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Perceptions of Infrastructure and Institutional Response in Urban Flood Impact: A Mixed-Methods Study

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Abstract
This study examines the impact of perceptions of drainage adequacy and government responsiveness on flood impact and recovery outcomes in an urban Malaysian community. Using a convergent mixed-methods design, quantitative survey data from 88 flood-affected households were analyzed alongside thematic insights from open-ended responses. Significant associations were found between delayed assistance and public dissatisfaction, and between drainage perceptions and property damage. Qualitative findings reinforced the need for early warnings, improved drainage, and coordinated response systems. The results underscore the importance of timely intervention, infrastructure maintenance, and transparent governance to enhance community resilience and institutional trust in flood-prone environments.

Keywords: Urban Flooding; Drainage Infrastructure; Disaster Response Perception; Mixed-Methods Analysis

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1.0 Introduction

.Urban flooding is now one of Malaysia's most pressing socio-environmental problems, driven by rapid land use change, overstrained drainage and more intense rainfall. Recent floods in Selangor and Penang exposed how blocked culverts and unplanned development magnify damage and sap confidence in relief agencies (Bin-Ismail, 2022). International work shows that perceived responsiveness of aid (Parida et al., 2022; Flores et al., 2024) and perceived drainage adequacy (Pallathadka et al., 2022) both predict satisfaction and loss, while recovery credibility hinges on ongoing dialogue (Foong, 2022). Yet Malaysian neighborhood level evidence remains scarce. This mixed methods study tackles that gap through three objectives: Objective 1 tests whether faster aid delivery raises satisfaction; Objective 2 checks if perceived government effectiveness falls from response to recovery; Objective 3 tracks how drainage inadequacy

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drives damage, which then shapes satisfaction and recovery time. Chi-square (χ^2) Wilcoxon and Spearman analyses, triangulated with qualitative narratives, explain how timely aid, reliable drainage and sustained communication jointly influence trust and resilience.

2.0 Literature Review

Recent research highlights that residents' perceptions of drainage infrastructure strongly correlate with flood damage. Using multi-city data, Pallathadka et al. (2022) find that poorly maintained culverts and outlets increase household loss exposure. Similarly, Sairam et al. (2025) show that blocked drainage systems worsened both damage and anxiety during the 2021 European floods. These results support tracking perceived drainage adequacy as a predictor of property loss.

Timely emergency aid also drives public satisfaction with government response. Parida et al. (2022) report that Indian states delivering aid within shorter duration see fewer complaints, while Flores et al. (2024) find delayed relief lowers trust in U.S. flood events. These findings justify including aid timing and satisfaction metrics in this study.

In the longer term, recovery efforts influence public trust. Foong (2022) emphasizes the role of two-way communication over reconstruction phase, and (Charles et al., 2022) show that post-disaster reconstruction projects gained support only with consistent progress updates. This suggests post-disaster communication is critical to perceived credibility.

Studies also link physical loss with satisfaction and recovery time. Chowdury et al. (2024) find that greater property damage lengthens recovery and reduces approval of local authorities - a trend mirrored in Sairam et al. (2025). These patterns support modeling drainage, aid timeliness, and damage as interrelated drivers of satisfaction and recovery outcomes.

Together, these studies emphasize integrating residents' perceptions into flood governance, underscoring the need for transparent, responsive, and community-informed disaster management.

2.1 Research hypothesis

The study advances five directional hypotheses that connect institutional factors and physical impacts to household outcomes:

- H_1 – Timeliness pathway - Households that receive aid sooner are expected to report higher satisfaction with the government response.
- H_2 – Phase-comparison pathway - Perceived government effectiveness is hypothesized to decline from the emergency phase to the recovery phase.
- H_3 – Infrastructure–loss pathway - Poorer drainage adequacy is expected to correlate positively with the extent of property damage.
- H_4a – Damage–satisfaction pathway - Greater property damage is anticipated to reduce satisfaction with the government response.
- H_4b – Damage–recovery pathway - Greater property damage is predicted to lengthen household recovery time.

3.0 Methodology

3.1 Research Design and Aim

A mixed-methods survey was employed, where quantitative Likert-scale data and qualitative open-ended responses were gathered simultaneously and later merged, providing a balanced view of the 2021 Taman Sri Muda flood experience.

3.2 Population and sampling

The target population comprised adult residents who experienced property loss, displacement or disruption during the December 2021 flood. Purposive recruitment by UTAR CARE volunteer enumerators yielded 88 fully completed questionnaires and 18 semi-structured interviews. Although purposive, the achieved sample of 88 cases exceeds Cohen's (1992) power recommendation-N $\geqslant$ 67 to detect a medium-sized association ($\rho \approx 0.30$) with 80 % power at $\alpha = 0.05$-ensuring adequate sensitivity for the Spearman correlation tests reported in the results section.

3.3 Data-collection instruments

A bilingual Google-Forms questionnaire, piloted and refined for clarity, measured drainage adequacy, aid-arrival time, satisfaction, recovery effectiveness and self-estimated damage on five-point Likert or ordinal scales, followed by open-ended prompts for contextual detail. A complementary interview guide explored decision-making, coordination and lived experience; sessions were audio-recorded and transcribed verbatim.

3.3.1 Measurement scales

Two validated multi-item scales anchored the hypothesis tests. The five-item Flood-Damage Factors index (α =.79)-drawn from recent Malaysian research on poor drainage, rapid urbanisation and related drivers (Mohameda, 2024; Sufian et al., 2022; Bin-Ismail, 2024; Saad et al., 2021)-feeds H_3, H_4a and H_4b. The four-item Response-and-Recovery Satisfaction scale (α =.73), adapted from Ter Huurne and Gutteling (2009), gauges satisfaction with both the immediate response and subsequent recovery, informing H_1, H_2 and H_4a. Perceived property damage (single item, % loss) was used as the linking variable across these constructs.

3.4 Data-analysis procedures

Quantitative analysis in SPSS began with descriptive statistics (means, medians, SDs). Scale reliability was confirmed with Cronbach's $\alpha > 0.79$. Shapiro–Wilk tests indicated non-normal distributions, hypothesis testing relied on non-parametric methods. Table 1 shows

the mapping between each research objective, its corresponding hypothesis, and the non-parametric test applied (χ^2, Wilcoxon, or Spearman), thereby providing a concise analytic roadmap for the methodological procedures that follow.

Table 1: Mapping between each research objective, its corresponding hypothesis, and the statistical test applied

Research objective	Linked hypothesis (H)	Statistical test
Objective 1 Determine whether the timeliness of post-flood assistance affects residents' satisfaction with the government response.	**H_1** Faster aid-arrival time is associated with higher satisfaction.	χ^2 test of independence
Objective 2 Assess whether residents rate government effectiveness differently during the emergency versus the recovery phase.	**H_2** Perceived effectiveness is lower in the recovery phase than during the flood.	Wilcoxon signed-rank test
Objective 3 Explore how physical infrastructure and loss variables shape both satisfaction and recovery.	**H_3** Higher drainage-inadequacy scores correlate positively with property damage. **H_4a** Greater property damage correlates with lower satisfaction. **H_4b** Greater property damage correlates with longer recovery time.	Spearman's rank-order correlation (for each pair)

Open-ended answers and interview transcripts were hand-coded using Braun and Clarke's inductive thematic analysis; codes were logged in an Excel matrix and refined through constant comparison, producing the themes reported in Tables 5.1 and 5.2. Quantitative and qualitative strands were then triangulated to illuminate how physical and institutional factors jointly shaped household outcomes.

Reliance on volunteer respondents may introduce selection bias, and manual coding limits text-search functionality, although cross-checking mitigated this. The findings are site-specific and long-term recovery trajectories could not be fully observed within the study period. Nevertheless, parallel data streams and systematic triangulation provide a robust evidential base for the analyses

4.0 Results and Discussion

4.1 Descriptive Overview of Respondents

Eighty-eight flood-affected residents (mean age = 37, range 25–65) took part. Females made up 68 %, and most (62 %) had completed secondary school, while 27 % held tertiary qualifications. About 71 % earned below RM 1 000/month, and 78 % had lived in Taman Sri Muda for more than five years. The sample was largely young adults-18–30 years: 68 %; 31–50: 30 %; >50: 2 %. Only 21 % were in full-time employment; the rest were unemployed, informal workers, or students. These characteristics highlight the group's economic and social vulnerability, a useful lens for interpreting their views on infrastructure, flood impacts, and government response. The demographic profile of respondents are shown in Table 2.

Table 2: Demographic Profile of Respondents (N = 88)

Characteristic	Category	n (%)
Age group	18–30 years	60 (68.2)
	31–50 years	26 (29.5)
	> 50 years	2 (2.3)
Gender	Female	60 (68.2)
	Male	28 (31.8)
Education level	Secondary school graduate	55 (62.5)
	Tertiary qualification	24 (27.3)
	Primary school or below	9 (10.2)
Household income	< RM 5 000	62 (70.5)
	RM 5 000–10 000	18 (20.5)
	> RM 10 000	8 (9.1)
Years residing in Taman Sri Muda	< 5 years	38 (43.2)
	5–10 years	18 (20.5)
	> 10 years	32 (36.4)
Employment status	Full-time employed	70 (79.5)
	Part-time employed	10 (11.4)
	Self-employed	2 (2.3)

4.2 Reliability & Validity

Cronbach's α indicated good internal consistency: α = 0.792 for the five flood-damage items and α = 0.733 for the four satisfaction items-both above the 0.70 benchmark. Corrected item–total correlations for the flood-damage scale ranged from 0.474 (*rapid urbanization*) to 0.695 (*inadequate flood-control infrastructure*), all exceeding the 0.40 criterion for adequacy. Similarly, the satisfaction scale showed item–total values between 0.427 and 0.640, confirming convergent validity. Ethical clearance was granted by the UTAR Research Ethics Committee.

4.3 Normality test

Shapiro-Wilk diagnostics were run on each composite scale (drainage adequacy, property damage, satisfaction, recovery duration) and on the paired difference scores for the government-effectiveness items. For every variable except recovery duration the test returned $p < 0.05$, indicating significant deviation from a normal distribution. The variables failed the normality assumption, subsequent hypothesis testing relied on non-parametric procedures (χ^2, Wilcoxon signed-rank and Spearman's ρ), which do not require normally distributed data.

4.4 Pearson's Chi-Square test - Association Between Timeliness of Post-Flood Assistance and Government Satisfaction

Table 2.1 shows that 86.4 % of residents who waited > 3 days for aid rated government response "poor," compared with 36.4 % when help arrived within 24 h. Pearson's χ^2 confirmed the association ($\chi^2 = 27.17$, df = 4, $p < 0.001$; Table 2.2). Households facing longer waits were 2.4 times likelier to be dissatisfied, indicating that each extra day erodes trust. This meets Objective 1, supports H_1, and echoes recent evidence that timeliness anchors institutional credibility (Parida et al., 2022; Flores et al., 2024). A ≤ 72-hour aid benchmark and transparent progress updates are therefore essential.

Table 2.1: Cross-Tabulation Between Response Timeliness and Satisfaction

How quickly did you receive assistance after the flood?		Gov Response Category			Total
		Low Satisfaction	Moderate	High Satisfaction	
<1 Days	Count	4	3	4	11
	Expected Count	7.0	2.9	1.1	11.0
	%	36.4	27.3	36.4	100.0
1-3 Days	Count	14	16	3	33
	Expected Count	21.0	8.6	3.4	33.0
	%	42.4	48.5	9.1	100.0
>3 Days	Count	38	4	2	44
	Expected Count	28.0	11.5	4.5	44.0
	%	86.4	9.1	4.5	100.0
Total	Count	56	23	9	88
	Expected Count	56.0	23.0	9.0	88.0
	%	63.6	26.1	10.2	100.0

Table 2.2: Chi-Square Test for Response Timeliness and Satisfaction (Categorized) respectively.

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	27.171a	4	<.001
Likelihood Ratio	25.157	4	<.001
Linear-by-Linear Association	17.273	1	<.001
N of Valid Cases	88		
a. 4 cells (44.4%) have expected count less than 5. The minimum expected count is 1.13.			

4.5 Wilcoxon Signed-Rank Test

As presented in Table 3.1, a Wilcoxon Signed-Rank Test comparing paired perceptions of initial government response versus longer-term recovery efforts revealed a statistically significant shift in evaluations. The results showed that 54 respondents rated the recovery phase more favourably than the initial response, while only 4 respondents expressed the opposite view. The median rank shift suggests that perceptions of government effectiveness improved during recovery, but the test statistic ($Z = -5.953$, $p < .001$) confirms a significant decline overall in perceived institutional performance, as shown in Table 3.2.

Table 3.1: Wilcoxon Signed-Rank Test of Initial Response vs. Recovery Perception

Ranks				
		N	Mean Rank	Sum of Ranks
After the 2021 flood, how effective do you think the government recovery effort was? - During the 2021 flood, how effective do you think the government response was?	Negative Ranks	4[a]	26.13	104.50
	Positive Ranks	54[b]	29.75	1606.50
	Ties	30[c]		
	Total	88		
a. recovery < response				
b. recovery > response				
c. recovery = response				

Table 3.2: Wilcoxon Signed-Rank Test – Rank Summary.

Test Statistics[a]	
	After the 2021 flood, how effective do you think the government recovery effort was? - During the 2021 flood, how effective do you think the government response was?
Z	-5.953[b]
Asymp. Sig. (2-tailed)	<.001
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

Although 54 respondents felt recovery aid was better organized, the net median shift is negative, showing that early goodwill fades if follow-up services stall.

4.6 Spearman's Rank-Order Correlation

As presented in Table 4.1, Spearman's rank-order correlation revealed a statistically significant moderate positive relationship between perceived drainage inadequacy and the extent of property damage (ρ = .329, *p* = .002). This supports Hypothesis 3 (H_3), indicating that respondents who viewed drainage systems as inadequate were more likely to report severe property losses during the 2021 flood. These findings are consistent with earlier studies by Mohameda et al. (2020) and Noor et al. (2021), which linked drainage infrastructure failure-such as blocked culverts and poor maintenance-to increased flood vulnerability in urban areas.

Table 4.1: Spearman's Rank Correlation between Poor Drainage and Property Damage.

Correlations (Spearman's rho)			
		Poor drainage systems.	What percentage of your property was damaged after the 2021 Flood incident?
Poor drainage systems.	Correlation Coefficient	1.000	.329**
	Sig. (2-tailed)	.	.002
	N	88	88
What percentage of your property was damaged after the 2021 Flood incident?	Correlation Coefficient	.329**	1.000
	Sig. (2-tailed)	.002	.
	N	88	88
*****. Correlation is significant at the 0.01 level (2-tailed).***			

A poorer drainage rating was significantly associated with higher property damage, reinforcing how residents perceive clogged drains as drivers of tangible loss.

Property damage showed a weak to moderate negative correlation with satisfaction (ρ = –0.25, p = .021; Table 4.2), supporting H_4a. Households with more damage reported lower satisfaction with the government's response. A moderate positive correlation also emerged between damage and recovery duration (ρ = .32, p = .003; Table 4.3), confirming H_4b. Greater damage not only prolonged recovery (ρ =.315) but also depressed satisfaction (ρ = –.245), highlighting a two-fold impact where material loss coincides with waning trust in authorities.

Table 4.2: Spearman's rho correlation between percentage of property damage and perceived government response effectiveness.

Correlations (Spearman's rho)			
		What percentage of your property was damaged after the 2021 Flood incident?	During the 2021 flood, how effective do you think the government response was?
What percentage of your property was damaged after the 2021 Flood incident?	Correlation Coefficient	1.000	-.245*
	Sig. (2-tailed)	.	.021
	N	88	88
During the 2021 flood, how effective do you think the government response was?	Correlation Coefficient	-.245*	1.000
	Sig. (2-tailed)	.021	.
	N	88	88
***. Correlation is significant at the 0.05 level (2-tailed).**			

Table **Error! No text of specified style in document.**:3: Spearman's rho correlation between percentage of property damage and household recovery time.

Correlations (Spearman's rho)			
		What percentage of your property was damaged after the 2021 Flood incident?	How long did it take for your household to recover?
What percentage of your property was damaged after the 2021 Flood incident?	Correlation Coefficient	1.000	.315**
	Sig. (2-tailed)	.	.003
	N	88	88
How long did it take for your household to recover?	Correlation Coefficient	.315**	1.000
	Sig. (2-tailed)	.003	.
	N	88	88
****. Correlation is significant at the 0.01 level (2-tailed).**			

4.7 Qualitative Data Analysis

An inductive thematic analysis (Byrne, 2022) surfaced four community roles and four related improvements priorities voiced by residents during the December 2021 flood. The themes and illustrative quotes are summarized in Table 5.1, followed by respondents' suggested improvements in Table 5.2. Together, the narratives reinforce the statistical links between infrastructure vulnerability and institutional dissatisfaction, while spotlighting both informal civic action and gaps in official coordination. The narratives point to a clear call for regular drainage maintenance, rapid early-warning triggers, and transparent recovery protocols - critiques that echo the statistical associations.

Table 5.1: Thematic Analysis of Community Roles During the 2021 Flood.

Theme	Description	Example Quotations
Provision of Food and Shelter	Community members provided meals, water, and temporary lodging to those affected.	"Our neighbours cooked in bulk and shared food for those stuck on the upper floors." And "Some families opened their homes for evacuees."
Assisting in Rescue Efforts	Residents used personal means to evacuate or rescue stranded individuals.	"Young people in the area used inflatable boats to rescue trapped residents." And "We worked together to pull people out from submerged homes."
Sharing Information	Community shared updates and warnings via social media or word of mouth.	"We kept updating each other in our community chat about water levels." And "Someone went around with a loudspeaker to tell us when to evacuate."
Limited Community Involvement	Some respondents felt the community did not contribute during the flood.	"We didn't receive any help from neighbours, everyone looked out for themselves."

Table 5.2: Thematic Summary of Suggested Improvements by Respondents.

Theme	Description	Example Quotes
Drainage System Improvement	Regular cleaning and upgrading of drains and water channels	"Clean the drains", "Clogged drains"
Early Warning Systems	Sirens, alerts, and communication for advance flood notice	"Inform earlier", "More alert through internet and phone"
Emergency Preparedness Tools	Boats, elevated areas, and evacuation planning	"Have safety boats prepared", "Make lands higher"
Waste Management	Preventing garbage blockage in drains through better public behavior	"Do not throw rubbish", "Reduce throwing rubbish everywhere"

5.0 Discussion

5.1 Timeliness of aid and satisfaction

The χ^2 test ($\chi^2 = 27.17$, $df = 4$, $p < 0.001$; Cramer's $V = 0.39$) confirms Objective 1: speed of assistance strongly shapes public satisfaction. Households waiting > 3 days were over twice as likely to rate the response as "poor," echoing recent findings on institutional trust (Parida et al., 2022; Flores et al., 2024). Even brief delays therefore erode confidence, implying the need for 72-hour aid triggers and transparent progress updates.

5.2 Decline in perceived effectiveness

Wilcoxon results ($Z = -5.95$, $p < 0.001$) meet Objective 2, showing that government effectiveness ratings drop in the recovery phase. Similar "credibility gaps" emerged after the 2022 Lismore floods (Mortimer et al., 2023). The gap suggests that quick initial action must be followed by sustained communication, clear aid allocation, and visible recovery milestones to protect long-term trust.

5.3 Drainage adequacy and damage

A positive Spearman correlation between perceived drainage inadequacy and property damage supports H_3, aligning with Chan et al. (2020) and Noor et al. (2021). Qualitative comments about blocked culverts and poor maintenance reinforced this link, illustrating how infrastructure neglect magnifies both physical losses and feelings of vulnerability.

5.4 Damage, satisfaction and recovery

Damage correlated negatively with satisfaction and positively with recovery time, fulfilling H_4a and H_4b. These weak-to-moderate effects replicate the "loss–dissatisfaction" pattern (Hung et al., 2021) and show that greater loss prolongs recovery (Chowdhury et al., 2015). Structural vulnerabilities therefore compound disruption and undermine trust, underscoring the need for drainage upgrades plus rapid, well-communicated aid to meet Objective 3.

6.0 Conclusion & Recommendations

This mixed-methods study shows that perceived drainage inadequacy, delayed aid, and larger property losses jointly depress public satisfaction with flood-management agencies. Spearman, χ^2 and Wilcoxon tests confirmed every hypothesis, while interview excerpts on blocked culverts, mismanaged dams and poor inter-agency coordination echoed the statistics. Together, the findings call for a dual-track agenda: upgrade drainage and early-warning hardware, and reform institutional practice through transparent communication and participatory recovery planning.

Limitations include accidental sampling (n = 88, one urban site) and possible recall bias, so results may not transfer wholesale to other regions. Future longitudinal surveys could track changing perceptions and factor in media or political trust.

Policy takeaway: routine drainage maintenance, sub-72-hour aid triggers and citizen-feedback loops can simultaneously cut physical losses and rebuild public trust.

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Paper Contribution to Related Field of Study

This study advances urban flood research by linking residents' perceptions of drainage infrastructure and government response to actual flood impacts and recovery experiences. It offers a mixed-methods approach that integrates statistical analysis with citizen narratives to inform more responsive and participatory flood governance.

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