TYPE Original Research
PUBLISHED 29 January 2026
DOI 10.3389/fenvs.2025.1742965

OPEN ACCESS

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RECEIVED 10 November 2025
REVISED 13 December 2025
ACCEPTED 17 December 2025
PUBLISHED 29 January 2026

CITATION
Suyuhan W and Khoso AR (2026) Bridging the watershed–urban disconnect: a mixed-methods analysis of flood-risk perception and preparedness in Sindh, Pakistan.
Front. Environ. Sci. 13:1742965.
doi: 10.3389/fenvs.2025.1742965

Bridging the watershed–urban disconnect: a mixed-methods analysis of flood-risk perception and preparedness in Sindh, Pakistan

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Introduction: Extreme flooding events are increasing in frequency due to climate change and posing major challenges for developing countries, where a clear disconnect exists between how floods develop at the watershed level and how communities perceive the risks they face. Thus, this study examines the disconnect between watershed-scale flood generation and community-scale risk perception and preparedness in Sindh, Pakistan.

Methodology: This research employed a mixed-method approach, containing 400 questionnaires as a survey using a 10-point Likert scale for quantitative analysis and 8 in-depth interviews for qualitative data. SPSS was used for statistical analysis, while NVIVO was used for thematic analysis.

Results: The findings revealed that education level significantly influenced causal attribution of floods (χ^2 = 35.82, p <0.001). Only 6.7% of respondents with no formal education implicated watershed-scale causes, compared to 56.7% of those with a bachelor's degree. Hierarchical regression analysis identified watershed awareness, self-efficacy, and trust in institutions as key predictors of preparedness, explaining 41% of the variance (R^2 = 0.41). Self-efficacy partially mediated the link between watershed perception and preparedness [indirect effect β = 0.08, 95% CI (0.041, 0.129)]. Thematic analysis of qualitative data identified inadequate local infrastructure as a primary community concern, with repeated flood losses exacerbating psychological vulnerability.

Conclusion: The study concludes that respondents with lower education levels primarily perceived floods as locally caused, indicating perceived deficiencies in infrastructure, whereas respondents with higher education emphasized watershed-scale causes. Governmental failure was also perceived as a major contributing factor to flooding. The study recommends tailored risk communication, enhanced watershed education, and transparent governance to enhance flood resilience.

KEYWORDS

flood disaster, mixed approach, Pakistan, public perception, Sindh, watershed

1 Introduction

Flooding represents one of the most devastating and widespread natural and environmental hazards, posing severe threats to human health and livelihood (Khushi et al., 2024). These climatic variations demonstrate severe hydrometeorological hazards and destroy significant environments globally (Brauch et al., 2011). The increasing population in urban areas is considered destructive to the environment due to urbanization and flood-related concerns, highlighting significant challenges for urban dwellers (Kumaresen et al., 2025). Such urbanization has not only affected the livelihood of the residents but also harmed societal structures (Chen et al., 2021). Among these hazards, flooding stands out for its severe damaging potential, a threat projected to increase in frequency and severity under the influence of climate change (Abuzwidah et al., 2024), which is expected to amplify the intensity and magnitude of such events (Franchi et al., 2024). Different developing and developed nations have faced a variety of floods, including fluvial (riverine) (Yin et al., 2021), pluvial (surface water) (Andrade et al., 2018), flash, and coastal flooding from storm surges, which has destructed the infrastructure, livelihood, and agriculture to a great extent (Mutahara et al., 2016), posing a universal challenge globally. Meanwhile, in Pakistan, specifically in Sindh, heavy rainfall has been deemed the main cause of flooding, as observed in 2010 and 2022, which greatly affected livelihoods in the northern parts of Sindh (Buriro and un nisa Jatoi, 2025). The socio-economic toll is profound; over the past 2 decades, floods have affected approximately 1.6 billion people, claimed over 100,000 lives (Grigorieva and Livenets, 2022), and caused economic losses exceeding US$ 537 billion (Rizvi et al., 2015). The floods in 2010 in Pakistan resulted in 1,800 deaths nationwide, affected 20 million people and 2 million homes, and devastated a vast area of Pakistan (Warraich et al., 2011). The impacts are specifically severe in developing or low-income nations across Asia, where a large proportion of the population resides in rural areas. In these regions, future projections indicate an increase in both flood impacts and associated losses (Rathore et al., 2025). To date, the increasing number of threats related to urban floods and waterlogging has presented significant challenges to achieving sustainable development globally, with economic, environmental, and deep humanitarian effects (Kaiser and Akter, 2025).

Global urban centers face increasing vulnerability as flood events become more frequent and intense, a trend accelerated by climate change and rapid, often unplanned, urbanization (Liu et al., 2024). This intensifying menace ensues not only from the strengthening of physical hazards but also from the inherent instability of socio-ecological structures (Massel et al., 2024). Conventional flood mitigation approaches have historically emphasized gray infrastructure such as concrete channels and subsurface drainage systems confined within municipal boundaries (Fletcher et al., 2022). This paradigm remains fundamentally limited because it neglects a crucial hydrological principle: flood generation in urban areas typically originates beyond city limits, across the entire contributing watershed (Zhou et al., 2021). Upstream land-use changes, including deforestation, agricultural expansion, and urban sprawl, significantly alter catchment hydrology, thus accelerating runoff and amplifying flood peaks that eventually converge on downstream urban areas (Babaremu et al., 2024). This recognition necessitates a paradigm shift from a narrow focus on discharging water from cities to an integrated strategy of landscape-scale management for urban resilience. However, achieving this integration is profoundly difficult. A key analytical and practical challenge is that transitions between global, regional, and local scales are abrupt. The central issue this research addresses is the critical disconnect between the physical scale of flood generation and the social scale of flood experience and governance. This disjunction operates across two interrelated dimensions.

From a biophysical perspective, the systemic failure to align watershed management with urban planning creates unavoidable vulnerabilities (Canteiro et al., 2024; Hamilton and Pearce, 1991). The severe 2020 flooding in Khartoum, for instance, resulted not only from local rainfall but was significantly worsened by catchment-wide land degradation and precipitation across the Blue Nile basin, which overwhelmed the city's local defense systems (Alfieri et al., 2024). Similarly, in developed contexts, the catastrophic flooding in Houston during Hurricane Harvey demonstrated how extensive watershed urbanization and the loss of natural wetlands generated unprecedented runoff volumes, paralyzing a major metropolitan region (Zhang et al., 2018). A more complex dimension of this problem lies in its socio-perceptual aspects. Urban communities and local decision-makers often conceptualize flood causality through a localized mental model. They tend to attribute disasters to immediate, visible factors such as blocked drains or inadequate pumping capacity, while the critical influence of upstream land-use decisions remains abstract and largely ignored (Tran et al., 2024). This perceptual gap observed in studies of flood-prone Asian megacities generates public and political pressure for localized engineering solutions (Adikari et al., 2010; Sörensen, 2018). Consequently, policy responses frequently misalign with the underlying drivers of flooding, perpetuating a cycle of maladaptation, where each flood event triggers investments in local defenses that are increasingly overwhelmed by watershed-scale hydrological changes, thereby exacerbating long-term risk.

For Sindh, this disconnect between watershed-scale processes and local risk perception is not a theoretical concern but a pressing, lived reality. The province's devastating floods, such as those in 2010 and 2022, are often catalyzed by heavy rainfall in northern Sindh and upstream catchments, yet local responses frequently focus on immediate, visible drainage issues within municipal boundaries. This study matters because it directly investigates this critical scale-mismatch, which perpetuates a cycle of maladaptation in the province. By integrating the physical drivers of flooding with community perceptions and governance structures, the research aims to provide a pathway for Sindh to break this cycle and build genuine, long-term resilience against escalating flood risks.

1.1 Conceptual framework and theoretical interpretation

This disjunction is conceptually and theoretically framed through the lens of social–ecological systems (SESs) and socio-hydrology, which emphasize the interconnectedness of human and natural systems and the bidirectional feedback between hydrological processes and societal responses (Berkes, 2000; Sivapalan et al., 2012). Within this framework, the disconnect emerges from mismatched spatial and temporal scales: watershed processes operate over large areas and long timeframes, while community experiences and governance responses are localized and immediate (Lebel et al., 2006). Furthermore, risk perception theories, such as the protection motivation theory (PMT), explain why individuals may prioritize visible, local causes (e.g., blocked drains) over systemic drivers (e.g., upstream deforestation) (Bubeck et al., 2012; Rogers, 1983). When communities perceive low self-efficacy or institutional trust regarding watershed-scale interventions, they default to local attributions, creating a governance trap where policy misalignment reinforces vulnerability rather than resilience (Adger et al., 2011). This framework interpretation connects the relationship between the variables in the study.

1.2 Statement of problem

Different nations around the world face diverse challenges regarding climate; however, floods have been a serious concern in developing nations such as Pakistan (Khoso et al., 2024). The solution for addressing flood-related threats at the local level is the construction of strong drainage systems and concrete channels, along with water storage in dams (Hansamali et al., 2025). However, such an approach is initially flawed because of the water intensity and flow from the entire surrounding watershed (Sharm et al., 2005). Meanwhile, changes in the upstream landscape, including deforestation and urban sprawl, increase the intensity of water flowing downstream, thus affecting local defenses of the urban area and creating a dangerous disconnect (Romero et al., 2018). Though the physical process of flooding occurs on a large, regional scale, residents suffering from its effects tend to perceive it through a local lens. This misdirected focus leads to a cycle of ineffective spending on solutions that fail to address the root cause, ultimately increasing long-term risk for urban populations. The central problem this research addresses is the critical disconnect between the watershed-scale physical generation of urban flood risk and the community-scale perception and management of that risk. Therefore, highlighting the concern and addressing it through appropriate solutions is crucial in the study area to tackle the issue in Sindh.

1.3 Research gap

Currently, the research on floods focuses on two dimensions that rarely connect. On one hand, the physical scientists create detailed models for understanding water movement across a watershed while focusing on the flood mechanism, such as distributed catchment analyses in China (Gao et al., 2017) or satellite-based river-basin studies in India (Bhati et al., 2021), but this process often overlooks the public perception of how people perceive the risks of flood and ways to cope with them. On the other hand, most social scientists frequently investigate vulnerability and public awareness through surveys or interviews, treating the watershed as a simple stage for human activity without focusing in detail on the processes that cause downstream flooding. This integrative mixed-methods design is essential for bridging the identified research gap. By quantifying broad perceptual patterns across the population (quantitative survey) and qualitatively excavating the underlying narratives, lived experiences, and socio-political contexts (in-depth interviews), the study can connect the process of physical flood generation with the reasons for community perception and (in)action, providing the holistic evidence base needed for effective, integrated risk management.

2 Methodology

This research aligns with the descriptive research methodology with an objective of analyzing the disconnect between watershed-scale flood and community-based risk perception and preparedness in Hyderabad, Sindh. This investigation utilized a mixed-method approach, combining quantitative data with sample size of n = 400 and qualitative data from in-depth interviews (n = 8) to gather perception-based and grassroots information from district Hyderabad. To ensure proportional representation and enhance the sample's demographic validity, the selection of households within each cluster (village/unit/colony) employed a quota sampling approach based on two key strata: gender of the household head and a socio-economic proxy (household construction type: cemented, semi-cemented, or mud-covered). Quotas were set to reflect the approximate distribution of these characteristics observed in preliminary field reconnaissance and available local data, aiming to prevent over-representation of any single group. While the primary sampling unit was the household, interviewers sought to alternately interview male and female respondents, where possible, to balance gender perspectives; however, final participation was subject to availability and consent. While small, this sample allowed for rich, detailed narratives and reached thematic saturation on core themes such as institutional distrust and psychological toll. The researchers acknowledge that a larger sample might reveal additional nuances, particularly in a heterogeneous urban setting. By integrating surveys with interviews, this research provides meaningful insights into flood disasters and the water-shed scale–urban disconnect. Thus, this integrative approach was deemed essential for addressing the identified research gap between the biophysical drivers and social perceptions of flood risk.

2.1 Study area

Figure 1 shows the map of the study area, including national, provincial, and local boundaries. This research was purposefully conducted in the urbanized District Hyderabad, encompassing four talukas, namely, Qasimabad, Hyderabad Urban, Latifabad, and Hyderabad Rural. The Hyderabad District is the second most populous city in Sindh province, after Karachi. The current population of Hyderabad District is 2,059,000, as of 2025, representing a slight increase of approximately 2.34% from 2024, partially reflecting rural-to-urban migration. The main reason for selecting this area is the frequent and severe exposure to floods from the Indus River system, a vulnerability starkly demonstrated during major flood events in 2010 and 2022 (Aziz et al., 2024; Wang et al., 2024). The flooding has not only affected the agriculture but also the livelihood of urbanized residents. The selection of these cities enables a robust examination of how upstream land-use and water management decisions manifest as flood risk for downstream urban populations.

2.2 Data collection procedures

2.2.1 Quantitative survey

To collect quantitative data, the research included a sample of n = 400 respondents to assess perceptions using a cross-sectional

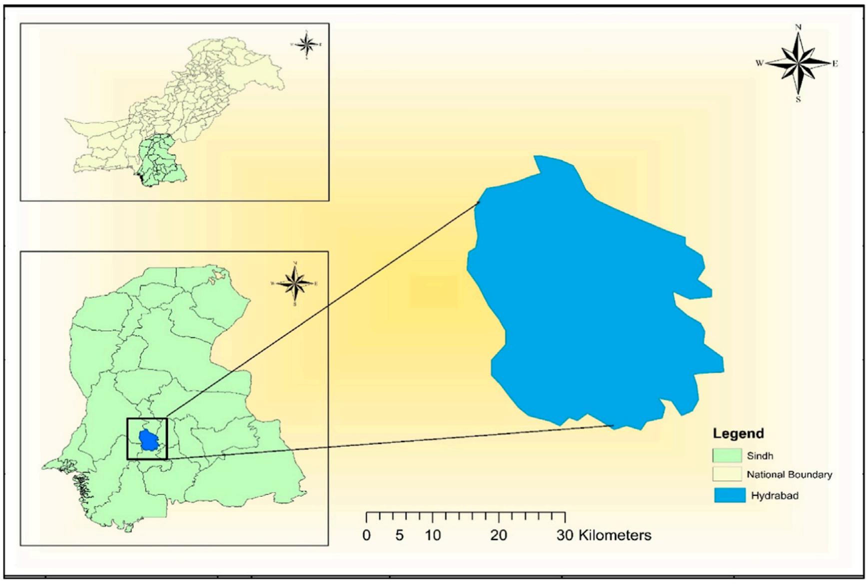

FIGURE 1
Map of the study area (source: authors' own analysis using GIS).

household survey employing multi-stage stratified sampling techniques. This type of method is strongly accepted in social-science research for gathering perception (Creswell et al., 2011). The data were collected from November 2024 to March 2025. The sampling followed a multi-stage stratified cluster design. First, four talukas were purposively selected. Second, within each taluka, two Union Councils (UCs) were randomly chosen. Third, from each UC, villages/neighborhoods were selected via probability proportional to size. Finally, within each village, households were selected using systematic random sampling (every fifth household). The inclusion criteria were as follows: age ≥18, residence ≥5 years, and prior flood experience. The exclusion criteria included non-consent or cognitive impairment. The response rate was 89%. Equal sample sizes per taluka (n = 100) were used to ensure balanced geographic representation, though this does not proportionally reflect the population size, which is a noted limitation.

All multi-item scales were adapted from established frameworks in disaster research. A pilot study (n = 30) was conducted in October 2024 to test the clarity, relevance, and reliability. Cronbach's alpha in the pilot ranged from 0.78 to 0.89. The 10-point Likert scale was selected over shorter scales to capture greater response variance and sensitivity, as recommended for perceptual studies (Joshi et al., 2015). Later, the sample size was determined to be 400 to achieve a 95% confidence level with a ±5% margin of error for a finite population. The survey was structured into six distinct sections, with multi-item constructs measured using a 10-point Likert scale (where 1 = strongly disagree and 10 = strongly agree) to enhance response sensitivity and variance. In addition, some questions, including the response of yes/no and detailed answers, were received, which were further included in the in-depth interviews to gain justified data. In addition to that, the sections in the questionnaire were as follows:

Socio-demographic profile: The socio-demographic section was used to capture the basic information, including the gender, age, education, monthly income, household structure, and flood experiences.

Perception of flood causality: This section utilized two 5-item sub-scales to gauge causal attributions. One sub-scale measured attributions to local factors (e.g., inadequate drainage and municipal solid waste), while the other measured attributions to watershed-scale factors (e.g., upstream deforestation and reservoir operations).

Socio-economic vulnerability: A composite 6-item index, adapted from established vulnerability frameworks, was used to measure dimensions such as livelihood precarity, access to resources, and household dependency ratios.

Preparedness self-efficacy: This 4-item scale assessed the respondents' belief in their capability to execute specific flood preparedness actions (e.g., creating an emergency kit and elevating belongings).

Institutional trust: A 5-item scale evaluated the respondents' confidence in the capacity, integrity, and fairness of key institutions, including local government, disaster management agencies, and water authorities.

The questionnaire was constructed in English and translated into Sindhi to facilitate better understanding for the respondents.

2.2.2 Qualitative interviews

For conducting the qualitative research, the study carried out in-depth interviews of n = 8 participants, including two from each taluka. The sample size was deemed sufficient to reach thematic saturation and provide meaningful insights from the selected participants. In addition, open-ended questions were posed through semi-structured interviews using purposive sampling to gather the perception of local residents regarding watershed-level floods, disasters, institutional trust, and factors influencing high/low levels of vulnerabilities in the study area. The interviews were conducted in the local language (Sindhi) to facilitate understanding and ensure nuanced communication. All

TABLE 1 Reliability and validity of constructs.

Construct	Number of items	Cronbach's alpha (α)	Composite reliability (CR)	Average variance extracted (AVE)
Perception of local causes	5	0.84	0.86	0.61
Perception of watershed causes	5	0.79	0.81	0.52
Socio-economic vulnerability	6	0.88	0.90	0.60
Self-efficacy in preparedness	4	0.81	0.83	0.55
Trust in institutions	5	0.91	0.92	0.70

interviews were audio-recorded, transcribed verbatim in Sindhi, and then translated into English for analysis. The translation was performed by a bilingual research assistant fluent in both Sindhi and English, with a focus on preserving the conceptual meaning and cultural context over literal translation. Each interview with a participant took approximately 30 min–45 min to gather detailed information. The participants were interviewed with their consent, respecting their time and their availability. In addition, all interviews were recorded using a mobile phone recorder to gather complete information for the thematic analysis.

2.3 Data analysis method

The data analysis was carried out through a mixed-methods approach. Quantitative analysis was conducted using SPSS Statistics (version 28.0) and the PROCESS macro. The psychometric properties of multi-item constructs were validated by establishing internal consistency (Cronbach's alpha >0.70) and convergent validity (composite reliability and average variance extracted) (Kimberlin and Winterstein, 2008), as shown in Table 1. Following descriptive statistics and bivariate analyses (chi-square and Pearson correlations), a three-step hierarchical regression was conducted to identify predictors of household flood preparedness, with demographic, perception, and psychosocial variables entered sequentially. Variance inflation factors (VIF <2.5) confirmed the absence of multicollinearity. VIF values were all below 2.5, which was well under the conservative threshold of 5.0 that is commonly used in social science to indicate the absence of multicollinearity (Marcoulide et al., 2019). Furthermore, a simple mediation analysis using PROCESS (model 4, 5,000 bootstrap samples) tested whether self-efficacy mediated the relationship between watershed perception and preparedness. Nevertheless, the qualitative data were analyzed thematically following Braun and Clarke (2014), using the interview guide, transcribing and translating the data, coding and decoding, and ultimately developing the themes. The data were later processed using NVIVO software (version 15) for contextual analysis of the qualitative results (Ozkan, 2004), generating a word tree to facilitate the development of concepts. In addition, to assess the common method bias, Harman's single-factor test was conducted. The unrotated factor solution revealed that the first factor accounted for 28.7% of the variance, which is below the 50% threshold, suggesting that the common method variance is not a major concern. Additionally, the mixed-methods design helps mitigate single-source bias.

2.4 Ethical consideration and informed consent

Ethical consideration and approval were waived for the study "Bridging the watershed–urban disconnect: a mixed-methods analysis of flood-risk perception and preparedness in Sindh, Pakistan." This study involves neither minors nor invasive procedures and adheres to the ethical standards of the 1964 Helsinki Declaration. In addition, the Ethics Review Committee of the School of Public Administration, Hohai University (REF: SPA-20241001), determined that the study qualifies for exemption from ethical review based on these factors. All participants provided informed consent verbally. They were informed of the study's purpose, their right to withdraw, and the assurance of confidentiality. No personally identifiable information was collected; demographic and flood experience data were anonymized.

3 Results

The demographic profile of the respondents in Table 2 reveals that 55% (n=220) of the respondents were male and 45% (n = 180) were female. While the majority of the respondents (n = 178; 44.5%) were within the age range of 31 years–45 years in the study area, the second-highest age range was (n = 112; 28%) 18 years–30 years. In terms of educational qualification, the primary level was the most frequently reported (n = 155; 38.7%), followed by intermediate education (n = 110; 27.5%) and bachelor's and higher education (n = 90; 22.5%). Regarding the socio-economic status, the largest proportion of participants (n = 168; 42.0%) reported a monthly household income falling within the range of 30,000 to 60,000. In addition, the majority of the respondents (n = 183; 45.75%) were residents of houses covered with mud, which was also personally observed, and approximately 34.5% (n = 138) were living in semi-cemented houses. The remaining 19.75% (n = 79) were living in cemented houses. Crucially, a significant majority of respondents (n = 315, 78.8%) reported prior experience with flooding, underscoring the relevance of the study area for investigating flood-related perceptions and preparedness.

Table 3 highlights the flood causality perception based on the education level, revealing a significant association ($\chi^2 = 35.82$, $p < 0.001$). The data disclose that respondents with no formal education attributed floods as to local causes to a greater extent (93.3%) and had minimal awareness of watershed-related factors (6.7%). This

TABLE 2 Demographic information of the respondents.

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	220	55.0
	Female	180	45.0
Age group	18–30 years	112	28.0
	31–45 years	178	44.5
	46–60 years	78	19.5
	60+ years	32	8.0
Education level	No formal education	45	11.3
	Primary	155	38.7
	Intermediate	110	27.5
	Bachelor's or higher	90	22.5
Monthly household income	<30,000 PKR	125	31.3
	30,000–60,000 PKR	168	42.0
	>60,000 PKR	107	26.7
Housing type	Mud (Kacha)	183	45.75
	Semi-cemented	138	34.5
	Fully cemented	79	19.75
Previous flood experience	Yes	315	78.8
	No	85	21.2

TABLE 3 Cross-tabulation of flood causality perception based on the education level.

Education level	Primarily local cause (n = 278)	Primarily watershed cause (n = 122)
No formal education	42 (93.3%)	3 (6.7%)
Primary	125 (80.6%)	30 (19.4%)
Intermediate	72 (65.5%)	38 (34.5%)
Bachelor's or higher	39 (43.3%)	51 (56.7%)
χ^2 (p-value)	35.82 (<0.001)	

attribution pattern shifts progressively through educational levels: primary-level-educated respondents maintained (80.6%) local attribution, while intermediate-level educated respondents showed more balanced perspectives (65.5% local vs. 34.5% watershed). In addition, respondents with higher education acknowledged flood as having primarily watershed-level causes (56.7%), exceeding the local cause (43.3%). The statistical analysis indicates that respondents with higher education attributed flood to watershed-level causes, whereas those with lower education emphasized local causes.

The analysis of variable relationships in Figure 2 reveals a clear psychosocial profile of flood vulnerability and adaptive capacity reflecting the SES dynamic. A strong negative correlation ($r = -0.45$, $p < 0.001$) between the perception of local and watershed causes indicates that respondents typically view flood causality through an either/or view, which is often found in communities experiencing scale mismatch. Critically, a watershed-scale perspective positively predicts both self-efficacy ($r = 0.28$, $p < 0.001$) and trust in institutions ($r = 0.31$, $p < 0.001$), whereas a local perspective shows a strong negative relationship with these factors. Furthermore, socio-economic vulnerability significantly erodes a household's capacity to respond, thus correlating negatively with both self-efficacy ($r = -0.32$, $p < 0.001$) and institutional trust ($r = -0.25$, $p < 0.001$). The strongest relationship uncovered ($r = 0.40$, $p < 0.001$) between self-efficacy and institutional trust suggests that these two elements are mutually reinforcing, acting as the foundational pillars of preparedness in this community.

The hierarchical regression results align with PMT's coping appraisal dimension, identifying the determinants of household flood preparedness through a sequence of three models, as shown in Table 4. A three-step hierarchical regression was performed, theoretically progressing from demographic controls

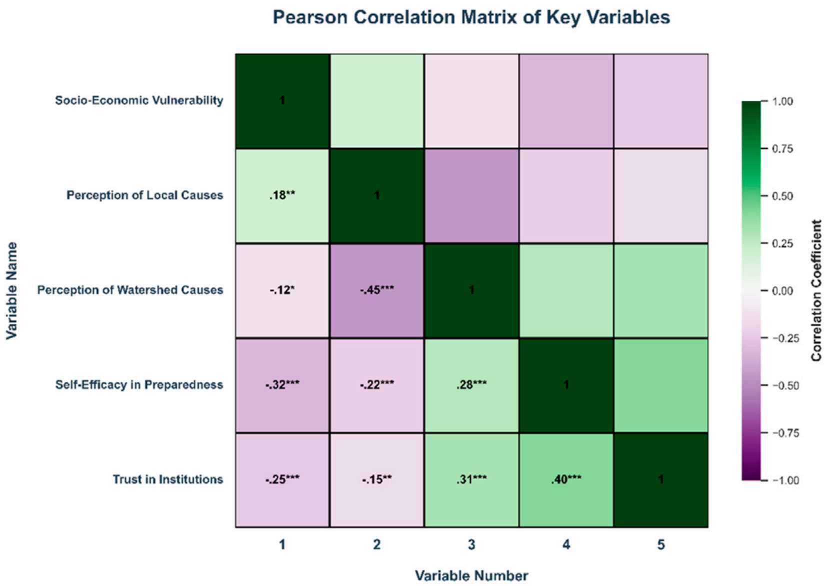

FIGURE 2
Pearson correlation matrix of key variables.

TABLE 4 Results of hierarchical regression analysis predicting household flood preparedness.

Predictor	Model 1 (β)	Model 2 (β)	Model 3 (β)
Step 1: Demographics			
Age	0.08	0.06	0.05
Education	0.21 ***	0.18 **	0.14 *
Income	0.25 ***	0.22 ***	0.19 ***
Step 2: Perceptions			
Perception of local causes		−0.17 **	−0.11 *
Perception of watershed causes		0.24 ***	0.16 **
Step 3: Psychosocial			
Self-efficacy			0.32 ***
Trust in institutions			0.21 ***
R^2	0.14	0.25	0.41
Adjusted R^2	0.13	0.24	0.40
ΔR^2	0.14 ***	0.11 ***	0.16 ***

β represents the standardized regression coefficient. *$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$.

(model 1) to causal perceptions (model 2) and finally to core psychosocial drivers of self-efficacy and institutional trust (model 3). Demographic characteristics alone accounted for 14% of the variance in preparedness, with education (β = 0.21, $p < 0.001$) and income (β = 0.25, $p < 0.001$) serving as significant positive predictors. The incorporation of perceptual variables in the second model substantially increased the explained variance to 25% ($\Delta R^2 = 0.11$, $p < 0.001$). In this model, attributing floods to watershed-scale causes was a strong positive predictor of preparedness (β = 0.24, $p < 0.001$), whereas a focus on local causes was a significant negative predictor (β = −0.17, $p < 0.01$). The full model, which added psychosocial variables, explained 41% of the variance ($\Delta R^2 = 0.16$, $p < 0.001$). In the final model, self-efficacy (β = 0.32, $p < 0.001$) and trust in institutions (β = 0.21, $p < 0.001$) emerged as the strongest predictors, underscoring PMT's premise that protective action depends not only on recognizing the threat but also on believing in one's ability to respond and in the support of reliable institutions.

A mediation analysis tested the hypothesized pathway whereby watershed perception influences preparedness behaviors through

TABLE 5 Mediation analysis: the indirect effect of watershed perception on preparedness through self-efficacy.

Path	Effect (β)	SE	95% CI (bias-corrected)
Total effect (X → Y)	0.24	0.05	[0.141, 0.339]
Direct effect (X → Y)	0.16	0.04	[0.081, 0.239]
Indirect effect (X → M → Y)	0.08	0.02	[0.041, 0.129]

self-efficacy. Here, X indicates the watershed causes by perception, M shows self-efficacy, and Y shows household flood preparedness. The results in Table-5 indicate that there is a significant total effect of watershed causes on the household preparedness (β = 0.24, $p < 0.001$). When accounting for the mediating role of self-efficacy, both the direct effect of watershed perception (β = 0.16, $p < 0.001$) and the indirect effect through self-efficacy (β = 0.08) remained statistically significant. The 95% bias-corrected bootstrap confidence interval for the indirect effect (0.041, 0.129) confirms mediation as the interval does not contain zero. Meanwhile, the mediation analysis suggests a plausible pathway through which watershed perception may influence preparedness via self-efficacy. The model is consistent with the PMT but requires longitudinal or experimental validation.

3.1 Divergent causal attributions: immediate failures versus systemic drivers

The qualitative themes of divergent causal attributions, psychological fatigue, and institutional distrust illustrate the lived dimensions of the SES–PMT framework. Narratives of "local failure" versus "upstream causes" mirror the spatial-scale mismatch that is central to socio-hydrology. The expressed hopelessness and erosion of self-efficacy after repeated floods demonstrate how chronic vulnerability undermines coping appraisal. Distrust in institutions emerged as a critical barrier, severing the link between risk awareness and the action and governance trap predicted by both SES (Adger et al., 2011) and PMT when the response efficacy is perceived as low. Participants' understanding of what causes floods fell into two distinct categories. The first and most common perspective blamed immediate, visible issues within the city limits. People holding this view focused on municipal services and local infrastructure as the primary problem. It was articulated as "The biggest concern of the flood in urban areas is mismanagement, as even in the rainy season, the road is full of water because the water has no way to transfer from the drainage to other areas. I have personally observed that the drains are always clogged with plastic bags and garbage, and the municipal departments never clean them. This is a failure of our local administration, not a problem from far away" (male, 48, shopkeeper, Hyderabad), suggesting the local solution to a greater extent, including better infrastructure, to maintain the drainage concerns while keeping in mind the environmental factors. Another perspective from a different group of participants discussed flood through the lens of an expanded watershed. These individuals described a system where actions far upstream directly impacted their lives downstream, demonstrating a more integrated understanding of the hydrological cycle. Another participant focused on watersheds and stated, "To understand our floods, you must look at the entire river basin. The main concern comes from upstream, where deforestation in the northern areas reduces the land's ability to hold water, leading to flooding in the watershed area. Then, the water and silt rush down, overwhelming the system here. We are at the mercy of decisions made elsewhere in the watershed. It is a basin-wide disaster that needs a coordinated plan" (male, 38, teacher). While this systemic awareness is crucial, it often comes with a sense of powerlessness, as the levers of change for watershed management lie beyond the community's control.

3.2 Intersection of material deprivation and psychological impact

The in-depth interview results revealed that repeated floods have caused destruction affecting not only the livelihoods of local residents but also their financial resources and psychological capacity to cope. Residents outlined a gradual erosion of hope and a slide into resignation. "Psychologically, we have been affected a lot, as whenever we hear that the flood is coming, we feel a deep fear internally, not just because our agriculture and livestock would be disturbed but also the houses, which are never ever easy for us to construct, articulating the material deprivation. Every time, we lose a little more of our savings, our belongings, and our strength. Now, when the monsoon clouds come, we do not even try to prepare. We just feel a deep fear and wait for the worst to happen." This demonstrates the key theme of psychological impacts determined from the respondents. "We are well aware of what is coming ahead but feel hopeless because of the mismanagement and deficiency in precautionary apparatus. There is no safe place to go, and no one is coming to help us in time. So, we simply wait. We pray, and we hope that this time, the water will be less. Living with this constant dread is itself a disaster" (female, 40, farm laborer).

3.3 The triad of adaptive capacity: knowledge, agency, and governance

The data suggest that knowing about flood origins is not enough to spur action. Preparedness depends on a combination of three factors: understanding the risk, believing in one's own ability to act, and having faith that institutions will do their part. For those who took action, knowledge was coupled with a strong sense of personal agency. A respondent stated, "Because I know the floodwaters come from the whole catchment area, I apprehend that we must be ready for a large volume of water. This awareness pushed me to act. I have built a small raised platform inside my home for my family to stay on. I keep our important papers in a metal box. I know I cannot stop

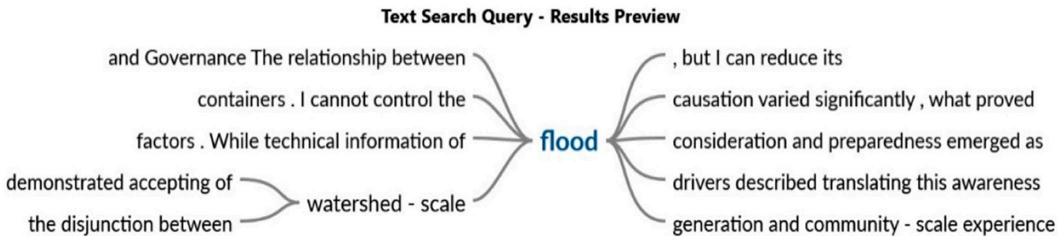

FIGURE 3
Word tree of the theme "Flood."

the flood, but I can make sure my family is safer" (male, 36, small business owner). However, for many, a deep-seated distrust in government bodies was deemed the single biggest barrier to preparedness. A respondent stated, "Why should I bother to prepare? The government's embankments are weak and break every few years. The warnings are always late. The aid never reaches the people who need it most. We have been forgotten. When you know the system has failed you, you start to believe that nothing you do will matter" (male, 52, community elder).

3.4 Foundations of adaptive capacity: knowledge, agency, and governance

The relationship between flood consideration and preparedness emerged as complex and was mediated by multiple factors. While technical information of flood causation varied significantly, what proved more consequential was how this awareness interacted with perceptions of personal agency and institutional reliability.

Some respondents who demonstrated acceptance of watershed-scale flood drivers described translating this awareness into concrete protective actions. They articulated that, "We very well know from which side water is coming; instead of government actions to be taken for controlling the flood or directing the floodwater to another side, we mentally prepare ourselves to drown. So, we keep our important objects, including documents and food materials, with us in a safe place. Obviously, we cannot control the flood but can reduce the impacts of the flood on our lives as much as possible" (male, 38, teacher). This articulation reflects how systemic consideration can foster practical adaptation when coupled with a sense of personal efficacy. Conversely, the capacity for interim measures was largely constrained by deep distrust in institutions, specifically the management authorities and government, which were seen as barriers to collective actions. With regard to the concerns about assistance and early warnings, one of the community leaders stated, "I have never heard the early warnings regarding the floods; besides that, if I still hear the warning calls, I do not get any assistance from the flood departments or government. It is only the order that we received from the officials to empty the houses and resettle in another area, which is quite hard for us to survive because the area is overpopulated and shifting the family to the area is disturbing for me as a whole" (male, 46, community elder). Thus, Figure 3 presents the word tree, illustrating the connections between the main theme and the statements. This perception of institutional failure undermined both individual motivation and community-based initiatives, highlighting how governance deficits can disrupt the pathway from risk awareness to protective action. The findings highlighted that the relationship between watershed flood generation and community-based experience is not only considered to be the geographical cause but also the involvement of political barriers. The narratives demonstrate how causal appreciativeness, psychological resilience, and institutional trust interact to shape vulnerability and adaptive capacity in complex ways that quantitative metrics alone cannot fully capture.

4 Discussions

The study provides significant empirical evidence regarding the watershed–urban disconnect in relation to disaster, risk perception, and preparedness in Hyderabad District, Sindh. Thus, a mixed-method approach was deemed necessary to quantify the gaps associated with flood disaster, the watershed–urban disconnect, and preparedness, using the 10-point Likert scale to assess perceptions and in-depth interviews to gather ground-level information on the issue. Thus, combining the mixed-method approach allows researchers to discuss the research within the broader global literature on flood risks and recommend evidence-based measures for sustainability. Importantly, the findings resonate strongly with the SES framework, socio-hydrology, and PMT, which are the three theoretical pillars guiding this research.

The analysis demonstrated flood causality perception based on education level using a cross-tabulation including chi-square, where the results revealed that there is a statistically significant association between education and flood causality perception ($\chi^2 = 35.82$, $p < 0.001$), which reflects a cognitive dimension of SES mismatch. Respondents with lower education overwhelmingly attributed flooding to local, municipal failures, while more educated respondents linked it to watershed-scale hydrological drivers, such as upstream deforestation and river-basin-wide water flows. This mirrors the SES model, which argues that communities often focus on proximate disturbances while broader ecological drivers remain invisible or technically complex (Berkes, 2000). The results align with those of Mambet Doue et al. (2020), who stated that individuals with higher education are more aware and better understand floods as environmental consequences rather than social factors, contextualizing local events within broader ecological and geographical systems. Such educational division has a direct impact in other countries as well, as discussed by Wu et al. (2021) in Ho Chi Minh City, where communities with lower educational background and less awareness regarding floods as natural disasters placed overwhelming blame on local administrators, discussing deficits in infrastructure misaligning with larger hydrological drivers. This aligns with our qualitative results, where a shopkeeper stated that failures of local administrators caused watershed–urban floods in Hyderabad. Similarly, in Bangladesh, educational attainment was found to influence localized perspectives of flood disasters (Haq, 2018).

The results from the hierarchical regression analysis highlight a nuanced set of factors influencing preparedness. The demographic data, including income and education, reveal initial variances in psychological factors, aligning with the research of Cerulli et al. (2020), which found education and income to be key areas for addressing hazards. While socio-economic capital provides a foundational resource base for protective measures, its explanatory power is limited. The inclusion of perceptual and psychosocial variables unveils a more complex behavioral terrain, where understanding watershed-scale causes fosters engagement, whereas the focus on local causes may induce a sense of helplessness, aligning closely with the study's findings on problem fatigue (Larsen et al., 2015). In addition, the final model with the strong predictive power of self-efficacy ($\beta = 0.32$, $p < 0.001$) and institutional trust ($\beta = 0.21$, $p < 0.001$) indicates that knowing what to do is insufficient without the belief in one's ability to act and confidence that the institution will provide the support. This finding is mostly aligned with nationwide research on disaster risk-reduction. For example, studies in the United States have highlighted that communities with strong social cohesion and trust are more likely to evacuate and take protective measures against disasters and watershed-related events resulting from urbanization and wetland loss (Tyler et al., 2019). In addition to this, the results from the mediation analysis offer an important psychological pathway, revealing that the watershed perception increases the preparedness indirectly by enhancing the self-efficacy [indirect effect $\beta = 0.08$, 95% CI (0.041, 0.129)], suggesting that the consideration of the systematic nature of threats, counterintuitively, fosters a greater sense of personal control. The observed mediation pathway aligns with PMT, wherein perceived systemic risk can enhance self-efficacy, thereby fostering preparedness. This theoretically informed model offers a mechanistic explanation for the disconnect but does not establish causality. Qualitative findings from the research supported the statistical relationships, highlighting how the watershed–urban disconnect is carved into the psychological and social fabric of communities. The narratives reveal a progression from resilience to fatalism, where repeated losses lead to a "paralyzing anxiety." This aligns with the socio-hydrology literature, highlighting how cumulative hazards can erode resilience. Such a statement is a critical dimension of vulnerability, which cannot be captured by the quantitative approach. As articulated by Khandoker et al. (2024), floods mainly disturb the psychological wellbeing of local farmers in Bangladesh, creating a sense of hopelessness. This is further discussed by the other researchers, who note that flooding in communities relying on agriculture, specifically in rural areas, destroys income sources and adversely affects the mental health of the residents (Paul and Routray, 2010). Most critically, this psychological vulnerability is compounded by a profound and pervasive distrust in institutions. The qualitative data are replete with accounts of "weak embankments." This loop directly reflects socio-hydrological modeling of governance traps (Sivapalan et al., 2012). The research in India elaborates the familiar cases, demonstrating late warnings and a deficiency in support during floods (Chatterjee, 2010). This perception of institutional failure, articulated by a community elder who asked, "Why should I bother to prepare?", emerges as the single biggest barrier to adaptive action. It severs the crucial link between risk awareness and preparedness, rendering knowledge inert. This triad of knowledge, agency, and governance is interdependent; when trust in governance collapses, as our correlation matrix shows ($r = 0.40$ between self-efficacy and trust), it undermines personal agency, creating a vicious cycle of inaction and heightened vulnerability.

4.1 Conclusions

The study identifies the precarious link between watershed flood generation and the perceived incoherence of local community residents. This research identifies the critical disjunction between watershed-scale flood generation and community-scale perception as a crucial barrier in flood risk management in the urban areas of Sindh. Based on the results, the study concluded that floods were perceived as locally caused, indicating deficiencies in infrastructure, by residents with lower levels of education, while watershed-level causes were acknowledged by respondents with higher levels of education. The convergence of quantitative and qualitative evidence firmly establishes that the watershed–urban divide transcends physical hydrology; it is a construct perpetuated by cognitive models and political economies that systematically reinforce vulnerability. Based on the findings and discussions, the study recommends a strong policy intervention for bridging the watershed–urban disjunction. The research further recommends tailoring risk communication by education level, integrating watershed concepts into curricula, and strengthening institutional trust via transparent and reliable governance to support sustainable development. In addition to this, the study also recommends implementing community-tailored watershed education programs to enhance flood-risk awareness across literacy levels, along with establishing formal upstream–downstream governance committees to improve cross-jurisdictional coordination and institutional trust in flood management.

4.2 Limitations of the study

The study has several limitations that should be acknowledged. It focused on one specific district of Sindh province, and the findings may differ in ther parts of the country with varied landscapes and community structures. Thus, the results cannot be generalized to the whole country. Methodologically, the reliance on self-reported data in the surveys and interviews introduces the potential for social desirability and recall bias, which may affect the accuracy of responses related to perceptions and preparedness behaviors. Furthermore, while providing in-depth insights, the small qualitative sample size ($n = 8$) limits the ability to capture the full spectrum of community experiences and opinions. In addition, the research focused on perceptions rather than actual behavior, which can be investigated further. Finally, the data were precisely collected at a specific time (November 2024–March 2025), and residents' trust in institutions and perceptions may change following major flood events.

4.3 Future research

Building on the limitations and insights of this study, future research should advance along three focused trajectories: conducting comparative and longitudinal mixed-methods analyses in other hydrological contexts to test the generalizability of the education–perception gradient and the adaptive capacity triad; carrying out behavioral experiments and ethnographic observation to bridge the critical gap between stated risk perception and actual preparedness behavior, especially under conditions of low institutional trust; and designing and evaluating targeted interventions to empirically assess the efficacy of tailored risk communication and participatory watershed governance in rebuilding trust and enhancing community-level resilience.

Data availability statement

The datasets presented in this article are not readily available because data would be provided on request. Requests to access the datasets should be directed to lx20220614007@hhu.edu.cn.

Ethics statement

The studies involving humans were approved by the Ethics Review Committee of the School of Public Administration, Hohai University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

WS: Conceptualization, Formal Analysis, Funding acquisition, Project administration, Resources, Supervision, Writing – original draft, Writing – review and editing. AK: Conceptualization, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review and editing.

Funding

The author(s) declared that financial support was received for this work and/or its publication. This work was supported by the National Social Science Fund of China, "Social Mechanisms of Green Development in Ecologically Vulnerable Counties" (Grant number 25BSH033).

Acknowledgements

The authors acknowledge the support of School of Public Administration, Hohai University, for providing the platform to research and issuing a letter for conducting the research. In addition, the authors also acknowledge the support of the community members for their valuable time and consideration. The authors also acknowledge that Gen-AI was used in the research paper for language polishing.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was used in the creation of this manuscript for language editing.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2025.1742965/full#supplementary-material

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