The Impacts of Losses and Damages by Floods: A Case Study in Klang, Selangor

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Abstract:
Flash floods are the most common and disruptive hydro-meteorological phenomena that Malaysian cities experience most often. The capital city of the country, especially, is experiencing more incidences of flash floods than in the past. Although flash flood are not always confined to monsoon seasons, the city experiences flash flood more frequently during this period of time of the years. While several mitigative and adaptive initiatives have been implemented, flash floods are still a major concern in the city. Therefore, it is important to revisit the factors for achieving the sustainability of Klang, bringing balance in between urban development and flood management. Understanding the impact of the flash flood is also important for the proper setup and implementation of land use regulations and for implementing stricter laws regarding the socioeconomic development of catchment areas. This study quantitively analyses the direct impact of flash floods based on loss and damage perspectives. It focuses on the association between factors of losses and damage caused by floods and respondents' willingness to live in a house that is at risk of flooding in Klang. The results show that houses and vehicles in Klang are directly affected, damaged, and disrupted by flash floods.

Keywords:
Floods; Losses; Damages; City; Impacts

1. Introduction:
Over the past decades, hundreds of disasters have been recorded causing 11,755 deaths, affecting 95 million people and resulting in US$ 103 billion in economic losses worldwide (EM-DAT, 2020). Climate changes is expected to contribute to an increase in disaster losses, particularly as global warming progresses to 1.5°C (IPCC, 2018). Information on disaster events is critical for formulating effective policies and actions that reduce future risks (Huggel et al., 2015). Economic loss and damage are rising globally and growing exposure has been identified as a main driver of this increase. Flash floods are common phenomena in the capital city of Malaysia. Every year, this city experiences several flash floods. The city is located within the river basin of two major rivers (namely Klang River and Gombak River) positioned in the middle of a valley. As a result, floods are an inevitable event in the city. Flash floods are mostly caused by the seasonal monsoon rains and inadequate drainage systems that are unable to properly channel the water flow. The overflow of the rivers is also a major reason for the occurrence of flash floods in the city.

According to Sanyal et al. (2004), a flash flood results from heavy rainfall within a short period of time or high river discharge. Flash floods can damage physical infrastructures such as houses, schools, health centers, roads, culverts, marketplaces, gabion embankments, spurs and hand pumps. Natural disasters including frequent flash floods can cause significant major damages to society, and they become particularly alarming when they occur in highly populated areas and regions with concentrated economic activities.

Flood is considered one of the most widespread disasters to affect countries all over the worldwide and causes extensive losses (Glaser et al., 2010). According to the World Meteorological Organization (MWO), flood rank as the third most devastating natural disaster globally claiming thousands of lives and resulting in the destruction of properties worth hundreds of billions (Tuan Pah Rokiah, Baharum, & Hamidi, 2014). In the context of flooding impacts, a disaster like a flood is classified into three categories by most researchers, namely hazard, risk and disaster. Flood is considered hazardous if it occurs in an area inhabited by humans and has the potential to cause damage and property loss as well as health impacts, injuries and loss of life. The hazard of flood can escalate into a disaster if its effects results in extensive of damage and loss of human lives (Sundar & Sezhiyan, 2007). Similarly, with risk such flood incident can be considered risky if it has the potential to cause a negative impact on humans' activity. In the context of disaster, an incident can be considered a disaster if the overall loss suffered by the community is severe, leading to the destruction of most public and private facilities, buildings, business premises and other assets (Eshghi & Larson, 2008).

At the end of 2021, Klang was hit by massive floods that affected all districts. However, Klang bare a significant impact as it experienced extensive damage and loss of property. The economic situation of Klang population was completely paralyzed due to the floods and most of the road network were impossible for light vehicles. Therefore, this research is limited to the flood effect assessment towards the economic aspect by evaluating the level of loss faced by the individuals in Klang, Selangor. Commonly, the loss caused by a disaster is stated as direct losses referred to the damages to physical property and infrastructures affected by flood water (Hammond, Chen, Djordjevic, Butler, & Mark, 2015).

Urban areas are vulnerable to small yet frequent climatic and hazardous events. The sudden hit of a flash flood in an urban area can disrupt the daily routines of the city and its residents. Multiple aspects of the productive sector can be shut down or interrupted, and a significant number of assets can be at risk as well. Flash flood event can also lead to severe destruction and damage, to the particularly affecting the more vulnerable segments of the population and their assets. Thus, the study aims to assess the impact of floods in terms of damage categories and the overall value of damages and losses in Klang.

2. Methodology:

2.1 Study Area

This survey is conducted to measure the impact of floods in terms of categories of damages as well as the value of damages and losses for affected areas. Klang is an administrative district located in Selangor. It comprises 12 mukim, namely Mukim Kapar, Mukim Klang, Bandar Klang, Bandar Port Swettenham, Bandar Sultan Sulaiman, Bandar Shah Alam Klang, Pekan Bukit Kemuning, Pekan Kapar, Pekan Meru, Pekan Telok Menegun, Pekan Batu Empat and Pekan Pandamaran. The total area of Klang is 631.58 square kilometres, with a total population of 1,088,942 and a population density of 1,724 people per square kilometres (DOSM, 2022).

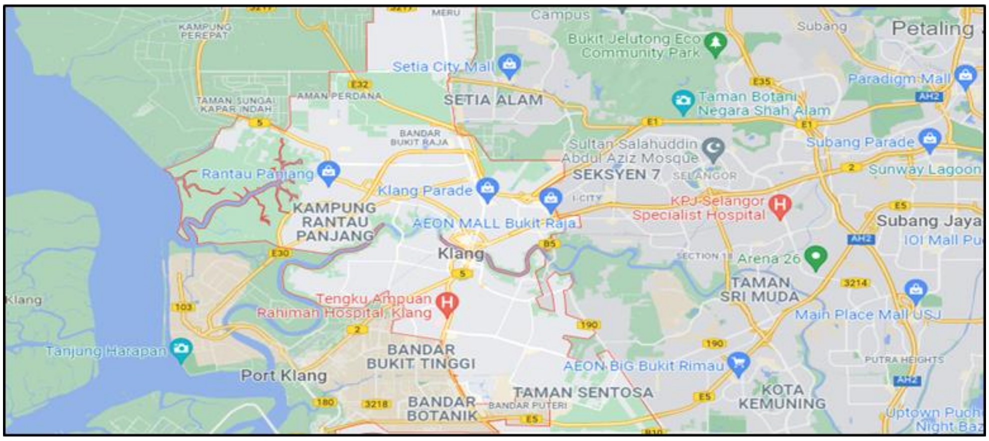

Figure 1: Map of Survey Area in Klang, Selangor

2.2 Data Collection Methods

This study was conducted based on primary data collected through face-to-face interviews from 10th to 14th January 2022. Direct face-to-face interviews are the most commonly used approach in contingent valuation studies (Carson et al., 2001; Carson et al., 1996). A face-to-face interview guide was formulated to collect the primary data. The research survey questionnaire comprises five main sections including section A (sociodemographic profile), Section B (information on living quarters profile), Section C (information on physical losses and damages), Section D (information on floods), Section E (information on socioeconomic losses and damages). The collected data were analysed using Statistical Package for Social Science (SPSS) software. This study utilised both used descriptive and regression analysis to identify the relationship between the level willingness of the respondent living in house with losses and various physical and socioeconomic variables.

2.3 Binary Logistic Regression

Binary Logistic Regression will be used with the purpose of highlighting the important independent variables with p-value is less than 0.05. The confidence level describes the uncertainty associated with the sampling method. Usually, the same sampling method is used to select different samples and compute different interval estimate for each sample. However, there is a possibility that some interval estimates may include the true population parameter, which other may not. For this study, a 95% confidence level will be used as being suggested by Sekaran and Bougie (2014). A significant level of 0.05 is suitable for social research. With a 95% confidence level, it can be inferred that in 95 out of 100 instances in this research, the estimation will accurately reflect the willingness of the respondent living in house with losses as the population. The parameter estimates table summarizes the effect of each predictor. The meaning of a logistic regression coefficient is not straight forward. The predictors and their coefficient values, as shown in the final step are used in the procedure to make predictions. According to Kutner et al. (2005), prediction equations, in two forms, which are:

i. Logit form (assume to be linear)

$$
\begin{aligned}
logit(\pi) &= \log\left(\frac{\pi}{1-\pi}\right) \\
&= \beta_0 + \beta_1 X_1 + \cdots + \beta_k X_k
\end{aligned}
$$

where,

$\pi = P(Y = 1), z = \beta_0 + \beta_1 x_1 + \cdots + \beta_k \beta_k$

ii. Logistic function

$$\pi = \frac{e^z}{1 + e^z}$$

$$P(Y = 1|X_1, X_2, \dots, X_k) = \frac{1}{1 + e^{-z}}$$

3. Result:

3.1 Descriptive Analysis

Based on Table 3.1, the majority of the respondent are male with 72.3%, as compared to female respondent are 27.7%. In terms of Ethnic, Malay has higher respondent compared to Indians, Chinese and other ethnicities at 51.7%, 32.1%, 14.4% and 1.8%, respectively. In terms of type of living quarter, townhouse was the highest at is 62.3%, followed by apartment (20.7%) and flat (9.7%). Moreover, for the duration of respondents occupancy in their living quarters, more than 9 years is the most prevalent category at 62.3%, followed by 1-3 years and 4-6 years, accounting for 12.8% and 11.8%, respectively. Majority of the houses are constructed using concrete as the primary building material representing 86.8% a while a combination of concrete and wood accounts for 10.1%.

In addition, the distance between houses and rivers situated within 0 – 2 km is 63.9%, while, 21.3% and 9.1% are within the range of 2.1 – 5 km and 5.1 – 10 km are respectively. Regarding the occurrence of floods, the majority of respondents i.e 45.8% have never experienced a flood while 20.5%, have faced floods four times or more, and 16.2% have experienced floods three times. Lastly the majority of respondents (89.9%) expressed willingness to continue living in their house despite the flood risk rather than relocating to other places.

Table 3.1: Summary of Descriptive Statistics

Variable		Percentage, %
Gender	(1) Male	72.3
	(2) Female	27.7
Ethnic	(1) Malay	51.7
	(2) Chinese	14.4
	(3) Indian	32.1
	(4) Others	1.8
Type of Living Quarters (LQ)	(1) Rumah Sesebuah	3.4
	(2) Rumah Berkembar	0.4
	(3) Rumah Teres/ Berangkai	0.4
	(4) Rumah Berkelompok	0.6
	(5) Town House	62.3
	(6) Rumah Kedai/ Pejabat	2.6
	(7) Rumah Pangsa	9.7
	(8) Apartment	20.7
Duration of Occupancy in Living Quarters	(1) Less than 1 year	5.3
	(2) 1-3 years	12.8
	(3) 4-6 years	11.8
	(4) 7-9 years	7.7
	(5) More than 9 years	62.3
Type of House Building Materials	(1) Concrete	86.8
	(2) Wood	3.2
	(3) Mix (Concrete & Wood)	10.1
Distance between House and River	(1) 0 – 2 km	63.9
	(2) 2.1 – 5 km	21.3
	(3) 5.1 – 10 km	9.1
	(4) More than 10.0 km	5.7
Occurrence of Floods	(1) None	45.8
	(2) 1 time	12.6
	(3) 2 times	4.9
	(4) 3 times	16.2

	(5) 4 times and above	20.5
Willingness Living in House	(1) No	10.1
	(2) Yes	89.9

3.2 Diagnostic Residual Plots

Based on Figure 3.1, the scatter plot closely aligns with a horizontal line with zero intercept, and the data points appear to be paralleled to each other. This observation suggest that the model is adequate. Any significant departure from this pattern would indicate potential inadequacy in the model.

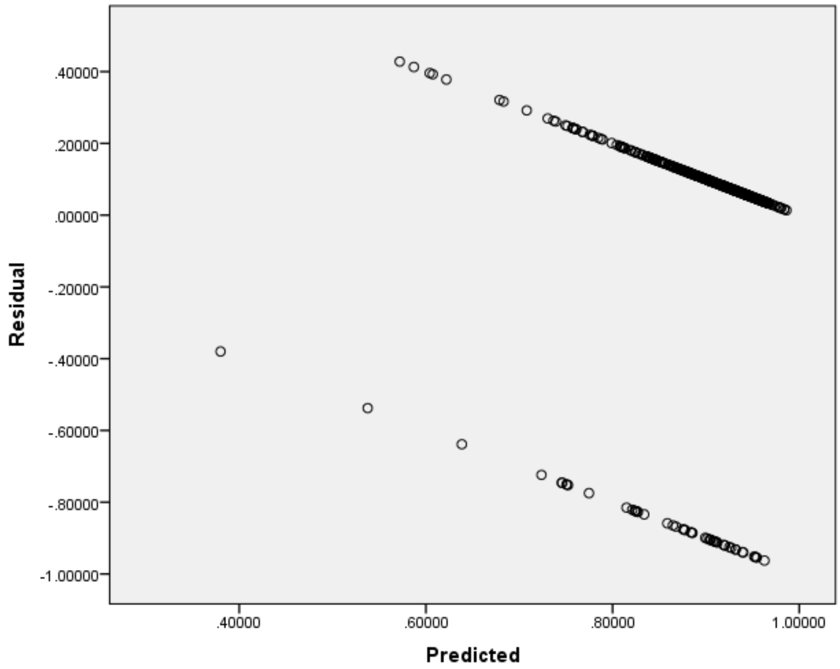

Figure 3.1: Scatter Plot of Residual against Predicted Probability

3.3 Binary Logistic Regression

3.3.1 The Full Model

$$\log\left[\frac{P(Y=1)}{1-P(Y=1)}\right] = z$$

where,
$P(Y=1)$ is the probability that the respondent has willingness living in house,

$z = 0.958 + 0.000094(Income) + 0.703(Duration_2) + 1.041(Duration_3) - 1.203(Duration_4) + 1.605(Duration_5) - 1.027(Material_2) - 0.714(Material_3) + 0.491(Occurance_2) - 0.385(Occurance_3) + 0.077(Occurance_4) - 0.072(Occurance_5) + 0.000001(Loss) - 0.000181(CleanUp) - 0.332(Distance_2) - 0.078(Distance_3) - 0.264(Distance_4)$

3.3.2 The Reduce Model

Below is the reduce estimated logistics regression model:

$$\log\left[\frac{P(Y=1)}{1-P(Y=1)}\right] = z$$

where,
$P(Y=1)$ is the probability that the respondent has willingness living in house,

$$z = 0.000094(Income) + 0.703(Duration_2) + 1.605(Duration_5) - 1.027(Material_2) - 0.000181(CleanUp$$

3.4 Likelihood Ratio Test of Reduce Model Coefficients

Based on the result of the Forward Selection method, it is recommended that the variables of Resident, Amount and Age should be removed from the model. Thus, the study performs the Likelihood Ratio test is to determine whether these variables should be removed from the model. Based on Table 3.2, the Chi-Square values are statistically significant since the p-value is greater than 0.05. This suggested that the variables should be removed from the model. Moreover, the Chi-Square model, which is 21.986, determines whether any of the independent variables have significant effects. It is the equivalent of a global F test. Lastly, the Chi-Square statistics is 210.881 with p-values 0.144, which is greater than 0.05. This indicates that the model is insignificant predictors in the logistics model.

Table 3.2: The Chi-Square Test of Model Coefficients

	Chi-Square	df	p-value
Step	21.986	16	0.144
Model	21.986	16	0.144

3.5 Reduce Model of Fit

Based on Table 3.3, is evident that the -2 Log Likelihood in Block 1 for the logistic model with five predictors is 308.965. Additionally, the Cox & Snell R-Square and Nagelkerke R-Square indicate the proportion of variation in the response variable explained by the predictors. The closer the value is to one, the better is the model. In this case, the Cox & Snell R-Square and Nagelkerke R-Square are 0.042 and 0.089 respectively.

Table 3.3: Reduce Model Summary

-2 Log Likelihood	Cox & Snell R Square	Nagelkerke R Square
308.965	0.042	0.089

3.5.1 The Hosmer-Lemeshow Test

Based on Table 3.4, the Chi-Square test is not significant, as the p-value is greater than 0.05. This suggest that the logistic regression model is a good fit for the data.

Table 3.4: The Chi-Square Test

Chi-Square	df	p-value
7.684	8	0.465

3.5.2 Classification Table

Table 3.5 shows the cross-tabulation of the predicted response categories with the observed (actual) response categories and predicted. The classification table shows that the percentage of correct classification is 90.1%, while, the error rate of the model is 9.9%.

Table 3.5: Classification Table

Observed		Predicted		
		Willingness Living in House		Percentage Correct
		No	Yes	
Willingness Living in House	No	1	50	2.0
	Yes	0	456	100.0
Overall Percentage				90.1

3.6 The Final Model

Table 3.6, it shows a significant post-flood clean-up cost and duration of occupancy in living quarters “Less than one (1) year” and “More than nine (9) years” respectively. Below is the final estimated logistics regression model:

$$\log\left[\frac{P(Y=1)}{1-P(Y=1)}\right]=z$$

where,

$P(Y=1)$ is the probability that the respondent has willingness living in house,

$$z=1.777-1.605(Duration_2)-1.605(Duration_2)-0.902(Duration_3)-0.000181(CleanUp)$$

Table 3.6: Variables in the Final Model

Variable	B	S.E.	Wald	p-value	Exp(B)	95% C.I. for EXP(B)	
						Lower	Upper
Income	0.000094	0.000075	1.595	0.207	1.000	1.000	1.000
Duration			10.838	0.028			
Duration(2)	0.703	0.592	1.412	0.235	2.020	0.633	6.440
Duration(3)	1.041	0.618	2.843	0.092	2.833	0.844	9.507
Duration(4)	1.203	0.725	2.752	0.097	3.330	0.804	13.794
Duration(5)	1.605	0.533	9.076	0.003	4.977	1.752	14.139
Material			4.180	0.124			
Material(2)	-1.027	0.693	2.198	0.138	0.358	0.092	1.392
Material(3)	-0.714	0.449	2.527	0.112	0.490	0.203	1.181
Occurance			1.321	0.858			
Occurance(2)	0.491	0.571	0.739	0.390	1.634	0.533	5.007
Occurance(3)	-0.385	0.680	0.321	0.571	0.680	0.179	2.580
Occurance(4)	0.077	0.473	0.027	0.870	1.080	0.428	2.731
Occurance(5)	-0.072	0.391	0.034	0.854	0.930	0.432	2.004
Losses	0.000001	0.000004	0.118	0.732	1.000	1.000	1.000
Clean-up	-0.000181	0.00009	4.092	0.043	0.9998	0.9996	0.9999
Distance			0.875	0.832			
Distance(2)	-0.332	0.371	0.800	0.371	0.717	0.346	1.485
Distance(3)	-0.078	0.573	0.019	0.891	0.925	0.301	2.841
Distance(4)	-0.264	0.671	0.155	0.694	0.768	0.206	2.860
Constant	0.958	0.601	3.192	0.074	2.606		

3.7 The Odd Ratio

For duration of occupancy in living quarters “1-3 years”, the odds ratio (“1-3 years” versus “Less than 1 year”) estimate equals 2.020. This means that for duration of occupancy in living quarters “1-3 years”, the odds of respondent willingness living in house are 2.020 times higher than the odds of duration of occupancy in living quarters “Less than 1 year”. While, the duration of occupancy in living quarters “More than 9 years”, the odds ratio (“More than 9 years” versus “Less than 1 year”) estimate equals 4.977. This means that for duration of occupancy in living quarters “More than 9 years”, the odds of respondent willingness living in house are 4.977 times higher than the odds of duration of occupancy in living quarters “Less than 1 year”.

Lastly, the post-floods clean-up cost, the odds ratio indicates that when a respondent increases the clean-up cost by RM1, the odds of respondent willingness living in house will decrease by 0.02%.

4. Discussion and Conclusion:

Flash floods are a common event in Malaysia; therefore, the study on urban flash floods is very substantial. This study identified the impact of flash flood events in Klang City through estimating the losses and damages due to flash floods. Based on the interview session, most of respondents willing to live in the house even though has risk of flood due to the difficult in finding another house, own house, rented house, financial factors, close to work, basic facilities and family.

With reference to study of flash floods in Kuala Lumpur by Bhuiyan et al. (2018), although in a separate time frame, the numbers of fluvial flash flood days are much lower as compared to the drainage related flash flood days. As both kinds of flash floods usually hit several parts of the city within a particular day, the numbers of affected locations are much bigger than the flash flood affected days. The most common and highly affected elements by both types of flash foods are roads and highways, houses, and vehicles. The number of affected vehicles is difficult to express in an exact figure in terms of fluvial flash flood. It is because, there are several incidents where the data set mentioned phrases like ‘several cars affected’, ‘several cars involved’ and ‘cars affected’.

Bari et al. (2021) shows that there are records of big floods occurring in Kajang during the years 1971, 1987, and 2011. Flash floods are also common with evidence of submerging houses along rivers up to the roof level (Muhamad, 2017). In Kajang, the event in December 2011 caused damages with an estimated value of RM2.4 million. Furthermore, at least three incidences were reported in 2014 causing losses estimated at approximately RM150,000 per event (Muhamad, 2017). Most settlements and economic and development activities in Kajang are focused along the Jelok River (Muhamad, 2016).

The study has discussed on the assessment of loss level faced by the traders in that town due to the 2014 flood incident which identify the highest loss of business property faced by the traders and to determine the relationship between types of business and level of loss the traders had to deal with in Kuala Krai. It was found that the traders in the Kuala Krai town suffered much damage and losses during the flooding event in 2014 especially the sale items business. This is because of the high destruction and damage of the sale items and premises/ stall/ kiosk (Nayan et al., 2017).

However, the impact of natural disasters such as floods can be reduced through natural disaster management before and after the disaster (Soetanto & Proverbs, 2004). In addition, an efficient disaster management is also able to reduce the impact of disaster and prevent disaster from happening and minimise the impact of disaster (Eden & Matthews, 1997; Khan, Vasilescu and Khan, 2008). However, an efficient flood management of other countries cannot be applied in our own country. This is because each disaster that hits a country varies according to its frequency and magnitude. Instead, Kaklauskas, Amaratunga and Haigh (2009) explains that flood management can only be adapted based on the country’s existing state or the actual situation, economic, social, cultural, institutional, technological, technical, environmental and legal /regulations.

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