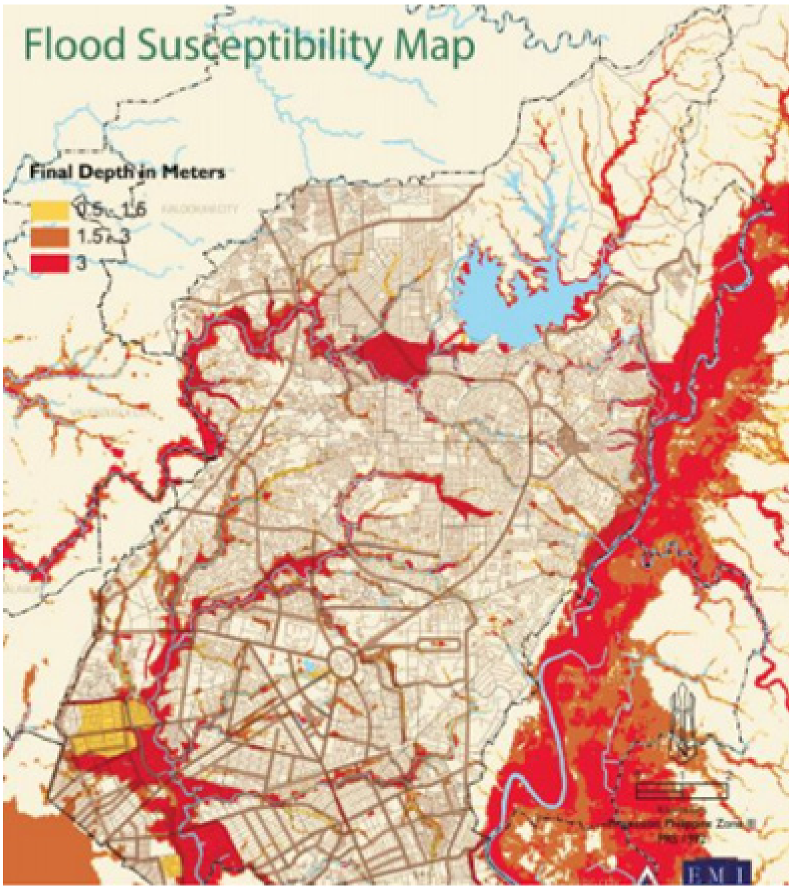

Figure 1. Flood Susceptibility Map of Quezon City Showing High Flood Risk Areas
Source: Quezon City Government Official Website

Further segmenting the decision based on the gender of the household heads is done. The logit models were used to analyze the data collected from the selected sites. The findings in this current study are essential for the government of Quezon City. It is envisioned to provide valuable insights into the behavioral factors that can be a basis for planning a more effective evacuation in the future.

REVIEW OF LITERATURE

Evacuation Destination Choice

Evacuation destination is increasingly gaining interest in recent evacuation studies. Evacuation destination can be the ultimate destination, that is the place where evacuees remain until they decide to go back home. Evacuation destination can also be the proximate destination, or a temporary place to stay, before moving to another place at a later time. Studies found that destination types include hotels and motels, public evacuation centers, rented apartments, and family/friends' houses (e.g., Sadri et al., 2013; Yin et al., 2014; Lindell et al., 2011; Wu et al., 2012; Lim et al., 2016). Wilmot et al. (2008), in their study on modeling destination choice for the hurricane, considered friends/relatives, hotels/motels, and public shelters as model outcomes. Friends'/relatives' houses are widely preferred destination choices followed by hotels/motels. This is also true to Cuellar et al. (2009), Lindell et al. (2011) and Wu et al. (2012). This might be so, as these studies were all done in the context of developed countries. Results might be different in the context of developing, and least developed countries as the socio-demographic characteristics in communities vary widely.

Exogenous Variables of Evacuation Destination Type Choice

The destination type choice of households during an evacuation is outlined here. The exogenous variables that explain evacuation destination include socio-demographic and economic variables as well as factors related to the hazard and evacuation-specific ones. A study in 2019 shows that evacuation destination choice is determined by different factors like distance, accommodation space, and facilities of cyclone shelters (Parvin et al., 2019). Also, factors such as the average evacuation time, allocation of safe areas, the level of trust in authorities, modes of evacuation, and the volume of traffic heavily affect the choice of destination (Nagarajan et al., 2021). The information and transparency during disaster response, as rumors shaped many individuals' evacuation behavior in areas facing little or no damage. Also, governance capacity, those areas with a budget and good resource management, well-provided with plans on shelter allocation, show higher evacuation rates (Fraser et al. 2021). Further, factors like social networks, recommended location by authorities, and economic factors (e.g., Do 2019) also affect the choice of destinations.

Furthermore, socio-demographic characteristics of evacuees such as gender, educational level, household income, housing type, the presence of seniors ad small children, evacuation warning from local government, marital status, and the number of household members, in addition to some destination-related factors, significantly affect evacuation destination choice (e.g. Wu et al., 2012; Abad et al., 2018; Golshani et al., 2018; Mostafizi et al., 2019; Alam et al., 2021; Lim et al., 2021). Additionally, the presence of flood equipment/materials, the distance of residence from the source of hazard, the distance traveled to the destination, and related costs and duration, are also linked to the decision-making (e.g. Lim et al. 2016). Travel behavior change also depends on employment type, possession of driver's license, ownership of the vehicle, and household characteristics (Abad et al., 2018).

METHODOLOGY

Data Collection and Study Area

The data utilized for analysis of gender-based evacuation destination choice was gathered from Quezon City, Metro Manila, Philippines. Considered the largest city in the Metro Manila area, Quezon City is prone to flooding (Figure 1). As of 2013, the City has a population of 2.68 million (Quezon City Planning and Division Office, 2013). The context of the data collected in 2013 was the flood experience of people due to the typhoon Trami in August 2013. When the typhoon entered the Philippine area of responsibility, the Marikina River, located in the eastern boundary of Quezon City, reached a critical height of 19 meters. When this happened, authorities enforced evacuation in affected areas. This resulted in thousands of households leaving their homes. Flood levels reached the rooftop of houses to 3-story buildings. Out of 643,281 households severely affected during the flood event, about 9,000 families went to designated evacuation shelters (Social Services Development Department, SSDD 2013). Affected areas in the City are barangays Bagong Silangan, Roxas, Sto. Domingo, and Toro. Face to face survey was done in these areas. The data collection procedure discussed in Lim et al. (2016) was employed.

The survey questionnaire consists of 3 sections including flood evacuation-related information, flood hazard information, and the characteristics of the respondents. The first section allowed the respondents to share their information such as their age, gender, monthly household income, type of work, vehicle ownership, number of household members, the presence of senior citizens, small children and pets, length of stay in the residence, homeownership status, house material, and floor levels. The second part of the survey form elicited information about the evacuation experience of households during the 2013 flood. The data elicited include the flood level, length of flooding, and damage level in the house. The source of warning was also elicited. Also, the household evacuation decision (whether they evacuated or not), the evacuation type (partial or full evacuation), departure timing (before the flood, or during floodwaters reaching the homes), and the destination type choice, were obtained. Additional evacuation details such as past flood experience, and the presence of flood equipment, were also asked from the respondents. Section 3 elicited comments and suggestions for better evacuation situations in the future.

At the beginning of the interview process, the researchers oriented the respondents to the study objectives, the scope, and questions to be asked, as well as the data privacy. Before the consent of the respondents was ensured, the researchers mentioned that data privacy indicates that personal information gathered will be kept confidential. Of the 740 household interviews that were completed, Bagong Silangan, Bahay Toro, Sto. Domingo, and Roxas, consisted of 340, 150, 142, and 108, respectively. After data collection, the raw data were encoded in the excel file. Data was validated and cross-checked. Also, missing information was excluded from the data analysis. Then, the data was coded to the requirement of the statistical tool utilized for analysis.

Discrete Choice Method of Analysis

The discrete choice model framework, particularly the logit model, was utilized for data analysis. Discrete choice models postulate that decision-makers face a set of choices among mutually exclusive ones (Wong et al. 2020). When they decide, they choose the alternative that gives the maximum benefit. Households that evacuated during the 2013 flood have two choice alternatives, including evacuation center/church/seminary, and friends'/relatives' home. With these alternatives, the binary logit model was used. The independent variables assessed for significance in the destination type choice, include initially all the variables that were collected. Then, variables included in the model were selected using the backward stepwise elimination of variables.

The utility functions for the destination type choice in this study are shown in Equations 1 and 2, for any household, r, evacuating to evacuation center/church/seminary, e, or friends'/relatives' home, f, respectively. In these equations ***βC_er*** and ***βC_fr*** are vectors of parameters for estimation. While ***λK_er*** and ***λK_fr*** are vectors of the independent variables that affect households' destination choice. ***β***, and ***λ*** are vectors of coefficients to be estimated for C and K, respectively. These are estimated using the maximum likelihood estimation method, with the log-likelihood function shown in equation 5. ***ε*** are terms for consideration of differences in preferences in the choice of the type of destination.

$$D_{er} = \beta C_{er} + \lambda K_{er} + \varepsilon_{er} \qquad (1)$$

$$D_{fr} = \beta C_{fr} + \lambda K_{fr} + \varepsilon_{fr} \qquad (2)$$

The probability, ***P*** that households choose to go to either of evacuation center/church/seminary, ***e***, or friends/relatives homes, ***f*** is denoted by P_{er} and P_{fr}, respectively, as shown in Equations 3 and 4.

$$P_{er} = \frac{e^{\beta C_{er} + \lambda K_{er}}}{e^{\beta C_{er} + \lambda K_{er}} + e^{\beta C_{fr} + \lambda K_{fr}}} \qquad (3)$$

$$P_{fr} = \frac{e^{\beta C + \lambda K_{fr}}}{e^{\beta C_{er} + \lambda K_{er}} + e^{\beta C_{fr} + \lambda K_{fr}}} \qquad (4)$$

R is designated as the household number and *J* is the number of alternative evacuation destination type choices available to the households.

$$LL = \sum_{j=1}^{J} \sum_{r=1}^{R} log\ (P_{er}) \log\ (P_{fr}) \qquad (5)$$

To assess the significance of the variables in the binary logit, the t-statistics were used. The nearer the value to 0, the more significant the variable becomes. Model fit is assessed using pseudo R^2.

Summary of Data Utilized

Table 1 shows the description and frequency of the variables collected and utilized for analysis of the effect of gender in choosing the destination type. As shown in Table 1, the descriptive statistics indicate that among the respondents, most are more than 50 years old (30.75%). This is followed by respondents who are between 20-30 years old, 31-40 years old, as well as those that are within 41-50 years old, consisting of 16.77%, 29.03%, and 23.44% of the total respondents, respectively. Also, 289 of all respondents (62.15%) went to the evacuation center/church/seminary, while 176 (37.85%) of them went to their family/friends' house. Among the 381 respondents, mostly 71.65% (273) male, and 71.43% (60) female, went to evacuation center/church/seminary. Table 1 details the data information on all the other independent variables used for analysis in this study.

Three binary logit models were estimated and calibrated to investigate the effect of gender on the evacuation behavior of households. Model 1 is estimated using the full data. Model 2 is estimated using the male respondent data only. While Model 3, was estimated using the female respondents' information. Table 2 details the intercorrelation matrix among all the variables for the 3 Models. These contain the variables that were initially seen to affect the choice of male and female respondents using the various models established. The correlation matrix shows the possible variables that are significant to the evacuation destination choice for the different models. Model 1 indicates that type of work (r= -0.124), income (r= 0.131), source of warning (r= -0.141), duration of stay in the destination choice (r= -0.122), and distance traveled to destination (r= -0.208), are significantly correlated with evacuation destination choice. While Model 2 indicates the number of house floors (r= 0.135), distance traveled (r= -0.136), distance traveled to the destination (r= -0.183), and source of warning (r= -0.209), are significantly correlated with the destination type choice. Lastly, the type of work (r= 0.315), distance traveled (r= -0.339), flood level (r= 0.293), and type of house materials (r= -0.291), are correlated with evacuation destination type choice.

Significant Variables in the Logit Model Estimation

The destination of evacuation centers/churches/seminaries was the basis for model parameter estimation. The models show less than a 0.05 level of significance, indicating that a relationship exists between the independent and dependent variables. Model 1, 2, and 3, area under the curve (AUC) values are 0.681, 0.687, and 0.813, respectively. This indicates that the models have acceptable levels of discrimination. The model pseudo-R2 for models, 1, 2, and 3, are 0.082, 0.072, and 0.215, respectively. Table 3 shows the parameter estimation of models 1, 2, and 3.

Model 1: All Respondents

Model 1 shows that significant variables to destination choice, include the distance traveled to the destination, duration of stay in the destination, monthly income, and the source of warning. Households with income within PHP 1,000-5,000 (b= 0.373) will probably go to the evacuation centers/church/seminary. This might be because relief goods and food donations from the government and private institutions are provided to the evacuation center/church/seminary. Basic goods such as food and water were provided by the governments, individuals, and organizations, for free. Household heads receiving evacuation from other sources aside from barangay or government officials are less likely to evacuate to the evacuation centers (b=-0.961). This result implies that it is more reliable for households if the warning comes from officials. Thus, reflecting the high level of trust in authorities. Also, households will less likely to go to evacuation centers if their distance is 200 m away from their current location. This is indicated by its coefficient b=-0.387. The negative coefficient of the duration of stay of households in a destination choice (b=-0.589) indicates that if they will stay for 1-2 days in that destination, they are more likely to leave the evacuation centers. This finding might be drawn from their past experiences in staying in the centers.

Model 2: Male Respondents

Distance traveled to the destination, the source of warning, and the number of house floors, are the exogenous variables that describe Model 2. The coefficient of the source of warning (b=-0.898) suggests that if the warning comes from officials, they tend to go to evacuation centers. They indicated that evacuation orders from authorities and officials tend to affect evacuees' decision to stay in evacuation shelters. Also, the negative coefficient of the distance to the destination (b= -0.475) indicates that if households travel 200 meters, they are less likely to go to evacuation centers. The result complements the findings of Nagarajan et al. (2021), and Mostafizi et al. (2019), as they found out the location of the shelter and how far it is from the centroid, significantly affect the percentage of people who evacuate to shelters. Moreover, the number of house floors with a positive coefficient (b = 0.632) shows that households with only one house floor during a flood disaster have a higher probability evacuate to evacuation centers.

Model 3: Female Respondents

For Model 3, the result shows that the house type of materials, and the type of work, are significant variables. The positive coefficient of the type of work (b=1.516), indicates that if the household head has full-time work, the household has a high probability of staying in the evacuation centers/church/seminary. While the type of house materials (b=-1.236) suggests that if a household's house is made of concrete material, the household is less

Table 1. Descriptive summary of variables used in the analysis of destination choice based on gender

Variables	Classifications	All		Male		Female	
		f	%	f	%	f	%
Destination Decision (DDEC)	Evacuation center, church and seminary	289	62.15	273	71.65	60	71.43
	Friends'/relatives' house	176	37.85	108	28.35	24	28.57
Marital Status (MAR)	Single	96	20.65	25	6.56	71	84.52
	Married	369	79.35	356	93.44	13	15.48
Educational Attainment (EDUC)	Primary/Elem	109	23.44	88	23.10	21	25.00
	High School	249	53.55	204	53.54	45	53.57
	College/Diploma	72	15.48	59	15.49	13	15.48
	Others (Graduate)	35	7.53	30	7.87	5	5.95
Type of Work of the respondent (TWORK)	Full-time	156	33.55	129	33.86	27	32.14
	Part-time	309	66.45	252	66.14	57	67.86
The number of household members (MEM)	1- 4 members	181	38.92	141	37.01	40	47.62
	> 4 members	284	61.08	240	62.99	44	52.38
Age of the respondent (AGE)	20-30 years old	78	16.77	66	17.32	12	14.29
	31-40 years old	135	29.03	125	32.81	10	11.90
	41-50 years old	109	23.44	97	25.46	12	14.29
	>50 years old	143	30.75	93	24.41	50	59.52
Monthly Income of the respondent (INCOME)	1,000-5,000 PHP	143	30.75	105	27.56	38	45.24
	5001-10,000 PHP	222	47.74	196	51.44	26	30.95
	>10,000 PHP	100	21.51	80	21.00	20	23.81
Presence of Children (PCHILD)	No child	160	34.41	120	31.50	40	47.62
	Have children	305	65.59	261	68.50	44	52.38
Presence of senior citizen (PSEN)	No senior	410	88.17	343	90.03	67	79.76
	Senior is present	55	11.83	38	9.97	17	20.24
House material (HMAT)	Concrete	260	55.91	214	56.17	46	54.76
	Wood and concrete	205	44.09	167	43.83	38	45.24
House Ownership (HOWN)	Owned	114	24.52	93	24.41	21	25.00
	Rented	351	75.48	288	75.59	63	75.00
Number of house floors (FLOOR)	1 floor	284	61.08	242	63.52	42	50.00
	>1 floor	181	38.92	139	36.48	42	50.00
Number of years living in (YLIVE)	<10 years	137	29.46	116	30.45	21	25.00
	10-20 years	177	38.06	148	38.85	29	34.52
	>20 years	151	32.47	117	30.71	34	40.48
Number of vehicles (VEH)	No vehicle	398	85.59	323	84.78	75	89.29
	With vehicle	67	14.41	58	15.22	9	10.71
Damage (DAM)	No damage	125	26.88	109	28.61	16	19.05
	Damage/severely	340	73.12	272	71.39	68	80.95
Flood level (FLEVEL)	<1 meter	111	23.87	97	25.46	14	16.67
	≥ 1 meter	354	79.13	284	74.54	70	83.33
Source of flood warning (SWARN)	Other sources	199	42.80	155	40.68	44	52.38
	Officials	266	57.20	226	59.32	40	47.62
Cost of evacuation (ECOST)	No cost	341	73.33	281	73.75	60	71.43
	With cost	124	26.67	100	26.25	24	28.57
Duration in the evacuation choice (DUR)	1-2 days	379	81.51	306	80.31	73	86.90
	3-4 days	77	16.56	67	17.95	10	11.90
	>4 days	9	1.94	8	2.10	1	1.19
Presence of flood Equipment (EQUIP)	No equipment	404	86.88	330	86.61	74	88.10
	With equipment	61	13.12	51	13.39	10	11.90

Previous flood experience (EXP)	No experience	11	2.37	10	2.62	1	1.19
	With experience	454	97.63	371	97.38	83	98.81
Distance travelled to destination (EDIST)	< 200 meters	111	23.87	94	24.67	17	20.24
	200 – 400 meters	44	9.46	35	9.19	9	10.71
	>400 meters	310	66.67	252	66.14	58	69.05
Distance (DIST)	≤ 10 meters	283	60.86	221	58.01	62	73.81
	10-20 meters	39	8.39	35	9.19	4	4.76
	21-30 meters	26	5.59	21	5.51	5	5.95
	>30 meters	117	25.16	104	27.30	13	15.48

Table 2. Variables and their Correlation in Terms of Destination Type Choice Based on Gender

Exogenous Variables	Evacuation Destination (DDEC)		
	All	Male	Female
Type of Work of the respondent (TWORK)	0.124*	-	0.315*
Monthly Income of the respondent (INCOM)	0.131*	-	-
Number of house floors (FLOOR)	-	0.135*	-
House material (HMAT)	-	-	-0.291*
Distance (DIST)	-	-0.136*	-0.339*
Flood level (FLEVEL)	-	-	0.293*
Source of flood warning (SWARN)	-0.141*	-0.209*	-
Duration in the evacuation choice (DUR)	-0.122*		-
Distance travelled to destination (EDIST)	-0.208*	-0.183*	-

significant at 95%

Table 3. Results of the model parameter estimation for gender-based models compared to the model with the complete data

Parameters	Coefficient,b		
	All	Male	Female
TWORK indicator variable (1 for part-time, 0 for full time)	-	-	1.516
INCOM indicator variable (2 for > PHP 10,000, 1 for PHP 5001-10,000, 0 for PHP 1-5,000)	0.373	-	-
HMAT indicator variable (1 for wood and concrete, 0 for concrete)	-	-	-1.236
FLOOR indicator variable (1 for >1 floor, 0 for 1 floor)	-	0.632	-
SWARN indicator variable (1 officials, 0 for other sources)	-0.961	-0.898	
EDIST indicator variable (2 for >400 m, 1 for 200-400 m, 0 for <200 m)	-0.387	-	-
DUR indicator variable (2 for >4 days, 1 for 3-4 days, 0 for 1-2 days)	-0.589	0.475	-
Constant	0.694	0.954	0.021
Number of Observations	465	381	84
LR chi^2 (4)	52.53	37.96	24.19
Prob > chi^2	0.0000	0.0000	0.0001
Pseudo R^2	0.082	0.072	0.215
CCR base rate	52.95%	59.37%	59.18%
CCR	77.78%	73.75%	80.95%
AUC	0.681	0.687	0.813

likely to go to evacuation centers/church/seminary. This finding is similar to that of earlier studies. Households with wood as a housing type have a higher probability of going to the evacuation shelter first (e.g. Damera et al. 2019; Golshani et al. 2018). However, these are in cases of a hurricane and no-notice disasters.

Model Internal Validation

To internally validate the three models estimated, the likelihood ratio (LR) test was employed. This was done to statistically test the model specification validity. For each model, the complete data were divided randomly into two subsamples. The whole data utilized to estimate the logit model is divided randomly into two subgroups with the same number of subsamples. The subsamples are indicated as ss1 and ss2 in equation 6. These two subsamples were used to estimate separate models to obtain the value of LL for each subsample. The LR (Equation 6) is then calculated to test the null hypothesis. The null hypothesis postulates that there is "no significant difference between the LR at the convergence of the model estimation results with the use of the whole data and the model estimated using the subsamples, respectively. The LL for models 1, 2, and 3 were calculated separately according to the entire data and subsamples of data utilized for each model.

$$LR_{full,male\ or\ female} = -2[LL(\beta_{full,male\ or\ female}) - LL(\beta_{ss1,male\ or\ female}) - LL(\beta_{ss2,male\ or\ female})] \quad (6)$$

In equation 6, the variables mean *LL* ($\beta_{full,\ male\ or\ female}$), *LL* ($\beta_{ss1,\ male\ or\ female}$), and *LL* ($\beta_{ss2,,\ male\ or\ female}$) are the log-likelihood at the convergence of the model estimated with the use of the entire data and the subsamples, respectively. Table 4 provides the details of the calculated values. For the first model using the combined data of male and female household heads, calculated values of the LL for the full data, and 2 subsamples are -281.025, -118.107, and -105.893, respectively. Calculating the LR gives the value of 114.05 with degrees of freedom equal to 4. Since the critical value of χ for a 5% level of significance and degrees of freedom equal to 4, $\chi^2 0.05, 4$, is equal to 9.488, the model validity is established. For the *LL (βMale)*, *LL (βss1)*, and *LL (βss2)*, the values of the complete data and the split samples are -231.087, -99.537, and -117.820, respectively. The value of LR is 27.46 with degrees of freedom equal to 3. Since the critical value of χ for a 5% level of significance and degrees of freedom equal to 3, χ20.05, 3, is equal to 7.815, the validity of the model is also established. Moreover, for *LL* (β_{Female}), *LL* (β_{ss1}), and *LL* (β_{ss2}), the values of the whole data and the split samples are -24.815, -26.217, and -16.779 respectively. The value of LR is 30.75 with degrees of freedom equal to 2. Since the critical value of χ for a 5% level of significance $\chi^2 0.05, 2$, is equal to 5.991, the validity of the model is also established.

SUMMARY AND CONCLUSIONS

To be better prepared for future flood events, the evacuation behavior of people needs to be understood. Understanding how households decide on the type of destination is an important subject that government officials need to know. Results from this can be a valuable factor to incorporate in evacuation plans. Such results can be used in the traffic simulation model and are necessary for the accurate assessment of network congestion and delay (Cheng et al. 2008). This study investigated whether the included independent variables affect evacuee behavior. The data used for analysis was gathered from households in Quezon City, Metro Manila, Philippines. The context of evacuation is due to a flood event in 2013. The correlation matrix was first analyzed to identify potential factors to be included in the logit models. Then, three binary logit models were estimated utilizing the whole data and the data from male and female respondents.

Results of variables significant to Model 1 indicate more that can be important in the decision-making of both male and female respondents. In general, significant variables found in Model 1 include distance traveled to the destination, duration of stay in the destination, income, and the source of warning. Households with an income within PHP 1,000-5,000, regardless of being male or female, will probably go to the evacuation centers/church/seminary. Most of the respondents located in high-risk flood areas have low to medium income levels. Also, household heads who received evacuation warnings from barangay officials are more likely to comply to go to the evacuation center/church/seminary. Households experience floods almost every year and most of them have past flood evacuation experience. This indicates their level of trust in the barangay officials which supports previous findings (e.g., Lim et al. 2016; Golshani et al. 2018; Lim et al. 2021). Also, households are less likely to go to an evacuation center/church/seminary if their distance is at least 200 m away from their current location, or longer than that. Households prefer to go to nearby destinations. This finding also supports past studies that found longer distances traveled are less chosen by the evacuees (e.g., Nagarajan et al. 2021; Mostafizi et al. 2019). The duration of stay of households in a destination indicates that if they will stay for 1-2 days in that destination, households are more likely to leave the evacuation centers according to past experiences.

Findings in Model 2 show that duration of stay in the destination, the source of warning, and the number of house floors, affect destination type choice. The source of warning suggests that if the warning comes from officials, they tend to go to an evacuation center/church/seminary. Similar to findings in model 1, this shows the compliance

Table 4. Values of the LL for Full Data and Sub Samples for the 3 Logit Models of Destination Type Choice

LL Values	Model 1 (Combined Male & Female Data)	Model 2 (Male Data)	Model 3 (Female data)
βfull data	-281.025	-231.087	-24.815
βss1	-118.107	-99.537	-26.217
βss2	-105.893	-117.820	-16.779

of households located in high-risk areas. Male household heads put importance on the warning they get from their authorities. Also, those with only one house floor are more likely to go to an evacuation center/church/seminary. Logically, these are the priorities to be evacuated as they do not have a choice. Male household heads also are less likely to stay in an evacuation center/church/seminary with a longer duration of stays. This is evidently due to the concerns that male heads indicated concerning their home and properties. They are concerned about the looting and security of their homes. Unlike the result in Model 3, female heads, when having a house material made of wood or half-concrete, likely go to evacuation centers/church/seminary. They do not put importance on the duration of stay in the evacuation centers/church/seminary or the number of floors the house have. This is in addition to the type of work of female heads, having full-time work, having a high probability to stay in the evacuation centers/church/seminary. This may be related to the female heads concerned for the family members when the home is flooded. They are more secure leaving their family members in an evacuation center/church/seminary while going to work.

Outputs of this study can help identify demand for evacuation centers, allocate evacuees in each evacuation center to reduce evacuation time, and effectively manage available resources when evacuating people at risk. Also, the findings in this study are important for government officials in charge of developing evacuation plans. Although findings in this study provide insights that can be helpful to evacuation planners, future studies are still needed to validate the logit models estimated here during an actual evacuation. Also, analyzing the transferability of the models to other areas in the Philippines that are flood-prone, can be a subject for future studies.

REFERENCES

Abad, R. and Fillone, A. (2018). Factors affecting travel behavior during flood events in Metro Manila, Philippines. Conference Paper.

Asian Disaster Reduction Center. (2019). Information on disaster risk reduction of the member countries: Philippines. Retrieved from https://www.adrc.asia/nationinformation.php?NationCode=608&Lang=en#:~:text=Located%20along%20the%20typhoon%20belt,five%20of%20which%20are%20destructive.

Alam, M.D., Habib, M., and Pothier, E. (2021). Shelter locations in evacuation: A Multiple Criteria Evaluation combined with flood risk and traffic micro-simulation modeling. International Journal of Disaster Risk Reduction 53, 102016. https://doi.org/10.1016/j.ijdrr.2020.102016

Cheng, G., Wilmot, C.G., & Baker, E.J. (2008). A destination choice model for hurricane evacuation. Retrieved from https://www.researchgate.net/publication/228866746_A_destination_choice_model_for_hurricane_evacuation Centre for Research on the Epidemiology of Disasters. (2019). Natural disasters 2018. Retrieved from https://www.cred.be/sites/default/files/CREDNaturalDisaster2018.pdf

Centre for Research on the Epidemiology of Disasters. (2020). Disaster year in review (2019). Retrieved from https://cred.be/sites/default/files/CC58.pdf

Cuellar, L., Kubicek, D., Hengartner, N., Hansson, A. (2009). Emergency relocation: population response model to disasters. In Proceedings of the IEEE Conference on Technologies for Homeland Security, Boston, MA, USA. doi: 10.1109/THS.2009.5168096.

Damera, A., Gehlot, H., Ukkusuri, S., Murray-Tuite, P., Ge, Y., and Lee, S. (2019). Estimating the Sequencing of Evacuation Destination and Accommodation Type in Hurricanes. Journal of Homeland Security and Emergency Management. doi: 10.1515/jhsem-2018-0071.

Do, X. (2019). Fukushima Nuclear Disaster displacement: How far people moved and determinants of evacuation destinations. International Journal of Disaster Risk Reduction, 33, 235-252. doi: 10.1016/j.ijdrr.2018.10.009.

Golshani, N., Shabanpour, R., Mohammadian, A., Auld, J., and Ley, H. (2018). Analysis of evacuation destination and departure time choices for no-notice emergency events. Transportmetrica A: Transport Science, doi: 10.1080/23249935.2018.1546778.

Iheukwumere, S.O., Nkwocha, K.F., Okoye, N.T., & Agulue, E. (2020). Environmental disaster management in Delta state: a public perception. IIARD International Journal of Geography and Environmental Management, 6(1), 49-50. Retrieved from https://www.researchgate.net/publication/341600411_Environmental_Disaster_Management_in_Delta_State_A_Public_Perception

Jeronen, E. (2020). Encyclopedia of Sustainable Management. Retrieved from https://www.academia.edu/43219402/Sustainable_Development_Summary

Lee, D., Yoon, S., Park, E., Kim, Y., & Yoon, D.K. (2018). Factors contributing to disaster evacuation: the case of South Korea. Sustainability, 10(10), 1-16. doi: 10.3390/su10103818

Lim, MB., Lim, H., and Anabo, J. (2021). Evacuation destination choice behavior of households in Eastern Samar, Philippines during the 2013 Typhoon Haiyan. International Journal of Disaster Risk Reduction 56 (2021) 102137. doi: 10.1016/j.ijdrr.2021.102137

Lim, M.B., Lim, H., Piantanakulchai, M., and Uy, F. A. (2016). A household-level flood evacuation decision model in Quezon City, Philippines. Natural Hazards, 80, 1539–1561. doi: 10.1007/s11069-015-2038-6.

Lindell, M. K., Kang, J. E., & Prater, C. S. (2011). The logistics of household hurricane evacuation. Natural Hazards 58:1093–1109. doi: 10.1007/s11069-011-9715-x.

Mostafizi, A., Wang, H., Cox, D. & Dong, S. (2019). An agent-based vertical evacuation model for a near-field tsunami: Choice behavior, logical shelter locations, and life safety. International Journal of Disaster Risk Reduction. doi: 10.1016/j.ijdrr.2018.12.018

Nagarajan, M., and Shaw, D. (2021). A behavioural simulation study of allocating evacuees to public emergency shelters. International Journal of Disaster Risk Reduction 55 (2021). https://doi.org/10.1016/j.ijdrr.2021.102083

Parvin, G., Sakamoto, M., Shaw, R., Nakagawa, H., and Sadik, M. (2019). Evacuation scenarios of cyclone Aila in Bangladesh: Investigating the factors influencing evacuation decision and destination. Progress in Disaster Science, 2, 100032. doi: 10.1016/j.pdisas.2019.100032.

Sadri AM, Ukkusuri S, Murray-Tuite P (2013) A random parameter ordered probit model to understand the mobilization time during hurricane evacuation. Transportation Research Part C 32:21-30. http://dx.doi.org/10.1016/j.trc.2013.03.009

Servallos, N.J. & Cabrera, R. (2020, November 13). Worse than Ondoy: Typhoon Ulysses triggers massive flooding in MM, Rizal, other areas; residents caught by surprise. The Philippine Star. Retrieved from https://www.onenews.ph/worse-than-ondoy-typhoon-ulysses-triggers-massive-flooding-in-mm-rizal-other-areas-residents-caught-by-surprise

Tulane University. (2018). Natural disasters & assessing hazards and risk. Retrieved from https://www.tulane.edu/~sanelson/Natural_Disasters/introduction.htm

Wu, C., Lindell, K., Prater, S. (2012). Logistics of hurricane evacuation in Hurricanes Katrina and Rita. Transportation Research Part F, 15 (5), 445–461. doi: 10.1016/j.trf.2012.03.005.

Yin W, Murray-Tuite P, Ukkusuri SV, Gladwin H (2014) An agent-based modeling system for travel demand simulation for hurricane evacuation. Transportation Research Part C 42:44–59. https://doi.org/10.1016/j.trc.201