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QUANTIFYING NATURE'S IMPACT: FLOOD VULNERABILITY AND THE MALAYSIAN RESIDENTIAL MARKET

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Abstract

Flooding, a frequent and devastating natural disaster, poses significant risks to residential property markets, including in Malaysia. This study aims to quantify the impact of floods on house prices in Johor Bahru, a region increasingly prone to flash floods. Approximately 468 property transactions from 2013 to 2022 were analysed using the Hedonic Pricing Model to determine how flood risk influences house prices. Contrary to the global consensus that flood exposure depresses property prices, the results indicate a modest price premium effect for properties located within flood-prone areas. This suggests that local market dynamics including strategic location, established neighbourhood amenities, and community risk adaptation offset the typical price discounts observed internationally. The findings offer new empirical insights for Malaysian urban studies and highlight that environmental risks may not be universally internalised in the same way across markets. The findings also offer insights for homeowners, buyers, planners, valuers, insurers, financiers, and policymakers, guiding informed decision-making in flood risk management and urban planning. Future research may explore other regions and incorporate additional spatial and environmental variables to better understand hazard-related price behaviour across diverse Malaysian contexts.

Keywords: Housing Prices, Real Estate Market, Flood Impact, Natural Disaster

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INTRODUCTION

Flooding is the inundation of land surfaces caused by water channels overflowing their banks, a river bank being overtopped, water overflowing onto normally dry land, or the presence of water in normally dry areas. Floods, which also significantly damage property, destroy crops, spread disease epidemics, and cause other losses, are the most frequent and significant losses each year. Land prices, according to land economics theory, represent the land's existing usage and future applications (Huang et al., 2006). Hence, floods may have an effect on the land's production and are likely to affect proximate property values. Residential areas affected by negative externalities are considered unattractive and undesirable for purchase, rent or investment resulting in price or rent discounts that may fetch up to 58% of discounts in price as disclosed by Jung and Yoon (2018).

Floods are one of Malaysia's most formidable and frequent natural disasters. The Department of Irrigation and Drainage 2012 research, which revealed that 10.1% (33,298 km²) of Malaysia's total land area of 330,436 km² is located within flood-prone zones and affects about 5.7 million Malaysians, highlighted the scope of this issue. The geographical location and climate of Malaysia make it susceptible to heavy rainfall and monsoons, leading to increased flood risk (Klijn et al., 2011). Between 2012 and 2019, Malaysia had the highest rate of flood hazards among ASEAN Member States. These flood events can have significant consequences for the residential property market, affecting property values, buyer behaviour, and overall market dynamics. Previous research has identified various factors influencing house prices in Malaysia, including government housing regulations, the country's economy, and demographics. However, there is a lack of research on the influence of flash floods on the Malaysian housing market. Thus, to address the knowledge gap, this research aims to ascertain the impact of floods on Malaysian house prices by utilising the Hedonic Pricing Model (HPM).

This paper offers two benefits. Firstly, it expands academic knowledge on flood impacts on house prices, particularly in Malaysia. This study significantly contributes to the discourse by juxtaposing worldwide assumptions, which uniformly indicate adverse pricing consequences of flood risk, with the actual dynamics of the Johor Bahru property market. International literature predominantly indicates price discounts; however, the Malaysian setting may reveal a distinct market logic influenced by local tastes, urban dynamics, and socio-economic adaptations. This constitutes a significant innovation of the study and highlights the necessity of localised empirical evidence for Malaysian urban research. The HPM approach allows for the estimation of the marginal contribution of various property attributes, including flood risk, to property values. By examining the relationship between flood exposure and property

values, this research will provide a comprehensive understanding of the impacts of floods on the Malaysian residential property market.

Secondly, the findings from this study guide property market participants in making decisions. Property owners will be aware of the potential risks and depreciation in property values associated with flood-prone areas and can make informed decisions regarding flood risk management and property investments (Shah et al., 2015). Buyers can use the findings to assess the potential risks and value of properties in flood-prone areas (Atta-ur-Rahman & Khan, 2011). Insurers and financiers can develop appropriate insurance and financing options tailored to the specific needs of properties in flood-affected regions (Muthusamy et al., 2019). Policymakers can utilise the research findings to formulate effective flood management and urban planning policies that mitigate the negative impacts of floods on the residential property market. This research elucidates the disparity between international findings and the pricing dynamics in Johor Bahru, so offering novel insights to Malaysian real estate scholarship and enhancing the comprehension of how urban markets in Southeast Asia assimilate environmental issues.

This paper is structured as follows. The second section gives a brief overview of the literature on how floods affect the housing market, and the third section elaborates on the methodology. The fourth section examines the impact of floods on house prices and discusses the results. The fifth section concludes the findings of this study. Based on previous studies findings, it is hypothesised that flooding will negatively impact the housing market through price discounts.

FLOOD IMPACTS ON THE HOUSING MARKET

Real estate's value is intrinsically tied to its purpose, utilisation, and the efficiency with which it fulfils its utility beyond its physical components of bricks and mortar. Among its defining features, the consumer's chosen location, the surrounding neighbourhood, and the quality of infrastructure stand out prominently. Within the global real estate industry, property values hold a pivotal position and are subject to a multitude of influencing factors. These encompass locational, structural, and neighbourhood attributes, each contributing to the overall value equation (Mohd Nazri et al., 2022; Suhaimi et al., 2021; Zihannudin et al., 2021). Structural attributes encompass elements such as bedrooms, bathrooms, fireplaces, garages, square footage, lot size, structural age, and even the presence of a pool. Meanwhile, neighbourhood attributes encapsulate the socio-economic characteristics of neighbours, the condition of neighbouring structures, ownership or rental status, ethnic composition, proximity to schools, tax districts, and the overall environmental quality. The concept of location holds particular prominence, encompassing access to various amenities and services.

Alonso's bid-rent theory further elucidates the significance of location, stating that individuals are willing to allocate a portion of their income based on the value of location. A residence positioned in a desirable locale will command a higher price during the bidding process, whereas a property in a less favourable area will naturally elicit a lower valuation.

A number of studies have observed that flooding events reduce property values compared to similar properties without flooding as a result of lower demand from buyers. An extensive literature has explored the effect on property sale prices from being located in a floodplain and flooding events. The consensus is that a property's location in a 100-year floodplain lowers its sale price by 4% to 21.5% (Bin & Landry, 2013; Miller & Pinter, 2022; Netusil et al., 2019; Zhang & Leonard, 2018) and 500-year floodplain lowers its sale price by 5% to 7% (Miller & Pinter, 2022). Meanwhile, in some studies major floods are estimated to cause price discounts that exceed 75% (Beltrán et al., 2018).

In research based in Australia, Fuerst and Warren-Myers (2019) demonstrate a discount of 1 to 3% for properties and a 2 to 5% discount in land value for properties located in a flood risk area. Meanwhile, in the Vietnamese housing market, Bui et al. (2022) revealed that houses exposed to the flood event underwent a notable price reduction of 9% following a substantial flood occurrence on September 30, 2017. Rabassa and Zoloa (2016)'s study in Argentina indicated that residences in floodplains are valued around 3.5% less than comparable houses. In fact, residences in higher risk locations receive a double discount on prices. This indicates that risk exposure leads to greater negative effects on property values.

Hurricane events may also lead to flood events that may impact the value of properties inundated. Ortega and Taspinar (2018) discovered a significant 9% drop in house prices post-hurricane Sandy. Bin and Landry (2013) analysed homes in Pitt County, North Carolina, that were hit by hurricanes in both 1996 and 1999 to estimate the reaction of prices post hurricane. Their estimates indicated that homes affected by floods fall in value by about 7% in immediate aftermath. Nevertheless, the discount dissipated within six years. These results echoed the findings of Atreya et al. (2013) and Atreya and Ferreira (2015), who documented that homes in flood plains that have not recently flooded do not sell at a discount relative to homes outside of flood plains. In another United States based study, Aliyu et al. (2016) also observed that the price discounts only affect properties temporarily. Flood price discounts may vary both temporally and geographically.

A study in the US by Zhang and Leonard (2018) observed a rise in price discounts by almost 13% following flood events and that the price discount increases by 8.6% when comparing properties inside the floodplain to those 1000-1500 ft away, compared to those immediately outside the 100-year floodplain.

Meanwhile, in South Korea, Jung and Yoon (2018) discovered that the impact of the distance of a flooding disaster is within 300 m of an inundated area. Market values of housing located 0–100 m, 100–200 m, and 200–300 m from inundated areas were lower by 11.0%, 7.4%, and 6.3%, respectively. Nonetheless, the effect lasted for 12 months' post-disaster. During the first month, first three months, and second three months after impact, houses located within 300 m of the inundated area experienced a price discount of about 57.6%, 49.2%, and 45.9%, respectively. However, after six months, the discount effects were reduced to 33.2%.

Overall, the existing studies provide limited evidence that natural disasters exert lasting effects on property prices. In the short run, price effects are limited to those homes that sustained damage, and prices will return to their previous pre-disaster level after 2–3 years at most, according to studies of Atreya et al. (2013) and Miller and Pinter (2022). In Australia, Rajapaksa et al. (2016; 2017) analysed the impact of flood on single dwellings and observed between 5% to 18% price discount. Nonetheless, this impact fades from the property market over time. Regions with more amenities and located in high income areas were shown to recover faster in spite of flood risks than regions without these characteristics (Rajapaksa et al., 2016; 2017).

Previous studies have disclosed findings for various countries except for Malaysia. This causes difficulties to draw conclusions on the impact of flood risk on property values in Malaysia. Homebuyers' flood risk perception may be impacted by government flood management initiatives, damage compensation laws, and insurance policies (Mutlu et al., 2023). Thus, the findings are expected to vary by country, including Malaysia. To the authors' knowledge, Ismail et al. (2016) is the only Malaysian study that quantified flooding's influence on property prices. The study found that a one-hour increase in flood duration decreased urban and rural land prices by 4.2% and 4.7%, respectively. This shows that prolonged flooding lowers property prices in urban and rural areas. The constant flooding causes property damage, leading to this depreciation tendency.

In another study based in Malaysia, Razali et al. (2018) examined the repercussions of flood hazards on residential property value within the Langat River area and concluded that the residential properties prices within the study area experienced only marginal effects. This study encompassed a range of housing estates, spanning both suburban and rural areas. A recent study in Kelantan by Abd Hamid et al. (2020) found that property values were unaffected by flood due to the strategic economic location and local people's adaptability and risk-taking mindsets when residing or working at flood-prone locations.

The emphasis on house price effects distinguishes the study from Ismail et al. (2016), who investigated land price impacts. By concentrating on a dense urban area with frequent flash-flood occurrences, this study contrasts with

Razali et al. (2018), who focused on low-density locations. It also differs from Abd Hamid et al. (2020), which explored flood impacts at a broader macro level instead of the micro-level perspective adopted in this paper.

RESEARCH METHODOLOGY

The research was conducted in Johor Bahru, Malaysia's second-largest metropolitan centre, home to over 876,000 residents (Mohd Nazri et al., 2022). Notably, Johor Bahru holds the unfortunate distinction of having the highest number of flash floods in Johor State, with the frequency of these floods showing a concerning upward trend over the years (Department of Irrigation and Drainage Malaysia, 2012). This surge in flood occurrences has direct implications for all types of properties in Johor Bahru, a city characterised by rapid development. It's expected that properties situated within flood-risk zones will face value depreciation. The research specifically scrutinised properties located within flood areas as well as areas outside flood areas to facilitate price impact comparisons between both areas. Residential areas under study encompass Taman Kempas, Taman Kempas Baru, Taman Kempas Permatang, Taman Setia Indah, Taman Sri Tebrau, Taman Tampoi Indah, Taman Tampoi Utama, and Taman Dahlia. Figure 1 illustrates the study area.

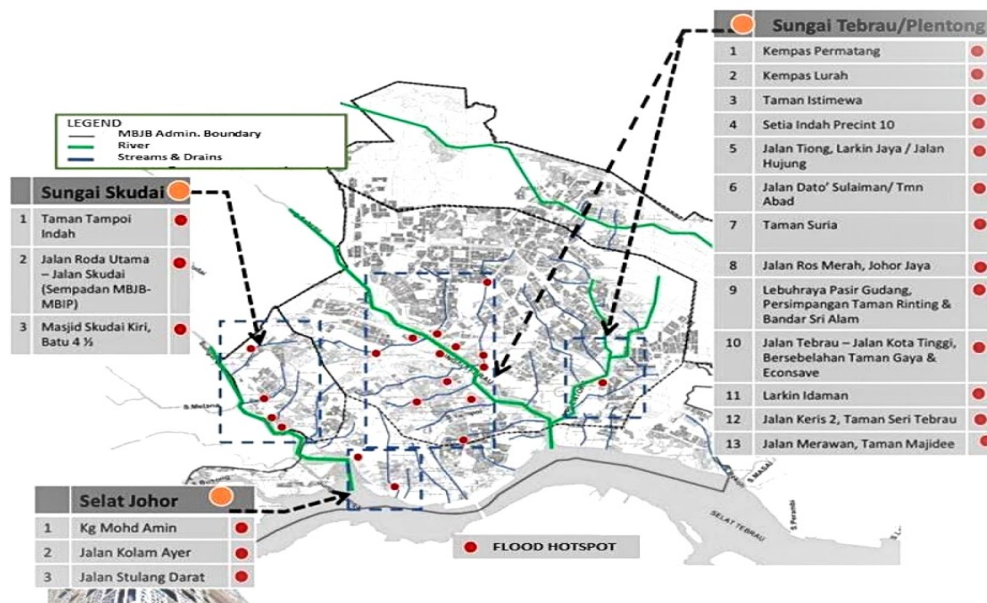


Figure 1: The Study Area
 Source: Johor Bahru City Council Data (2023)

The study's dataset comprised 588 property transactions spanning from 2013 to 2022, meticulously collected from the Valuation Management System. The database contained property transaction prices, location, structural features, and neighbourhood characteristics, which are theorised to affect property prices. To ensure high quality results, data containing anomalies and missing attributes were excluded. The accepted data range were as follows; transaction price between RM 115,000 and RM 890,000, land area between 1,040 ft² and 2,939.73 ft², terrace and semi-detached house types; single storey and double storey houses. Most homes (92%) were either intermediate, end, or corner terrace houses. This thorough cleaning process resulted in the elimination of 120 observations, yielding 468 observations as the final estimation sample. The dataset underwent analysis employing the Hedonic Price Model to assess the impact of various housing attributes on prices, encompassing flood-prone regions. Table 1 tabulates the dataset.

Table 15: Descriptive Statistics

Variables (N=468)	Min.	Max.	Mean	Std. Dev.
Price (RM)	115,000	890,000	468,821.97	147,569.42
Hotspot Flood Area	0	1	.55	.498
Land Area (ft ²)	1,040.00	2,939.73	1,624.32	506.10
Taman Dahlia	0	1	.03	.009
Taman Kempas	0	1	.13	.335
Taman Kempas Baru	0	1	.02	.007
Taman Kempas Permatang	0	1	.01	.004
Taman Setia Indah	0	1	.57	.023
Taman Sri Tebrau	0	1	.08	.012
Taman Tampoi Indah	0	1	.09	.014
Taman Tampoi Utama	0	1	.06	.011
Year 2013	0	1	.1538	.36119
Year 2014	0	1	.0385	.19251
Year 2015	0	1	.0983	.29803
Year 2016	0	1	.1004	.30089
Year 2017	0	1	.1303	.33704
Year 2018	0	1	.1197	.32491
Year 2019	0	1	.1068	.30927
Year 2020	0	1	.0513	.22081
Year 2021	0	1	.0598	.23742
Year 2022	0	1	.1410	.34842

Source: Author's Analysis

The subsequent equation depicts the house price function.

$$P = f(L, S, N) \quad (\text{Eq. 1})$$

P represents house prices, L represents locational attributes, S represents structural attributes, and N represents neighbourhood attributes.

Equation 2 below defines the general equation for the Hedonic Price Model:

$$Y_{it} = \beta_0 + \beta_1(X_{1m1}) + \beta_2(X_{2m2}) + \beta_3(X_{3m3}) + \beta_4(X_{nmn}) + \varepsilon_i \quad (\text{Eq. 2})$$

Where; Y_{it} = Forecasted House Price; m = Price of house i at time period t ; X = Property attributes; β = Regression coefficient; ε_i = Error term

In this study, the response variable was Price (RM), while the predictor variables encompassed land area, housing scheme, transaction year, and flood-prone regions. The model's performance was evaluated through statistical tests including R Squared (R^2), Adjusted R Squared ($\bar{R}^2$), F value and Sum of Estimated Errors (SEE). A robust model is characterised by R^2 and $\bar{R}^2$ values that approach 1, a substantial F value, and a minimal SEE value (Adi Maimun, 2011; 2016; Adi Maimun et al., 2015; Adi Maimun & Choon, 2024). Meanwhile diagnostic test through Variance Inflation Factor (VIF) and tolerance was conducted to detect any presence of multicollinearity or strong relationship between independent variables. Multicollinearity causes high variances and specification errors (Kennedy, 2003) leading to inaccuracy in prediction (Rahman et al., 2019; Sa'at et al., 2021). A model with a VIF value under five and a tolerance value exceeding 0.2 indicates no evidence of multicollinearity (O'Brien, 2007).

RESULTS AND DISCUSSION

Table 2 presents the regression findings. Linear Model delineates the price impacts of flood measured in monetary value (RM), while Semilog Model elucidates the outcomes measured in percentage (%). Overall, considering the R^2 and $\bar{R}^2$ values, both models demonstrate the ability to account for 84% of the price variation, employing factors like land area, housing scheme, transaction year, and flood-prone regions, yielding a Sum of Estimated Errors (SEE) of 60,924 or 16%. Importantly, neither model exhibited any indications of multicollinearity.

Table 16: Regression Results

Variables	Linear Model		Semilog Model	
	B	t	B	t
Constant	-29197.706	-1.453	11.636	225.971
Hotspot Flood Area	33976.428	4.433	.063	3.227
Land Area (ft ²)	82.720	10.614	.000	8.749
Taman Dahlia	Reference	Reference	Reference	Reference
Taman Kempas	84758.890	4.874	.373	8.373
Taman Kempas Baru	34521.710	1.376	.175	2.720
Taman Kempas Permatang	-25120.195	-.628	.072	.698
Taman Setia Indah	301404.862	17.446	.948	21.428
Taman Sri Tebrau	155195.372	6.796	.628	10.740
Taman Tampoi Indah	187513.261	9.287	.708	13.694
Taman Tampoi Utama	155111.946	7.989	.602	12.112
Year 2013	Reference	Reference	Reference	Reference
Year 2014	37083.440	2.289	.094	2.268
Year 2015	84871.376	6.937	.191	6.083
Year 2016	89937.344	7.698	.224	7.476
Year 2017	132540.397	12.256	.320	11.533
Year 2018	152344.170	13.827	.375	13.289
Year 2019	166958.076	14.731	.400	13.764
Year 2020	175689.755	12.069	.404	10.820
Year 2021	167337.273	12.030	.416	11.680
Year 2022	210148.975	20.001	.500	18.576
R	0.914		0.916	
R Squared (R^2)	0.836		0.838	
Adjusted R Squared ($\bar{R}^2$)	0.830		0.832	
Sum of Estimated Errors (SEE)	60923.764		0.156	

Source: Author's Analysis

All variables corresponded the theoretical principles. Referring to Table 2, it's evident that land area significantly influences the property value per square foot, as indicated by the positive Beta value of 82.720. This suggests that a mere increment of one square foot in land area could potentially lead to a price augmentation of RM82.72 in the property's overall value. Notably, for transaction years, most variables displayed significant values below 0.05. The upward trajectory of Beta values from 2014 to 2022 underscores the trend of ascending property values observed in recent transactions, indicating a potential continued increase in property values.

The influence of floods on residential properties in Johor Bahru stands as a significant point of insight for researchers. The coefficient for the hotspot flood area was unexpectedly positive (RM33,976.43 or 6.3%), implying that properties located within this zone do not experience a detrimental impact that would lead to decreased property prices. The findings of this study diverge from prior research which asserted a negative correlation between floods and property prices. Rather, this finding echoes with Abd Hamid et al. (2020) who discovered

that flood did not impact on property prices. This contrast is attributed to the infrequent occurrence of floods and a confluence of other factors that enhance property value, including the strategic housing location, land size, built-up areas, number of floors, and various other variables.

CONCLUSION

This research aimed to investigate the influence of floods in the Johor Bahru property market in Johor Bahru. Through a comprehensive examination involving both the flood and its adjacent residences in Johor Bahru, this study effectively discerned the repercussions of the flood's impact on house prices within its vicinity. Drawing from a sample of 468 house observations spanning from 2013 to 2022, the application of hedonic analysis did not demonstrate a negative response of house prices to floods. The price risk associated with owning residential properties in both flood-prone and non-flood zones was comparably similar. Interestingly, property owners in flood-prone areas seem to pay slightly higher prices compared to those in non-flood prone regions. This study's analysis uncovered a positive coefficient value, an outcome contrary to the anticipated norm as disclosed in previous studies, which suggested that flood occurrences typically correlate with a decrease in property prices. This leads to the conclusion that, perhaps due to the relatively minor scale of the floods under investigation, they did not exert a detrimental impact on residential property prices in Johor Bahru.

This insight has implications for the real estate profession; valuers can proceed with their property assessments in Johor Bahru without immediate concern for flood risk, unless findings indicate otherwise, prompting adjustments in flood-prone areas. Notwithstanding, it is foreseeable that the flood-hazard element could significantly influence property values in the future. This concept warrants further exploration in comparable case study locales in forthcoming research endeavours. The findings of the study yield a robust model; however, its precision could be augmented by incorporating all factors influencing property values.

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ETHICS STATEMENT

This research complies with established ethical standards for the use of secondary administrative data in real estate and urban studies. All transaction records were

obtained from the Valuation Management System through authorised channels and used strictly for academic purposes. No personal identifiers, confidential information, or sensitive individual-level data were accessed or disclosed. Analytical procedures adhered to Universiti Teknologi Malaysia's research integrity guidelines, ensuring accuracy, transparency, and responsible handling of data throughout the study.

DISCLOSURE STATEMENT

The authors declare that they have no relevant financial and non-financial interest to disclose. The authors also declare no competing interests.

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