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An assessment of multiple variables predicting the psychological effects of flooding: Case study in Peninsular Malaysia

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ABSTRACT

Floods are among the most disastrous environmental hazards, causing devastating tangible and intangible impacts. The psychological impact, which can be classified as intangible damage, is an important aspect of human's well-being. The psychological impact of flooding has begun to receive attention in recent years, but the complexity of measuring it makes it less attractive to be considered in actual flood damage and risk studies. The present study seeks to evaluate the psychological impact of flooding experienced by households and business premises and the different factors that could be the determining variables of the psychological impact. A total of 217 respondents have participated in the empirical face-to-face survey conducted in different vulnerable places in Peninsular Malaysia. Through the willingness-to-pay (WTP) method, only 107 and 34 respondents from residential and business premises, respectively, expressed their agreement to spend on flood risk reduction efforts. The study found that flood durations and family sizes are statistically significant contributors to intangible damages for households, reflecting the intangible damages to residential sector. The results suggest a greater investment to support affected people's welfare by improving community awareness and shelter facilities. These will enhance risk management efforts and reduce the psychological impacts to people at risk of flooding. The findings also revealed a key challenge: the inability to reliably infer intangible flood damages for business sectors through empirical evidence.

Keywords: Intangible damage, Flood psychological effect, Socioeconomic variables, Willingness-to-pay.

1. Introduction

Flooding caused significant harm beyond immediate physical damage, causing long-lasting psychological effects on affected communities. Flood impact is increased by climate change, which increases the frequency and intensity of flooding, causing a psychological impact on residents. The psychological impact includes stress,

https://doi.org/10.5194/egusphere-2025-2917
Preprint. Discussion started: 14 July 2025

anxiety, fears, and worries, with vulnerable populations, particularly women, suffering greater effects (Salleh & Mustaffa, 2016). Historical event of flooding, like the 2014 disastrous flooding in Malaysia, highlights the extensive psychological impact on individuals and the community, underscoring the importance of intangible damage in flood risk assessment (Ridzuan et al., 2022).

Conventional flood risk models have primarily focused on tangible damages, such as physical and economic losses; however, psychological damages are frequently neglected. This omission has resulted in an incomplete assessment of how floods affect the community's well-being. Psychological impact is important to address to achieve a more holistic understanding of flood impacts (e.g., Akhir et al., 2021).For instance, studies have shown that communities with strong social networks and organized shelter systems experience less anxiety and stress during flood recovery periods (Zahari & Hashim, 2018). It is important to consider both tangible and intangible damage to better manage flood impacts.

Flood risks and their impact are disproportionately spread across various socioeconomic groups. Elements such as building age, closeness to flood-prone areas, and family income levels play an important role in determining flood vulnerability (Fatemi et al., 2020). Vulnerable communities often live in poorly maintained homes, heightening the physical and psychological damage during floods. Geographic factors, such as living closer to the river or in a low-lying zone, face severe flood impacts (Yang et al., 2020). The socio-spatial inequalities require focused strategies that address both physical and social vulnerabilities.

Recent advancement in flood risk assessment emphasizes the importance of integrating multiple variables to understand the interaction between flood characteristics, socioeconomic characteristics, building characteristics, and psychological effects. Research utilizing the multivariate methods has shown that assessing multiple variables, such as flood depth and building conditions, provides a more precise evaluation of community vulnerability and resilience (Hudson et al., 2017). This holistic approach assists in identifying important factors affecting both physical and psychological impacts, thereby improving disaster preparedness and recovery strategies (Foudi et al., 2017). This study has recommended models that capture these complex relationships to support more effective and fair policy-making.

A comparison of flooding events across different periods reveals that the impact on both residential and business properties has intensified over time (Merz et al., 2010). Numerous studies have quantified the tangible damage to those two type of properties (Van Ootegem et al., 2015; Kabirzad et al., 2024). However, intangible damage to residential and business properties has often been overlooked due to challenges in assessment and valuation, as well as ethical and social complexities (Frongia et al., 2016; Nafari & Mendis, 2018, Babcicky et al., 2021). Intangible damage is critical for understanding the full impact of floods on individuals and communities (Babcicky et al., 2021). Research emphasizes that intangible flood damages can, in many cases, be more severe than tangible losses (Nga et al., 2018;Han et al., 2023). There remains a need for flood risk models that integrate physical, social, and psychological dimensions.

https://doi.org/10.5194/egusphere-2025-2917
Preprint. Discussion started: 14 July 2025

This study aims to assess intangible flood damage represented by the psychological effects of flooding experienced by households and businesses in Peninsular Malaysia. The contribution of multiple variables was analysed to gain insights into the factors governing the intangible losses. The multiple variables include flood characteristics, building/business/physical characteristics, and socioeconomic characteristics. The damage is quantified using the willingness-to-pay (WTP) approach based on the flooded area, and its relationship is assessed with a linear regression model.

2. Methods

This study defines intangible damage as psychological health impacts such as stress, emotional instability,

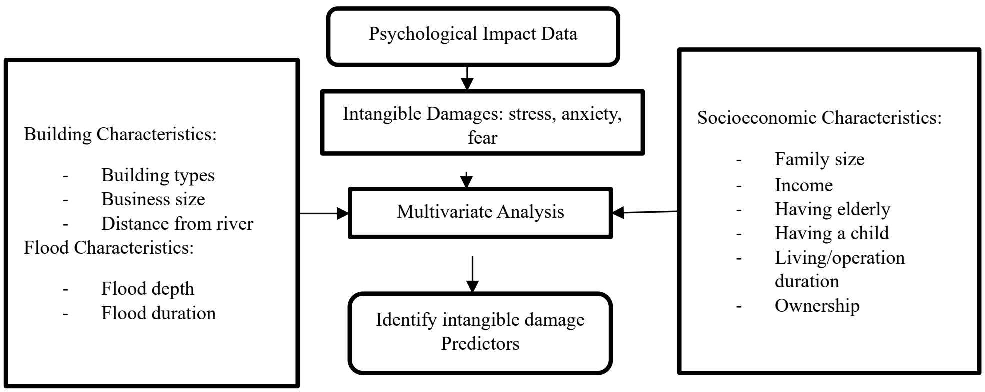

Figure 1. The intangible damage assessment and the independent variables used in the multivariate analysis for the damage model.

wariness, and anxiety that befall people exposed to flooding. Questionnaires and interviews were used to survey respondents and gather information on flood damage and its independent variables. Figure 1 shows briefly the methodology of this study. The dependent variables focused on intangible damages, while a total of eleven independent variables were considered: flood depth, flood duration, building type, proximity to water bodies, business type, household size, years of living/operation duration, ownership, income, and the presence of elderly individuals or children. Of the aforementioned variables, seven were specifically applied to business premises. The method applied to assess the non-market value of the intangible damage is the Contingent Valuation Method (CVM) through the willingness-to-pay (WTP) approach. Ultimately, a multivariate regression analysis was undertaken to identify the contributing factors to the intangible damage of residential and commercial premises. The data underwent outlier treatment using skewness and a three-standard-deviation cutoff, followed by necessary preparation before model fitting. To ensure no data fell outside the acceptable range, further cleaning was performed using the Mahalanobis distance method. This included transformations(e.g., Svenningsen et al., 2020) to accommodate non-Gaussian variables in their original form. For residential buildings, the datasets were log-log transformed, except for categorical independent variables such as building type, presence of elderly residents, presence of children, and ownership status. For commercial buildings, the datasets remained untransformed (except for income data, which was log-transformed), as the other variables met Gaussian distribution criteria. Microbusinesses were defined as those with fewer than five employees, while small-to-medium enterprises (SMEs) were classified as having up to

https://doi.org/10.5194/egusphere-2025-2917
Preprint. Discussion started: 14 July 2025

2.1. Study Area and Respondents

Approximately 10% of Peninsular Malaysia is vulnerable to flooding, impacting 21% of the total population (Department of Drainage and Irrigation, 2012). Survey locations were identified through a rigorous review of authorized documents and reports, such as those published by the Department of Irrigation and Drainage (2012), Kuala Lumpur City Hall (2015), and the National Statistics Department. Grey literature and open-source websites were also consulted to verify and supplement case study area selection. Figure 2 displays the study sites where the data were collected: Kuala Lumpur Federal Territory, Selangor, and Kelantan states. In Kuala Lumpur, the Segambut area was chosen because of its history of frequent flooding and significant past evacuations. In Selangor, survey locations included Kajang and Dengkil, where previous flood events had led to large-scale evacuations. Surveys were conducted in 2020 across various locations. Each respondent was approached individually at their residential or business premises, where only those who had lived in the flood-affected areas within the last ten years and had experience of flooding.

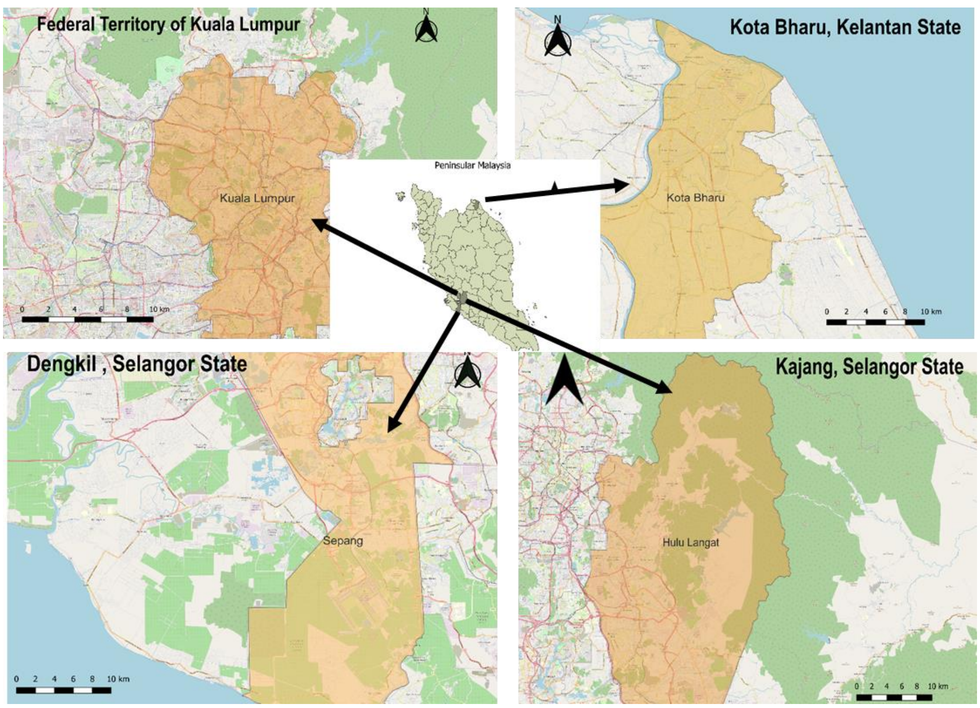

Figure 2. Areas where surveys were conducted in Peninsular Malaysia, and the yellow area is the district or territory boundaries. Top left: Kuala Lumpur Federal Territory; Top right: Kota Bharu district, Kelantan; Bottom left: Dengkil, Sepang district, Selangor; Bottom right: Hulu Langat district, Selangor (© OpenStreetMap 2024). Distributed under the open Data Commons Open Database License (ODbl) v1.0.

Within the capacity of the study, 380 face-to-face interviews were successfully conducted. From the total, 217 were valid responses. Out of the 217 respondents, only 141 (107 residential and 34 businesses) expressed willingness to pay for disaster risk reduction measures to reduce their psychological distress. The remaining 76

https://doi.org/10.5194/egusphere-2025-2917
Preprint. Discussion started: 14 July 2025

respondents denied the willingness to pay due to different reasons. Table 1 shows the number of buildings, both residential and business, where households and business owners were interviewed. ~~Forty-two percent~~ of residential respondents and 67% of business respondents were from the Kota Bharu (Kelantan) study area, where terrace buildings constituted the majority, accounting for almost 40% of the total, followed by low-cost houses. The respondents from the Segambut district of Kuala Lumpur were minimal, mostly living in terraces and low-cost houses. This indicates that respondents from the Kajang and Dengkil area of Selangor and the Kota Bharu district of Kelantan reside in terrace building types. In the business premises, the predominant type of businesses were micro-sized enterprises, followed by small-medium-sized businesses. The Kota Bharu study site recorded the highest flood depth for both residential and commercial buildings, attributed to a significant flooding event in 2014. The case study sites and flooding events occurred in different years, but these locations have experienced severe flooding over the past decade, affecting both residential and business.

Table 1. Summary of the respondents in residential and business premises categories across the study sites

Study Site	Respondents' flood-year experiences	Residential building type				Business Type		
		Bungalow	Terrace	low-cost	Total	Micro	Small-medium	Total
Segambut	2010-2020	2	8	17	27	2	2	4
Kajang & Dengkil	2020	5	21	9	35	6	1	7
Kota Bharu	2014	16	14	15	45	18	5	23
Total respondents (%)	Sample size	23 (21%)	43 (40%)	41 (38%)	107 (100)	26(76%)	8(24%)	34 (100)

Most respondents were from residential buildings, with fewer businesses represented due to limited commercial activity in the surveyed regions. Engaging with the business sector was challenging because of their demanding schedules. Additionally, some retailers and service shops had relocated to safer areas. During the interviews, efforts were made to ensure that the cost of intangible losses was accurately estimated. First, household heads, business managers, and owners in the exposed area to flooding were asked about the psychological impact they faced during previous flood events. After listening to their description, they were then explained about the effects of stress, wariness, and the various flood mitigation efforts that can help reduce flood impacts that their facing. Despite the efforts, getting the respondents' positive response to the issue and in valuing the psychological impacts proved to be challenging and even sensitive to some. When they were asked about their willingness to contribute monetarily to safeguard themselves from the psychological effects by flooding, some expressed their contribute, and others did not. Respondents also shared their reasons for not contributing, such as: "I do not have enough income," "It is the government's responsibility," "I cannot trust anyone," and "The flood impact is not very severe" The survey evaluated various factors essential for assessing flood-related intangible damage.

2.2. Relation of income and business size with WTP

https://doi.org/10.5194/egusphere-2025-2917
Preprint. Discussion started: 14 July 2025

The present study elicited the monetary value of psychological impact from respondents to better understand and address future flood impacts. The elicited value is assumed to represent the economic value of the health impact, based on respondents' flooding experiences and their recollection of its effects on their health. This value is presented as an absolute figure in US dollars (US$) for each flood event. Furthermore, the results were adjusted for the inflation rate using the Malaysian Consumer Price Index calculator to maintain consistency and comparability across different periods (Malaysia CPI Inflation Calculator, 2021).

In order to assess how the monetary value of WTPs varies according to income categories and business sizes, samples were sorted according to income levels and business sizes of respondents. Residents were divided into three socio-economic groups: B40 (bottom 40%), M40 (middle 40%), and T20 (top 20%). The B40 group included those earning less than US$11301 per month, the M40 group covered incomes between US$1130 and US$2553.45 per month, and the T20 group consisted of households earning more than US$2553.45 per month. This classification followed national standards and previous research (e.g. Kabirzad et al., 2024), but remains open to revision as socio-economic conditions change (Department of Statistics Malaysia, 2020). Businesses were categorized into micro and small businesses based on the number of full-time permanent employees. Micro businesses were defined as having fewer than five employees, while small businesses included those with five to thirty employees (SME Corporation Malaysia, 2022).

The data visualization methods, such as bar charts, were used to analyse patterns of flood exposure and the extent of damage across different income groups. The study concentrated on assessing whether lower-income households and small businesses suffered high risks and greater intangible losses, especially in terms of psychological health effects and interruptions to business operations. The result aimed to offer empirical evidence to target flood mitigation measures and mental health assistance for at-risk communities.

2.3. Regression Analysis and Model Specification

A multivariate regression analysis was performed to explore the relationship between flood intangible impacts and multiple factors. Samples were treated based on statistical assessments of skewness and standard deviation, where outliers with extreme values were winsorized, before the regression. The data was also transformed (e.g., Svenningsen et al., 2020) to accommodate non-Gaussian variables in their original form. For residential buildings, the dependent and independent variables were log-transformed, except for categorical independent variables, such as building type, presence of elderly residents, presence of children, and ownership status. For commercial buildings, only the income variable was log-transformed, and other variables met the Gaussian distribution criteria.

The regression models produced coefficients for all significant variables, with equations designed to assess predictors of intangible flood damages. These models enabled the identification of key factors contributing to damage severity among different socio-economic groups (Lee, 2020).The regression analyses related to statistical

[1] US$ values have been exchanged from Malaysian currency (MYR) used in the Survey(s).

https://doi.org/10.5194/egusphere-2025-2917
Preprint. Discussion started: 14 July 2025

significance for this study employed different significance thresholds, such as 5% or 1 % (e.g., Lamond et al., 2015).

The regression models included both categorical and continuous variables to conduct a thorough analysis of the variables impacting intangible damage (Table 2). Variables such as building and household attributes, including size and distance from rivers, were assessed alongside socioeconomic indicators like income and length of residence (Kabirzad et al., 2024). The goal of the analysis was to identify predictors that significantly influenced the psychological condition of respondents in the face of flood events.

Table 2. The independent variables were used in the multiple regression assessment.

Explanatory Variables	Description	Multivariate analysis
Flood characteristics		
Flood depth	Water depth inside the building from the ground floor, range residential (0.3-2m), business (0.3-1.6m)	Continuous variable
Flood duration	Water duration stays around the house during the day, ranging (1-14 days)	Continuous variable
Building or business characteristics		
Building type (low-cost type, Terrace, Bungalow)	Low-cost, terrace or bungalow	Dummy variable (Low-cost house = 0, Terrace & bungalow =1)
Business size	The micro or small-medium business premise	Dummy variable (Micro = 0, Small to medium = 1)
Distance from River	Distance of building from the fluvial flood stream, residential(15-1307m) and business(5-1250m)	Continuous variable (meter)
Socioeconomic conditions		
Family Size	Number of members in the household or family(1- 12 persons)	Continuous variable
Ownership	Tenant or owner	Dummy variable (Tenant = 0, Owner=1)
Income (family/Business)	Average monthly income per household or revenue per premise of residential (MYR500-10,000) and commercial (MYR500-20,000)	Continuous variable
Year of living or business operation duration	Number of years the respondent lives in the area or operated a business in the area (1-64Yrs).	Continuous variable
Having children	With children or not.	Dummy variable (Without children under 14 years old = 0, with =1)

https://doi.org/10.5194/egusphere-2025-2917
Preprint. Discussion started: 14 July 2025

Having elderlies	Households with the elderly.	Dummy variable (Without elderly above 65 years old = 0, with =1)

Independent variables were assessed for multicollinearity, and the regression model confirmed that the models met statistical assumptions. Standardized coefficients were utilized to determine the relative significance of each predicting variable, allowing for a comparison of their effects on intangible damages. The final models include error terms to address unexplained variations. These models were expressed as general equations, encompassing all essential variables to ensure reproducibility for future research investigating flood impacts in comparable settings (Svenningsen et al., 2020).

3. Results

The results are presented in two parts: The first is to understand the variations of monetary intangible losses over the determinant variables, and the second is on the analysis of multiple regressions.

3.1. Intangible Damages Variations over Determinant Variables

Intangible damages variations from the residential sector were analysed according to income groups and intangible flood damages. The results show that most respondents with flood experiences are in the bottom 40% (B40) income group, highlighting their vulnerability to floods. The middle 40% (M40) income group has the second-highest exposure level, while the top 20% (T20) group demonstrates significantly lower exposure. Additionally, the sample sizes for the M40 and T20 groups are far smaller than for the B40 group. For instance, there are only 13 and 5 respondents from the M40 and T20 groups, respectively, compared to the B40 group. The B40 group incurred relatively higher total damages than the other income groups. However, the average damages across all income groups for intangible losses are within the range of USD 46.6-186.4, as shown in Figure 3~~**Error! Reference source not found.**~~. The maximum value is from the T20 group, reflecting a larger contribution from high-income households. Interestingly, the B40 group shows slightly lower average damages than the other income groups. This is opposed to findings from another study, which observed that high-income households typically incur less damage (Abdullah et al., 2019).

https://doi.org/10.5194/egusphere-2025-2917
Preprint. Discussion started: 14 July 2025

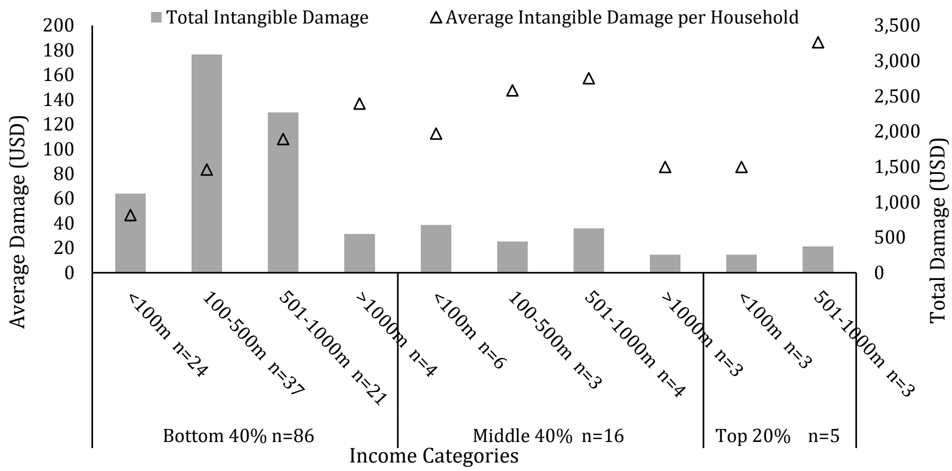

Figure 3. A comparison of the total and average values of intangible damages was conducted across income groups, distance-from-river categories, and the number of samples (n).

Figure 4 illustrates the total and average damages reported by respondents from the business sector, categorized by the size of their business premises. The results indicate that micro-sized businesses incurred relatively higher total damages than small-medium-sized businesses. This finding is supported by Kreibich et al. (2010), which suggests that micro-sized businesses implement fewer precautionary measures to mitigate asset damage, making them more susceptible to higher damages. It is worth noting that the magnitude of intangible damage for small-medium-size businesses could vary if a larger proportion of respondents were from this category. Additionally, micro-sized businesses experienced higher damage per premises unit, with most of these businesses located between 501 and 1,000 meters from the flooding source.

https://doi.org/10.5194/egusphere-2025-2917
Preprint. Discussion started: 14 July 2025

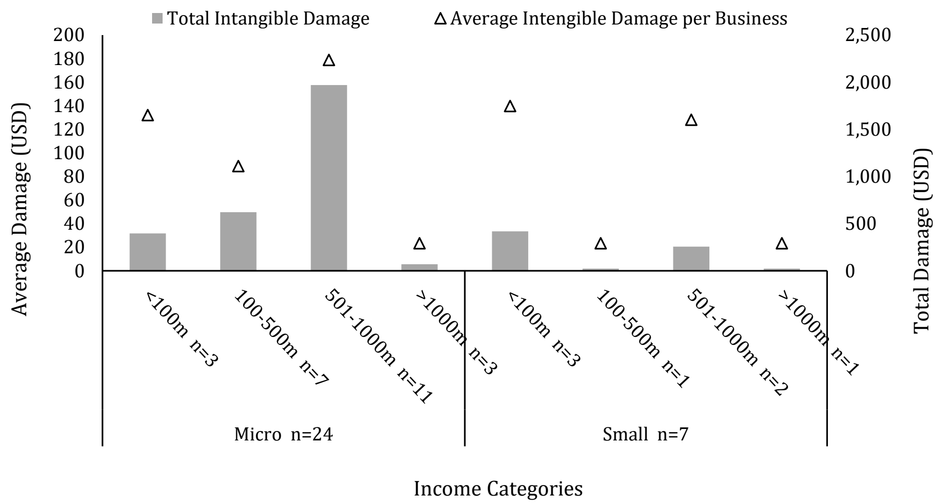

Figure 4. Intangible damage assessment of business premises considering income categories, distance from the river, and the number of samples (n)

When comparing residential and business losses, residential properties suffered more intangible damages. This reflects their increased susceptibility to flooding, as highlighted in the Department of Statistics' Special Report on flood damages (Prime Minister Department, 2022).

3.2. Multiple Regression Analysis of Intangible Damages

The results for multiple regression of the considered factors with intangible damages are distinguished between the residential sector and the business sector.

3.2.1. Residential Building Intangible Damage Regression Analysis

Table 3 presents the correlation matrix, which examines the relationship between intangible damage and each independent variable in terms of direction and strength. The results indicate that there is an association between intangible damage and the explanatory factors considered for households. The majority of the variables exhibited positive correlations with varying levels of statistical significance, as indicated by the correlation coefficients. In the case of intangible damage, three explanatory factors were statistically significant at a 10% significance level. These factors include flood duration, household family size, and building type. Flood duration and family size variables are statistically significant at the 5% significance level, while building type demonstrates statistical significance at the 10% level.

Table 3. Correlation matrix of flood intangible damages to households with damage predictors.

	IntD	FD	FDu	BT	DfR	HC	HE	Ow	FS	Inc
Intangible damage IntD	1									

https://doi.org/10.5194/egusphere-2025-2917
Preprint. Discussion started: 14 July 2025

Characteristics of flood										
Log (Flood depth) FD	.131	1								
Log (Flood duration) FDu [a]	.291***	.171*	1							
Characteristics of Building										
Building Type BT	.163*	.013	.128	1						
Log (Distance from River) DfR [a]	.123	.172*	.667***	.257***	1					
Socioeconomic characteristics										
Having children HC	.075	.023	-.230**	-.102	-.340***	1				
Having elderly HE	-.029	.121	.089	.021	.102	-.172	1			
Ownership Ow	-.037	.100	.071	.018	.023	-.013	.159	1		
Log(Family size) FS	.262***	-.071	-.004	-.082	-.114	.383***	-.031	-.260	1	
Log(Income)Inc	.151	-.108	-.168*	.304***	-.072	.138	.044	.038	.114	1
Log(Living duration) LDu	-.049	.059	.057	-.321***	-.104	.094	.173	.403***	.214**	-.152

Note: *. Correlation is significant at the 0.1
**. Correlation is significant at the 0.05
***. Correlation is significant at the 0.01
[a] Distance from the river and living duration variables have multicollinearity issues

The intuitive nature of their positive correlation is evident. As flood duration increases, there is an associated increase in intangible damage. Other studies found that, in addition to flood depth, other variables, such as building type and ownership, are correlated (Babcicky et al., 2021). There also appears to be a positive association between the type of building and the intangible damage caused by flooding. Another study by Lamond et al. (2015) showed that household income correlated with stress or mental impact. The finding argued by (Babcicky et al., 2021) that income and building type have a negative correlation. Individuals of lower socio-economic status residing in proximity to the river demonstrated relatively higher vulnerability but possessed fewer material belongings. Consequently, they may experience comparatively lower losses to the residences.

The regression analysis on intangible damage shows the presence of multicollinearity among the two independent factors: flood duration and distance from the river. The presence of multicollinearity poses significant concerns about the precision of the results. Therefore, the omission of distance from the river was necessary to improve both the accuracy and reliability of the results obtained from the regression analysis. From the remaining independent factors considered, two variables, namely flood duration and family size, present a statistically significant regression in relation to intangible damage.

Another study illustrated that flood duration is not statistically significant with mental health; however, flood depth is statistically significant in the regression model (Lamond et al., 2015).
The regression analysis results in Table 4 indicate that among the components examined, two variables, flood duration and family size, significantly influence the outcomes of the multivariate flood study.

https://doi.org/10.5194/egusphere-2025-2917
Preprint. Discussion started: 14 July 2025

Table 4. Intangible damage multiple regression results for the residential sector. Variables statistically significant at a 10% significance level for intangible damages are included.

Residential Sector				
	Intangible damage (R-squared = 0.231)			
Explanatory variables	Unstandardized Coefficient B	Standard Error	p-value	Standardized Coefficient β
Characteristics of flood				
Log (Flood duration)	0.486	0.156	0.002	0.299
	1.12 [a]			
Socioeconomic characteristics				
Log (Family size)	0.65	0.222	0.004	.301
	1.50 [a]			

The coefficient of determination (R2) indicates the degree of accuracy of the regression analysis, specifically for intangible damage, with a value of 0.23. However, the physical and socio-economic variables R2 is lower than 20% without flood perceiving probability (Babcicky et al., 2021). The acceptability of this value is acknowledged for intangible damage, as other studies have reported similar findings, such as an R^2 value close to 25% (Wijayanti et al., 2017).

Correlation results indicated a positive relationship between flood duration and intangible damage, as well as between family size and damage. Flood duration and intangible flood damage were positively correlated (Lamond et al., 2015). Specifically, a 1% increase in flood duration is associated with a 1.12% increase in willingness-to-pay. The flood duration is a key parameter in quantitative evaluations of health impacts caused by flooding. The regression results demonstrated that a 1% increase in family size is associated with a proportional rise of 1.5% in intangible damage. For example, adding an individual to a household can lead to a relative increase in intangible damage of approximately 12.50%. Larger families experienced more intangible impacts due to the increased willingness-to-pay associated with healthcare interventions.

3.2.2. Business Premises Intangible Damages Regression Analysis

Analyses were conducted on intangible flood damage to businesses through correlation and regression analysis. The analysis of intangible damage over the seven independent variables, presented in Table 5. In the correlational analysis, the factors of years of business operation and income were statistically significant in describing the intangible damage, with a p-value of 0.1. The interaction between flood duration and the length of time (years) a company's operation suggests a significant interrelationship between these two variables. Consequently, the flood duration was excluded from the multiple regression analysis.

https://doi.org/10.5194/egusphere-2025-2917
Preprint. Discussion started: 14 July 2025

Table 5. Correlation matrix of flood intangible damages to business with damage predictors

	IntD	FD	FDu	BS	DfR	Ow	YBO	Inc
Intangible damage (IntD)	1							
Characteristics of flood								
Flood depth (FD)	-.038	1						
Flood duration (FDu [a])	-.052	.404***	1					
Characteristics of Building								
Business size (BS)	.068	-.150	-.231	1				
Distance from river (DfR)	-.238	.322**	.424***	-.231	1			
Socio-economic Characteristics								
Ownership (Ow)	.117	.082	.007	-.028	.137	1		
Years of Business Operations (YBO)	-.320*	.348*	.530***	-.171	.350**	.201	1	
Income (Inc)	.370**	-0.152	-.171	.067	.053	.014	-.114	1

Note: *. Significant at 0.1 level
**. Significant at 0.05 level
***. Significant at 0.01 level
[a] variable was removed due to multicollinearity between the independent variables

A negative correlation exists between the years the business operation and intangible damage, suggesting that older businesses tend to experience more intangible impacts. However, it has been argued that older businesses that have experienced flooding before may have a better coping capacity and preparedness to mitigate flood impacts (Abdullah et al., 2019). Businesses with lower income often possess fewer assets, leading to a reduced vulnerability to flood-related consequences.

The regression analysis of intangible damage over the seven independent variables revealed that the p-value associated with the regression model is 0.15, which exceeds the threshold of 0.05. The threshold p-value of 0.05 was used by other flood damage studies (Wijayanti et al., 2017; Svenningsen et al., 2020). This result leads to the acceptance of the null hypothesis, indicating that the factors under consideration do not significantly predict intangible damage within the business sector. This may suggest a gap in understanding how intangible impacts contribute to business losses over extended periods.

4. Discussion

The variables influencing flood damage considered in this study range from flood characteristics, building type, business size, and socio-economic features of the affected area. The findings of this research demonstrate that individual variables influence intangible economic flood losses for residential buildings and business premises. For residential, like tangible damage, flood characteristics, building type, and social variables also show statistically significant contributions to intangible damage. However, unlike tangible damage, the income variable does not show a statistically significant contribution to intangible damage (Kabirzad et al., 2024). A multivariate linear regression approach was employed to evaluate the contributions of independent variables and examine their associations. Multivariate analysis offers a great potential for pragmatic strategies in managing flood effects.

The results of the multivariate analysis were used to assess for tangible damage before assessing intangible damage. A previous study for Peninsular Malaysia has confirmed that flood depth is one of the key physical factors providing a reliable indicator of tangible flood damage for residential buildings (Kabirzad et al., 2024), where its use in quantitative flood risk analysis has been widely practiced (e.g., Rehan & Yiwen, 2023). However, the present study found that flood depth is correlated with intangible damage, but not significantly. Other studies found that flood depth is moderately correlated with intangible damages (Lamond et al., 2015; Czajkowski & Cunha, 2020). What was discovered in the current study is that flood duration is a statistically significant explanatory factor and, therefore, it is a reliable contributor to flood damage. This discovery has confirmed that flood duration plays a crucial role in establishing the relationship between flood features and intangible impacts. A similar result was found in a previous study that flood duration has a positive correlation with a moderate contribution to the willingness-to-pay of flood mitigation measures (Czajkowski & Cunha, 2020).

Moreover, the previous study found that among socio-economic variables, family size is a significant factor in determining tangible damage models for risk assessment for residential buildings, and this is also found to be the same for intangible damage. The findings support the hypothesis that communities characterized by bigger family sizes have a statistically significant association with the prediction of intangible damages. The findings indicate that households with fewer members have a lower propensity to contribute towards the mitigation of intangible damage. Babcicky et al. (2021) support the result that household size contributes to psychological impact due to flooding, but it is not significant. The larger family size showed low willingness-to-pay for the mitigation measures, therefore, the result produced a lower contribution (Ghanbarpour et al., 2014). Low contribution of willingness-to-pay from residents can cause a challenge in supporting financial resources to propose structural mitigation. Hence, the utilization of non-structural measures costs less funding and might serve as a viable option to improve their potential in mitigation efforts.

The present study results also demonstrated that income does not affect a household's intangible damage. The analysis reveals that households' willingness to pay for addressing psychological impacts caused by flooding is not influenced by households' monthly income. The results indicate that families prioritize addressing the mental health effects on their members regardless of their wealth or income. However, other studies have found that household monthly income shows statistically significant contribution to the willingness-to-pay for mitigating flood-related mental health impacts (Ghanbarpour et al., 2014; Yusmah et al., 2020). Addressing intangible damage, particularly psychological effects, may help households mentally prepare for flooding or improve their ability to cope with it. The integration of non-engineering measures enhances risk reduction strategies. This intervention is an effective additional method for flood management (Van Duivendijk, 2006). It is also cost-effective approach to managing flood risks, but requires the combined efforts of all stakeholders (Mishra & Sinha, 2020).

The connection and prediction of flood physical features and socioeconomic factors, combined with the assessment of intangible damage, can contribute to the quantification of flood risk and the identification of various mitigation strategies, particularly those that require less physical input and cause minimal environmental damage. Nevertheless, assessing intangible damages is a highly intricate activity that necessitates a comprehensive examination of the numerous elements present in flood-prone neighbourhoods. Several studies have employed the willingness-to-pay technique to measure intangible damages (Meyer et al., 2013; Ghanbarpour et al., 2014; Czajkowski & Cunha, 2020), revealing statistically significant contributions to the overall assessment of flood damage. The long-term psychological impacts underscore the necessity for implementing effective mitigation strategies to alleviate these effects on vulnerable populations.

The flood economic damage and multiple potential influencing variables were collected from various states in Peninsular Malaysia. People in the Kuala Lumpur area show strong interest in supporting willingness-to-pay initiatives for flood risk reduction activities. Some families express a willingness to allocate part of their monthly income to mitigate flooding risks driven by feelings of despair regarding their ability to survive future floods. Additionally, some households have implemented property-level structural mitigation measures to reduce the risks. Respondents in Kelantan exhibit strong religious beliefs, viewing the impact of flooding as predetermined and beyond human control. They appear less distressed by flooding events. Moreover, some respondents displayed a lack of interest in providing information, possibly due to a loss of trust because of the more frequent floods they have encountered in the northeastern region of Peninsular Malaysia, hence, they were not willing to participate in the interviews.

In most places, flooding exacerbates distress and anxiety, particularly for heads of households concerned about protecting vulnerable members, such as the elderly and children. Elderly individuals experience heightened levels of anxiety and stress as a result of flooding, especially during the night. In terms of the exposed area where the data was collected, the findings indicate that Kelantan residents live with higher flood risks due to family social conditions, emphasizing the need to improve their social resilience. To increase resilience, it is essential to implement measures such as raising awareness, enhancing early flood forecasting systems, and incorporating land-use planning.

The present study shows that the intangible damage model for businesses is insignificant for regression analysis and cannot predict the intangible damage. After a thorough literature review, few publications were found addressing business flood damage models, making it challenging to find supporting evidence in the business sector. Additionally, incorporating intangible damage into the business damage model is far more complex compared to residential intangible damage. Understanding intangible losses in the business sector proved difficult, as during observations and interviews, very few individuals were willing to provide relevant data. The limited sample size for the business sector may introduce bias and reduce the accuracy of the damage model. Consequently, the intangible impact on the business sector cannot be effectively modelled using a multivariate approach. The model for intangible damage to businesses failed to reject the null hypothesis, the independent variables do not significantly predict intangible damages. The results highlight the challenges in obtaining reliable and greater returns from respondents to assess the intangible flood damage in business premises.

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5. Conclusion and recommendation

This study conducts the analysis on intangible damages caused by flooding based on empirical data collected from multiple places in Peninsular Malaysia. Multiple variables are considered for residential and business premises, and intangible impacts were quantified based on the contingent valuation method. The analysis showed that different income groups suffered varying impacts, and flood characteristics and social variables statistically contribute to the intangible damage.

The intangible flood damages experienced by residential households and family size findings highlight the importance of considering socio-economic variables in decision-making and planning. The family, having children, and the elderly could be priorities in the intangible damage reduction. It can also increase the resilience of the people at risk, such as children, the elderly, and women. In business premises, the micro-sized business may have suffered greater damage, but due to limitations of business respondents, the result could support a biased result to represent the accurate findings.

The flood duration and the intangible damage relation impact on residential communities, which requires community early preparedness and an effective response team to evacuate the vulnerable population. Planning preparedness and managing the response team during the flood would be a challenging task. Moreover, it emphasizes the importance of incorporating social dimensions into resilience-building efforts, such as increasing public awareness, enhancing preparedness, and engaging local communities. Additionally, it underscores the importance of non-structural measures, including flood forecasting, land use planning, and the preparation of awareness guidelines at the regional and national levels.

The present study integrates multiple variables; however, there may be additional independent variables that could influence the intangible damages. Additional samples from other places in the country can also improve the prediction accuracy of the flood damage model, particularly in the business sector's intangible damage model. To improve the accuracy of damage models in the commercial sector, others, such as agricultural, construction, and other industries, need to be included in the damage assessment. Flooding may have a significant impact on larger companies located in flood-prone areas.

Authors Contribution:

Authors Name	**Contribution**
S A K	Writing (original draft preparation, review, editing), Conceptualization, Data Curation, Formal Analysis, Investigation and Methodology, Software, Validation, Visualization
B M R	Writing (review and editing), Conceptualization, Supervision, Methodology, Funding Acquisitions, Validation, Visualization
Z Z	Conceptualization, Supervision, Methodology
B Y	Conceptualization, Supervision, and Methodology
B H-B	Conceptualization, Supervision, and Methodology
M E T	Project administration, Conceptualization, and Validation

E C P-R	Review

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