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,

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

39

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

47

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

54

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

63

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

73

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

80 **2.   Methods**

81 This study defines intangible damage as psychological health impacts such as stress, emotional instability,
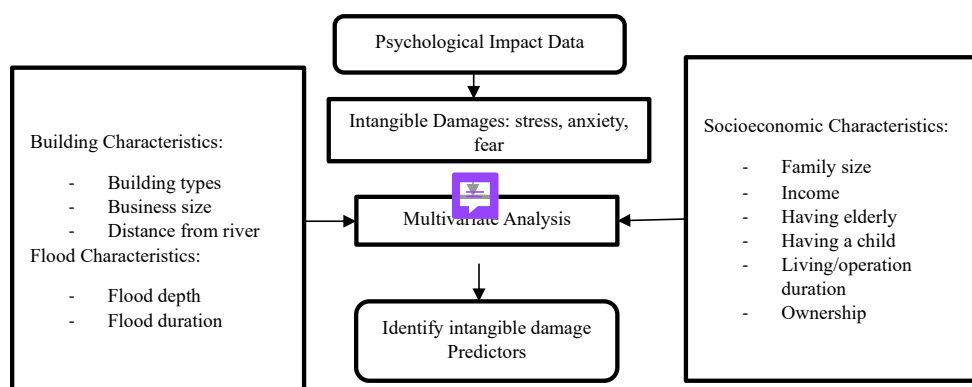
Figure 1. The intangible damage assessment and the independent variables used in the multivariate analysis for the damage model.

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

2.1. Study Area and Respondents

100

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

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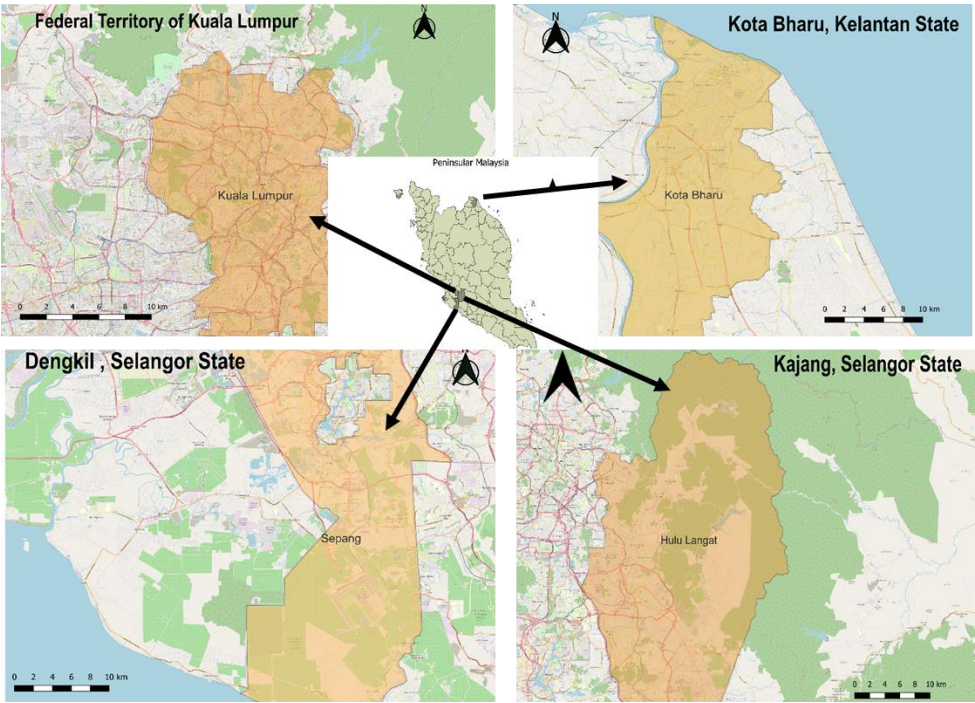
Figure 2. Areas where surveys were conducted in Peninsular Malaysia, and the yellow area is the district or territory boundaries. Top left: Kuala Lumpur Federal Territory; Top right: Kota Bharu district, Kelantan; Bottom left: Dengkil, Sepang district, Selangor; Bottom right: Hulu Langat district, Selangor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

118

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

122 respondents denied the willingness to pay due to different reasons. Table 1 shows the number of buildings, both
123 residential and business, where households and business owners were interviewed. Forty-two percent of
124 residential respondents and 67% of business respondents were from the Kota Bharu (Kelantan) study area, where
125 terrace buildings constituted the majority, accounting for almost 40% of the total, followed by low-cost houses.
126 The respondents from the Segambut district of Kuala Lumpur were minimal, mostly living in terraces and low-
127 cost houses. This indicates that respondents from the Kajang and Dengkil area of Selangor and the Kota Bharu
128 district of Kelantan reside in terrace building types. In the business premises, the predominant type of businesses
129 were micro-sized enterprises, followed by small-medium-sized businesses. The Kota Bharu study site recorded
130 the highest flood depth for both residential and commercial buildings, attributed to a significant flooding event in
131 2014. The case study sites and flooding events occurred in different years, but these locations have experienced
132 severe flooding over the past decade, affecting both residential and business.

133 **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)

134

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

148 **2.2. Relation of income and business size with WTP**

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

155

156 In order to assess how the monetary value of WTPs varies according to income categories and business sizes,
157 samples were sorted according to income levels and business sizes of respondents. Residents were divided into
158 three socio-economic groups: B40 (bottom 40%), M40 (middle 40%), and T20 (top 20%). The B40 group included
159 those earning less than US$1130[1] per month, the M40 group covered incomes between US$1130 and US$2553.45
160 per month, and the T20 group consisted of households earning more than US$2553.45 per month. This
161 classification followed national standards and previous research (e.g. Kabirzad et al., 2024), but remains open to
162 revision as socio-economic conditions change (Department of Statistics Malaysia, 2020). Businesses were
163 categorized into micro and small businesses based on the number of full-time permanent employees. Micro
164 businesses were defined as having fewer than five employees, while small businesses included those with five to
165 thirty employees (SME Corporation Malaysia, 2022).

166

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

172 **2.3. Regression Analysis and Model Specification**

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

181

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

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

185 significance for this study employed different significance thresholds, such as 5% or 1 % (e.g., Lamond et al.,
186 2015).

187

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

193 **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)

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).

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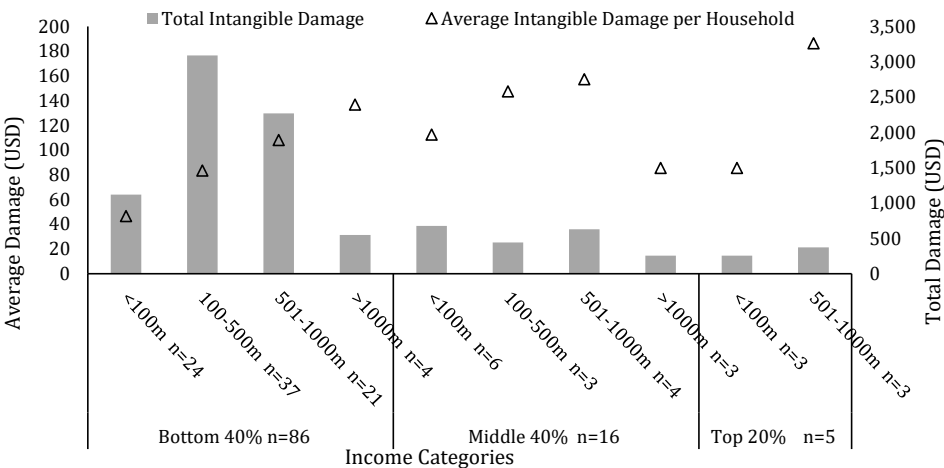
Figure 3. A comparison of the total and average values of intangible damages was conducted across income groups, distance-from-river categories, and the number of samples (n).
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220

221   Figure 4 illustrates the total and average damages reported by respondents from the business sector, categorized

222   by the size of their business premises. The results indicate that micro-sized businesses incurred relatively higher

223   total damages than small-medium-sized businesses. This finding is supported by Kreibich et al. (2010), which

224   suggests that micro-sized businesses implement fewer precautionary measures to mitigate asset damage, making

225   them more susceptible to higher damages. It is worth noting that the magnitude of intangible damage for small-

226   medium-size businesses could vary if a larger proportion of respondents were from this category. Additionally,

227   micro-sized businesses experienced higher damage per premises unit, with most of these businesses located

228   between 501 and 1,000 meters from the flooding source.

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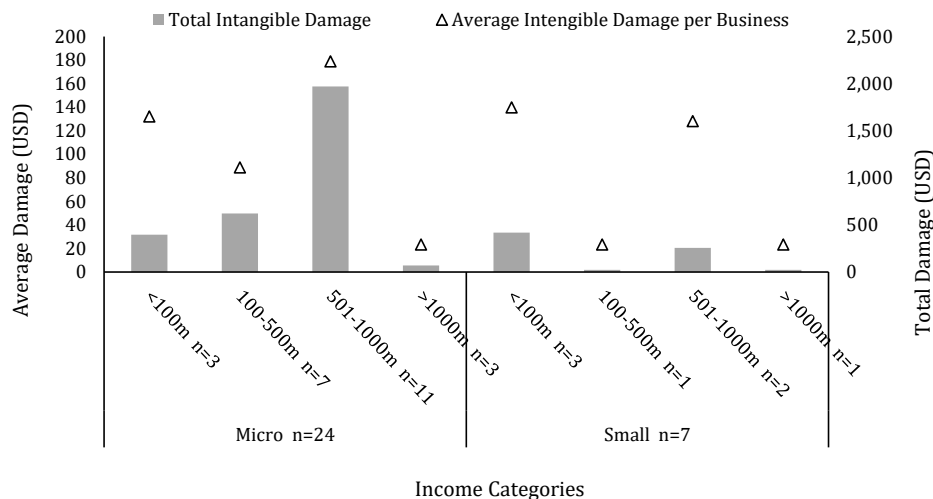
Figure 4. Intangible damage assessment of business premises considering income categories, distance from the
river, and the number of samples (n)

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									

		FD	FDu	BT	DfR	HC	HE	Ow	FS	Inc	LDu
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.

272
273 **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]			

274
275 The coefficient of determination (R2) indicates the degree of accuracy of the regression analysis, specifically for
276 intangible damage, with a value of 0.23. However, the physical and socio-economic variables R2 is lower than
277 20% without flood perceiving probability (Babcicky et al., 2021). The acceptability of this value is acknowledged
278 for intangible damage, as other studies have reported similar findings, such as an R² value close to 25% (Wijayanti
279 et al., 2017).

280

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

289 **3.2.2. Business Premises Intangible Damages Regression Analysis**

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

296

297 **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

298

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

304

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

311 **4.   Discussion**

312 The variables influencing flood damage considered in this study range from flood characteristics, building type,
313 business size, and socio-economic features of the affected area. The findings of this research demonstrate that
314 individual variables influence intangible economic flood losses for residential buildings and business premises.
315 For residential, like tangible damage, flood characteristics, building type, and social variables also show
316 statistically significant contributions to intangible damage. However, unlike tangible damage, the income variable

317   does not show a statistically significant contribution to intangible damage (Kabirzad et al., 2024). A multivariate

318   linear regression approach was employed to evaluate the contributions of independent variables and examine their

319   associations. Multivariate analysis offers a great potential for pragmatic strategies in managing flood effects.

320

321   The results of the multivariate analysis were used to assess for tangible damage before assessing intangible

322   damage. A previous study for Peninsular Malaysia has confirmed that flood depth is one of the key physical

323   factors providing a reliable indicator of tangible flood damage for residential buildings (Kabirzad et al., 2024),

324   where its use in quantitative flood risk analysis has been widely practiced (e.g., Rehan & Yiwen, 2023). However,

325   the present study found that flood depth is correlated with intangible damage, but not significantly. Other studies

326   found that flood depth is moderately correlated with intangible damages (Lamond et al., 2015; Czajkowski &

327   Cunha, 2020). What was discovered in the current study is that flood duration is a statistically significant

328   explanatory factor and, therefore, it is a reliable contributor to flood damage. This discovery has confirmed that

329   flood duration plays a crucial role in establishing the relationship between flood features and intangible impacts.

330   A similar result was found in a previous study that flood duration has a positive correlation with a moderate

331   contribution to the willingness-to-pay of flood mitigation measures (Czajkowski & Cunha, 2020).

332

333   Moreover, the previous study found that among socio-economic variables, family size is a significant factor in

334   determining tangible damage models for risk assessment for residential buildings, and this is also found to be the

335   same for intangible damage. The findings support the hypothesis that communities characterized by bigger family

336   sizes have a statistically significant association with the prediction of intangible damages. The findings indicate

337   that households with fewer members have a lower propensity to contribute towards the mitigation of intangible

338   damage. Babcicky et al. (2021) support the result that household size contributes to psychological impact due to

339   flooding, but it is not significant. The larger family size showed low willingness-to-pay for the mitigation

340   measures, therefore, the result produced a lower contribution (Ghanbarpour et al., 2014). Low contribution of

341   willingness-to-pay from residents can cause a challenge in supporting financial resources to propose structural

342   mitigation. Hence, the utilization of non-structural measures costs less funding and might serve as a viable option

343   to improve their potential in mitigation efforts.

344

345   The present study results also demonstrated that income does not affect a household's intangible damage. The

346   analysis reveals that households' willingness to pay for addressing psychological impacts caused by flooding is

347   not influenced by households' monthly income. The results indicate that families prioritize addressing the mental

348   health effects on their members regardless of their wealth or income. However, other studies have found that

349   household monthly income shows statistically significant contribution to the willingness-to-pay for mitigating

350   flood-related mental health impacts (Ghanbarpour et al., 2014; Yusmah et al., 2020). Addressing intangible

351   damage, particularly psychological effects, may help households mentally prepare for flooding or improve their

352   ability to cope with it. The integration of non-engineering measures enhances risk reduction strategies. This

353   intervention is an effective additional method for flood management (Van Duivendijk, 2006). It is also cost-

354   effective approach to managing flood risks, but requires the combined efforts of all stakeholders (Mishra & Sinha,

355   2020).

356

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

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

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

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

397   **5.   Conclusion and recommendation**

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

403

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

410

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

418

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

425   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

426

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431
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434

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