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Flood Risk and Its Effect on Property Value in Kuala Krai, Kelantan

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Abstract. The effect of flood risk on property value is vital because property is the most asset coveted by people for ownership. The attraction to live in a location induces people to give less priority to environmental threat such as flood. This study investigates whether the value of the properties was affected by flood risk by taking Kuala Krai, Kelantan, as a case study. By combining spatial analysis, Geographic Information System mapping and statistical analysis, this study included flood risk as one of the tested variables to determine whether it has affected property value. The statistical methods used were the Ordinary Least Squares regression model (OLS) and Geographically Weighted Regression (GWR). Market prices of a total of 811 transacted properties in the district of Kuala Krai were used to generate statistical model and property maps. The ArcGIS software was used to display and store modeled flood in the study area. The findings showed that higher property values were found around urban centers such as Kuala Krai, Dabong, and Manik Urai, although these areas were among the areas with deep flood inundation. The study disclosed that despite living in areas exposed to flood, the value of property was unaffected. On the other hand, the strategic location in the population concentration area has made it a more important factor than flood risk in determining the impact on property value. Furthermore, people's receptiveness, adaptability, and risk-taking attitudes were likely to have caused flood to have failed to dislodge the population from flood-prone areas. Another possibility was that flood-prone areas were important economic activity zones so much so that people were more interested to live and work there rather than responding to flood risk.

1. Introduction

Flooding is the inundation of land surface when water channels overspill their banks, a river bank is overtopped, water is overflowing onto land that usually is dry or when there is presence of water in areas that are usually dry, land not normally covered by water becomes covered by water, or there is a significant rise of water level in a stream, lake, reservoir or coastal region [2,3,7,8]. Flood is defined as a relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defenses [5].

Much has been said about floods. They are a disaster of global phenomena. They are the world's greatest natural disaster. A "flood disaster" is a flood that significantly disrupts or interferes with human and social activity. Many countries in all the five continents often suffered from flood. It causes great damage to buildings and natural environments and, further, it incurs cost of emergency measures, cleaning up and subsequent restoration that runs into millions of ringgits [8]. It causes disruption, financial loss, and irreplaceable possessions. Floods not only cause direct damage to the areas affected; they also have a cascading effect due to the decrease in property values in the affected areas. Flood is also a major concern for Malaysia [4]. It is the most severe natural disaster in Malaysia from the perspective of area extent, population affected and economic impact. It was estimated that some 29,000 sq. km (9% of the total land area) was flood prone and more than 2.7 million people (18%) were affected [7]. The average flood damage was estimated at RM100 million at 1995 price [1]. In the major flood event between 17th and 30th December 2014, two phases of heavy rainfall took place that caused discharges with an estimated return period of 500 years in various parts of the state of Kelantan, Malaysia, leading to severely disastrous flood along the length of rivers, especially Galas River and Kelantan River proper [9].

There was an extensive coverage throughout the flood and attention was drawn to the disruption it caused to people's livelihood and the hazards it posed. Figures on damages have been assessed but they were less than accurate. Most severely destructed areas were in Gua Musang, Kuala Kerai, and Dabong. Other severely inundated areas were in Machang, Pasir Mas, Tanah Merah, and Rantau Panjang [9].

Malaysia's National Security Council (NSC) said that the recent floods in Kelantan were the worst recorded in the history of the state. River levels in the December 2014 exceeded those of recent record floods of 2004 and 1967 [9]. Local media reported that the water level of Sungai Kelantan at Jambatan DiRaja, which has a danger level of 25 meters, reached 34.17 meters compared to 29.70 meters in 2004 and 33.61 meters in 1967. The levels at Tangga Krai, which has a danger level of 5 meters, reached 7.03 meters compared to 6.70 meters in 2004 and 6.22 meters in 1967 [9].

Agriculture is the main economic mainstay as well as the state's main landscape everywhere. The main crops cultivated are rubber, oil palm, paddy, and arable crops. Many of those living in towns or urban areas are doing small businesses to support their livelihood.

A large proportion of the agricultural areas is flood prone and has low productivity. The data on total Gross Domestic Product (GDP) of these affected areas were not available; however, most of the affected districts have a GDP lower than that of the states. Based on this guide, most of the population that was struck by flood has an estimated RM15,000 of annual per capita GDP on average. The state that has been frequently experiencing flood disaster almost annually has yet to recover from the destruction. Apart from possible income loss, flood has an important impact - loss of assets. In Kelantan alone, the estimated loss of assets from the December 2014's flood disaster was no less than RM 300 million [10]. Building assets (residential, industrial, commercial, institution, etc.) and non-building assets were severely affected. In smaller flood events, some areas in Gua Musang, Pasir Mas, Tanah Merah, Bachok, and Kota Bharu are still inundated by flood. With the low-level economic development and agriculture-dominated sector, it is interesting to discover whether flood has actually any significant impact to the people and one indirect way of finding out the answer is by examining the effect of flood risk on property value.

2. Material and Method

2.1 Flood Modelling
The flood modelling was performed utilizing the data set derived from the December 2014 flood event in Kelantan. The rainfall and river water levels for Kelantan were obtained online from the Malaysian Department of Irrigation and Drainage's (DID) telemetry stations (Figure 1) as well as from field work. Actual flood level was recorded on sites for the selected locations. An example of measurement is shown in Figure 2. The actual flood level measurement is based on the colour mark left on an object (e.g. wall). Based on the photo (Figure 3), the depth of the flood from the ground level was 3.7m. The location of

the site was also recorded using the Global Positioning System (GPS). Based on Figure 2, flood depth shown in the flood map was based on the height difference between the earth's surface including the normal or current level of the river and the maximum water level. If the current level of the river is higher or lower than the normal level, during data recording, the maximum flood level in the river will be in difference with the calculations made using normal level and telemetry station data.

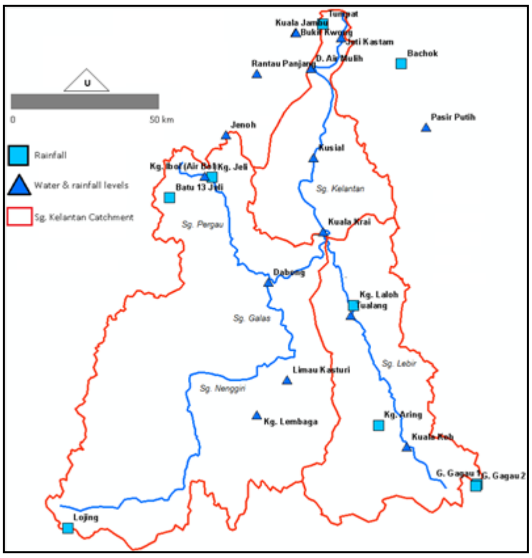

Figure 1. Telemetry Stations in Sungai Kelantan Catchment

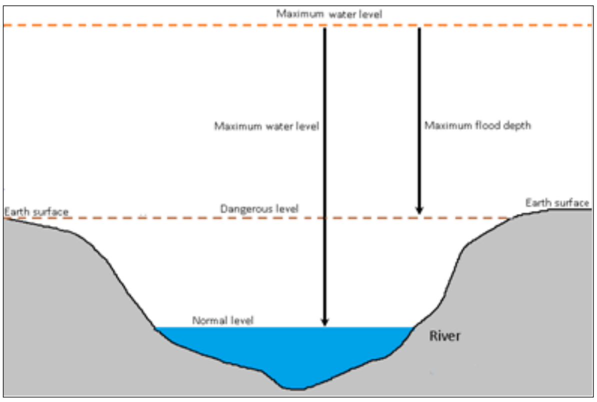

Figure 2. The Concept of Maximum Flood Depth

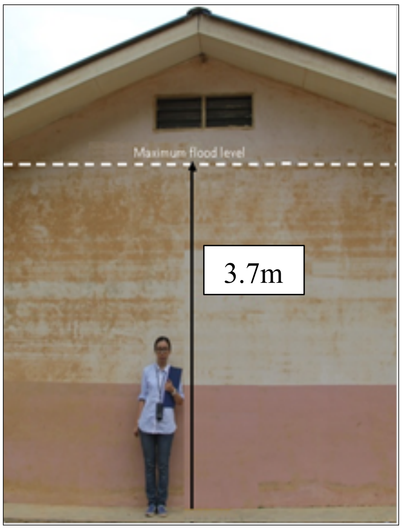

Figure 3: Measuring Actual Flood Depth

2.2 Property Value Modelling

The model was run using the OLS regression first with a purpose of checking for the significant factors determining property value. Since spatial prediction of property value was required, the GWR was then run using the list of variables from the OLS results.

The model was evaluated as the basis of variable significance. At least, each variable must be significance at 10% level (t= 1.65). Nonetheless higher level of significance at 5% (t=1.96) or 1% (2.3) was expected. Models goodness was also assessed based on plausible sign.

The general equations are specified as follows:

LANV = f (Flood Depth + *Mukim* + Current Activity + Length on Market + Percentage Damage + Distance to Town + Distance to Road + Lot Size)

BUIV = f (Flood Depth + Buildng Area + *Mukim* + Current Activity + Type of Building + Number of Rooms + Number of Floor + Percentage of Damage + Length on Market + Distance to Town + Distance to Road)

The lists of variables are summarized in Table 1.

Table 1. Description of Variables in the Study

Variable Names	Descriptive
LANV	Land value (RM/sq.m.)
Current Activity_1	Current activity- rubber (1=Yes, 0=No)
Current Activity_2	Current activity- oil palm (1= Yes, 0=No)
BUIV	Building value (RM/sq.m.)
Building Area	(sq.m)
Number of Rooms	Number of rooms
Number of Floor	Number of floor
Lot Size	Lot area (sq.m.)
Current Activity_1	Current activity – bungalow (1=Yes, 0=No)
Current Activity_2	Current activity – semi-detached (1=Yes, 0=No)

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Variable Names	Descriptive
Current Activity_3	Current activity – terraced (1=Yes, 0=No)
Type of Building_1	Residential (1=Yes, 0=No)
Type of Building_2	Commercial (1=Yes, 0=No)
Type of Building_3	Industrial (1=Yes, 0=No)
Length on Market	Length on the market (number of years of the parcel being sold as from January 2002)
Distance to Town	Distance to nearest town (m)
Distance to Road	Distance to main road (m)
Mukim	
Mukim_1	Mukim Kenor (1=Yes, 0=No)
Mukim_2	Mukim Kuala Pahi (1=Yes, 0=No)
Mukim_3	Mukim Manjor (1=Yes, 0=No)
Flood Depth	Flood depth (m) based on modeled flood*
Percentage of Damage	Structural x Content Damage

2.3 Damage Assessment
This study used a simple survey-based damage assessment involving a two-step procedure. In the first step, field inspection was conducted in the study area immediately after the December 2014's flood. Purposive random sampling was adopted in choosing locations for data collection. The sample was purposely chosen based on the extent of modeled flood – its coverage and direction – (see Figure 4), and then property damages were roughly assessed by visual estimates at 337 randomly selected points (ground sites) within the area of flood inundation (Figure 4). Each of these 337 observation sites was inspected.

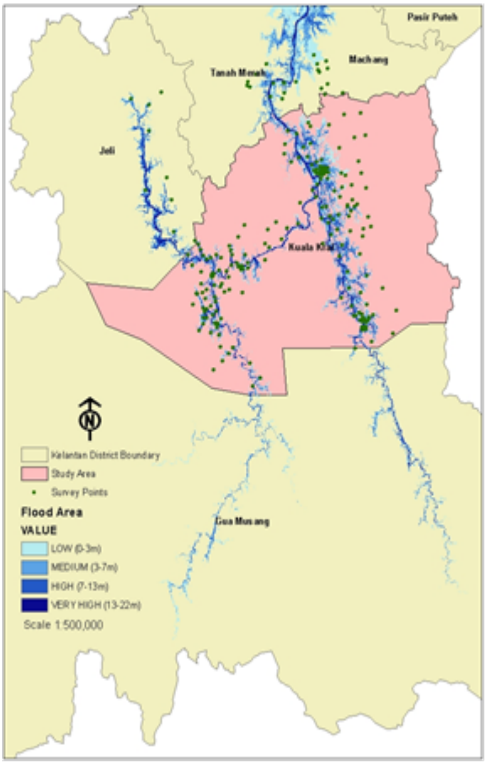

Figure 4. Surveyed Points of Flood Damage Assessment in the Study Area

During the field inspection, several aspects were observed and assessed. First, damages to property contents and structure were carefully examined. Structure refers to any building such as farm building, house, factory, etc. For agricultural property, structure can be the soil, trees, and any building on it. Content refers to any non-structural moveable components of a property such as furniture, tools, and equipment. The content and structural damages was expressed in percentage.

3. Result and Discussion

3.1 Ordinary Least Square

From Table 2 and Table 3, flood depth was found to be positive which means locations with deep flood were locations with high property value and significant at least at 10% level (0.06) while percentage of damage was positive which means locations with high damage were locations with high property value but was insignificant (0.86). The result for flood depth in Table 2 tells that as flood depth increased land value had increased as well. This outcome did not seem to conform to the basic theory that flood risk should have negatively affected property value [6,11,13,14,17].

Lot size did not seem to influence per unit property value while distance to town was found to be significant and has plausible sign. The regression result for length on market was quite interesting to interpret. The negative coefficient means that property value could have declined over time. The effects of property's current uses (bungalow, semi-detached, and terraced houses) were all seemed to be negative compared to the reference use ('others'). In the same way, properties located in Mukim1, Mukim2, and Mukim3 were all having lower average prices than those located in the reference location (other mukim).

Table 3 shows the results of OLS regression for building asset. Based on the table, F_DEPTH was positive but was insignificant while P_DMG remained insignificant. Based on Table 3, flood risk has no significant effect on building value. Number of floors, nearest distance to town, and size of main building were significant (5% level) and have plausible sign while number of rooms was significant (5% level) but did not show plausible sign for building asset. Other significant variables for building assets were Mukim 3, Current activity_1 and Type of building_2 but their sign can be regarded as sorta.

Table 2. OLS Regression for Per Sq. Meter Non-Building Value (LANV)

Variable	Coefficient	Std Error	t-Statistic	Prob.	VIF
Intercept	30.124044	3.244740	9.283963	0.000000*	-
Flood Depth	0.503940	0.271917	1.853287	0.064432	1.288918
Mukim_1	-9.989227	2.454975	4.068973	0.000061*	1.636756
Mukim_2	-1.455003	2.317652	0.627792	0.530429	1.194492
Mukim_3	-1.538732	2.354321	0.653578	0.513684	1.232587
Current Activity_1	-8.286236	1.893737	4.375599	0.000018*	1.422777
Current Activity_2	-13.042703	3.594478	3.628538	0.000327*	1.411629
Length on Market	-1.469779	0.273532	5.373330	0.000000*	1.061136
Percentage of Damage	0.000123	0.000711	0.172496	0.863110	1.262218
Distance to Town	-0.000346	0.000103	3.360193	0.000853*	1.681890
Distance to Road	-0.000987	0.000471	2.096606	0.036520*	1.197709
Lot Size	0.004536	0.027103	0.167350	0.867154	1.055161
Multiple R^2	**Adjusted R^2**	**Number of Observations**	**DOF**		
0.158278	0.139723	511	499		

Significant at *0.05 levels (2-tailed)

Table 3. OLS Regression for Per Sq. Metre Building Value (BUIV)

Variable	Coefficient	Std Error	t-Statistic	Prob.	VIF
Intercept	686.051901	197.276718	3.477612	0.000598*	-
Main Building Size	3.556362	0.337053	10.551354	0.000000*	2.222637
Number of Rooms	-73.294965	33.660666	-2.177466	0.030251*	2.157120
Number of Floor	341.494829	70.689258	4.830930	0.000003*	4.769542
Flood Depth	30.737480	17.209498	1.786076	0.075159	1.568064
Mukim_1	17.424721	173.843669	0.100232	0.920218	5.610233
Mukim_2	190.140760	177.729593	-1.069832	0.285596	3.190221
Mukim_3	250.363469	175.502162	-1.426555	0.154818	1.763579
Current Activity_1	543.755244	137.060777	-3.967256	0.000099*	1.616669
Current Activity_2	-65.268938	219.126657	219.126657	0.766036	1.319443
Current Activity_3	137.686229	108.438054	1.269722	0.205228	1.968195
Type of Building_1	251.739207	147.512393	1.706563	0.089005	1.657265
Type of Building_2	840.727723	169.255908	4.967199	0.000002*	2.296737
Type of Building_3	- 299.475258	322.177059	-0.929536	0.353389	1.323400
Percentage Damage	0.108113	0.055894	1.934254	0.054072	1.955947
Length on Market	-51.256451	14.271899	-3.591425	0.000399*	1.307153
Distance to Town	-0.019554	0.012300	-1.589786	0.113008	3.192553
Distance to Road	0.080169	0.112576	0.712132	0.476962	1.388259

Multiple R^2	Adjusted R^2	Number of Observations	DOF
0.680992	0.664143	300	284

Significant at *0.05 levels (2-tailed)

Looking at the multiple R^2 in Table 2, it can be concluded that the included variables in the non-building value model were lacking the explanatory power since they explained only 15.83% variation in the dependent variable. By contrast in Table 3, with multiple R^2 = 68%, the explanatory power of the building value model was moderately good.

To test the hypothesis that property value was more influenced by the locations of population centers or zones of economic activities, the property sample was split into four sub-samples, with four dependent variables that were used to measure property value namely, Flood-Hit Non-Building Value (143 sold properties), Flood-Hit Building Value (190 sold properties), Flood-Free Non-Building Value, (368 sold properties) and Flood-Free Building Value (110 sold properties).

Table 4 shows the OLS regression outputs. In Tables 4, except for Flood-Free Building Value the coefficient of distance to town which is -3.805 was significant at least at 10% significant level (two-tail test). It was clear then that there was some evidence of property value being negatively influenced by the locations of population center or zones of economic activities. From Table 4, it shows as property site was located farther away from the nearest town/population center, non-building value of flood-hit property could have dropped as much as RM 0.0007/sq.m. A drop of RM 0.03/sq.m. occurred to flood-hit building property. The value of flood-free non-building property could have dropped as much as RM

0.0002/sq.m. as distance was farther away from the nearest town. Overall, however, although the influence of distance to town/population center/activity zone was significant, the drop in property value against distance was very small indeed. All in all, we can consider that flood risk has a very little or no influence on property value in the study area irrespective of property value category.

Further, it can be said, from Table 4, that the factors included in the OLS regressions did not explain property value in the same way. For example, the reduction in value for building properties was higher against flood hazard as proxied by flood depth compared to non-building properties. The effect of property damage on property value was also slightly higher for building properties compared to non-building properties.

Besides, property value structure was also different by many other factors such as location (mukim) and type of activity. These results have indirectly demonstrated that the local property sub-markets have been influenced by value factors in a complex manner so much so that a generalization on the effects of these factors may not be possible. In other words, the influence of these factors needs to be assessed on the case by case basis.

Table 4. Results of OLS Regression for Property Value (RM/sq.m)

	Non-BuildingValue		**Building Value**	
	Flood-Hit	**Flood-Free**	**Flood-Hit**	**Flood-Free**
Multiple R	0.4556505	0.4762224	0.8084519	0.637423
R-Square	0.2076174	0.2267877	0.6535945	0.406308
Adj. R-Square	0.1410814	0.2073494	0.6237319	0.332861
Standard Error	27.837109	6.7764712	718.72176	677.337
Sample size	143	368	190	110
	Coefficients	*Coefficients*	*Coefficients*	*Coefficients*
Intercept	55.595862 (5.422) **	19.060971 (11.023) **	1297.183817 (3.197) **	787.93351 (2.437) **
Lot Size	-0.889826 (-0.963)	0.0045171 (0.393)	-	-
Building Size	-	-	-0.0327 (-0.824)	-0.007432 (-0.3515)
Flood Depth	0.1377431 (0.183)	-	-13.15029 (-0.413)	-
Mukim_1	-27.92434 (-3.391) **	-4.34325 (-3.568) **	186.71446 (0.513)	-164.705 (-0.577)
Mukim_2	-10.61445 (-1.533)	1.9643856 (1.607)	-219.9031 (-0.615)	-377.314 (-1.343)
Mukim_3	5.2035945 (0.244)	-0.056055 (-0.053)	-686.5801 (-1.760) *	-185.097 (-0.701)
Current Activity _1	-11.028871 (-2.051) **	-5.557287 (-4.967) **	-759.2716 (-4.230) **	-267.759 (-0.801)
Current Activity_2	-1.358412 (-0.086)	-9.913688 (-5.472) **	89.454971 (0.274)	149.0747 (0.342)
Current Activity_3	-	-	-29.16118 (-0.168)	507.5455 (2.482) **
Type of Building_1	-	-	829.86158 (4.176) **	545.5657 (1.920) *
Type of Building_2	-	-	1990.8023 (10.183) **	1578.517 (5.782) **
Type of Building_3	-	-	916.39823 (2.608) **	-
Length on Market	-3.042785 (-3.667) **	-0.769637 (-5.423) **	-72.74217 (-3.282)	-50.6538 (-1.978) **
Percentage of Damage	0.0008832 (0.630)	-	0.1537534 (2.079) **	-

	Non-BuildingValue		**Building Value**	
	Flood-Hit	**Flood-Free**	**Flood-Hit**	**Flood-Free**
Distance to Town	-0.000752	-0.000201	-0.034933	-0.00028
	(-2.274) **	(-3.805) **	(-1.609) *	(-0.009)
Distance to Road	-0.001274	-0.000938	-0.02376	-0.00714
	(-0.811)	(-3.952) **	(-0.102)	(-0.043)

Significant at **0.01 and *0.05 levels (2-tailed)

3.2 Geographic Weighted Regression

Apart from the OLS model, Geographically Weighted Regression (GWR) model was also run by assuming that each regression coefficient changes across space. Each coefficient was calculated as the mean of individual spatial coefficients of each variable, i.e. $\beta_i = \frac{\sum_i^n \beta_i}{N}$ where N is sample size. In this context, the GWR regression coefficients were equivalent to those of OLS. Tables 5 and 6 show the summarized coefficients of GWR. The non-building value model is shown in Table 5 while the building value model is shown in Table 6.

Based on R^2 in Table 5, GWR model for non-building value, the included variables have explained 16% variation in property value while 84% remained unexplained. Nevertheless, several variables were found to be statistically significant at least at 5% level. Again, flood depth was positively influencing property price, meaning locations with deep flood (high water level) were also locations with high property price. Interestingly, distance to town and distance to access road were negatively influencing property price.

Property price was plausibly related to these two variables whereby properties in locations far away from town or road have lower prices than those closer to them. Results for building value show that there was no evidence that flood hazard has reduced property value (coefficient for F_depth was positive). However, the product of property damage (%contents damage x %structural damage) did affect building value negatively. For building property, its distance from the nearest town positively increased property value although very marginally. Other significant variables were building size, properties located in Mukim Manjor (negative effect), Current Activity_3, Type of Building_1, Type of building_2 (negative effect), and distance from road.

Table 5. Results of GWR for Non-Building Value (LANV) (RM/sq.m)

Local R^2	0.16		
Cond	11.40		
Intercept	**Coefficient**	**std.dev.**	**t-value**
	30.12679043	3.244748438	9.28**
Flood Depth	0.503974096	0.271917539	1.85*
Mukim_1	-9.990157822	2.454981409	-4.07**
Mukim_2	-1.455428322	2.317658209	-0.63
Mukim_3	-1.538625995	2.354326593	-0.65
Current Activity_1	-8.286937247	1.893742744	-4.38**
Current Activity_2	-13.04337622	3.594487858	-3.63**
Length on Market	-1.469928671	0.27353303	-5.37**
Percentage of Damage	0.00012264	0.000710804	0.17
Distance to Town	-0.000346583	0.000103118	-3.36**
Distance to Road	-0.000987129	0.000470825	-2.10**
Lot Area	0.004537499	0.027103073	0.17

Significant at **0.01 and *0.05 levels (2-tailed)

Table 6: Results of GWR for Building Value (BUIV) (RM/sq.m)

Local R^2	0.68		
Cond	17.71		
Intercept	**Coefficient**	**std.dev.**	**t-value**
	3.51621239599	205.2610295	0.02
Main Building Size	26.93080388837	0.337440202	79.81**
Flood depth	110.24367483269	17.77714065	6.20**
Mukim_1	- 118.84758175435	180.7253504	-0.66
Mukim_2	- 275.58461721050	181.7303167	-1.52
Mukim_3	- 579.82204899702	176.4406971	-3.29**
Current Activity_1	-78.07500107166	141.3768013	-0.55
Current Activity_2	128.12274692646	218.2822584	0.59
Current Activity_3	243.60636465792	109.0069365	2.23**
Type of Building_1	827.56278511419	147.3285091	5.62**
Type of Building_2	- 278.49209266928	168.9802088	-1.65*
Type of Building_3	0.15758048736	320.8097948	0.00
Percentage of Damage	-50.77437010982	0.06261156	-810.94**
Length on Market	-0.00435989531	14.42423273	0.00
Distance to Town	0.06304863854	0.014266031	4.42**
Distance to Road	0.19786943919	0.114639173	1.73*

Significant at **0.01 and *0.05 levels (2-tailed)

4. Conclusion

From this study, two main findings had been discovered; There was no evidence of declining property value neither among flood-hit or nor flood-free locations. Even, there was indication that property value had continued to increase in those neighbor hoods over time, reflecting people's ignorance of flood risk within their living neighbor hoods. In the meantime, value factors such as land and building size, type of activity, location, and time factor (date of transaction) had remained as the pertinent property value determinants.

Also, with the seemingly non-declining property value against flood risk, in an indirect way, this study has examined property value as a reflector of people's willingness to pay to live in a flood-prone location. It was disclosed that while high flood depth has caused high property damages, high flood depth and high property value have also co-existed in almost all locations in the study area. This was evidence that flood risk has not deterred people in property ownership or in the choice of location for living.

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References

[1] CADMU (Crisis and Disaster Management Unit) 1999 Accomplishment, Current Activities and Future Requirements for Disaster Reduction in Malaysia. Division for National Security, Prime Minister's Department, Kuala Lumpur.

IOP Conf. Series: Earth and Environmental Science **549** (2020) 012074 doi:10.1088/1755-1315/549/1/012074

[2] Diya, S G, Gasim, M B, Toriman, M E, and Abdullahi, M G 2014 *International Journal of Interdisciplinary Research and Innovations*, **2(4)**: 59-65.
[3] Doswell, C. A. (2003). Encyclopedia of Atmosphere. London and New York: Elsevier Science Ltd.
[4] Dorasamy, M. and Raman, M. (2011). Proceedings of the 8th. International ISCRAM Conference, Lisbon, Portugal, May.
[5] DID (Drainage and Irrigation Department) 2003 Flooding Affecting the Klang Valley and the Generalised Procedures and Guidelines for Aassessment of Flood Damages. Final Report, Vol.2. Federal Territory / RTB Lembah Sg. Klang.
[6] Eves, C & Wilkinson, S 2013 *Natural Hazards*, **71(3)**, 1519–1536.
[7] National Water Resources 1982 National Water Resources Study, Malaysia. (**Vol.1**). Retrieved from: http://open_jicareport.jica.go.jp/pdf/10311934_01.pdf
[8] Pradhan, B, Shafiee, M, and Pirasteh, S 2009 International *Journal of Geoinformatics,* **5 (2)**: 11-23.
[9] Wan Nik, W Y and Hassan, U 2017 Pusat Kajian Strategik Negeri Kelantan
[10] Zainal Abidin Akasah and Sunitha V. Doraisamy 2015 *Journal of Scientific Research and Development*, **2 (14)**: 53-59.