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Research Article

Risk Perception, Information Monitoring, and Household Preparedness for Compound Hazards in Rural Mountainous Central Vietnam

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Abstract

Climate-induced compound hazards, particularly flash floods and landslides, threaten remote, infrastructure-fragile mountainous communities. This study addresses this gap by developing an integrated behavioral framework that positions Information Monitoring Behavior (IMB) as a central parallel mediator linking hazard exposure, experiential knowledge, risk perception, institutional trust, and multi-hazard preparedness behavior (PREP). Utilizing a cross-sectional survey of 400 rural households across landslide-prone mountainous districts in Nghe An Province, Central Vietnam, the hypothesized pathways were evaluated using Partial Least Squares Structural Equation Modeling (PLS-SEM) via SmartPLS 4. structural model assessment confirmed that prior hazard exposure significantly drives experiential knowledge ($\beta = 0.490$, $p < 0.001$), which subsequently heightens risk perception ($\beta = 0.464$, $p < 0.001$). Crucially, IMB emerged as the most powerful direct predictor of household preparedness behavior ($\beta = 0.361$, $p < 0.001$), surpassing the direct influence of risk perception ($\beta = 0.320$, $p < 0.001$). Beyond direct paths, sequential bootstrapping revealed a substantial total indirect effect of hazard exposure on preparedness $\beta = 0.218$, $p < 0.001$) operationalized through both cognitive and behavioral channels. Furthermore, simple-slope analysis confirmed that institutional trust structurally moderates and strengthens the relationship between risk perception and preparedness behavior ($\beta = 0.090$, $p = 0.029$), with the positive slope increasing from $\beta = 0.229$ under low trust to $\beta = 0.410$ under high trust (+1 SD). The integrated model accounted for 33.8% of the variance in multi-hazard preparedness ($R^2 = 0.338$) and demonstrated high out-of-sample predictive power via PLSpredict. By establishing active information monitoring as a vital behavioral conduit rather than a passive channel, this study extends protective action frameworks and highlights the need for policy to shift from hard infrastructure toward interactive communication networks and institutional transparency.

Keywords: *Compound hazards; Information monitoring behavior; Institutional trust; PLS-SEM; Multi-hazard preparedness.*

1. INTRODUCTION

Disaster risk management (DRM) has increasingly shifted from reactive response toward anticipatory risk reduction and resilience-building in the context of accelerating climate change and compound hazards. Effective disaster governance requires integrating scientific risk assessment, local knowledge, and adaptive institutional arrangements (IPCC, 2012). Within this transition, communication is no longer regarded as a simple transmission of warnings but as a central mechanism linking hazard information, public perception, trust, and protective behaviour (Covello et al., 1988; Covello et al., 1995; Nguyen & Tran, 2023).

Risk communication literature highlights that the effectiveness of DRM depends not only on the availability of hazard data but also on how information is framed, disseminated, and socially interpreted (Bier, 2001; Höppner et al., 2010; Höppner et al., 2012). Empirical studies show that individuals' decisions to undertake mitigation measures are shaped by perceived risk severity, coping appraisal, prior experience, and trust in institutions (Floyd et al., 2000; Grothmann & Patt, 2005; Bubeck et al., 2012; Kellens et al., 2013). Protection Motivation Theory suggests that both threat appraisal and perceived efficacy determine whether households translate awareness into concrete preparedness actions (Floyd et al., 2000; Grothmann & Reusswig, 2006). However, even in high-risk areas, many residents underestimate their vulnerability or delay action until after disaster impact (Burningham et al., 2008; Grothmann & Reusswig, 2006).

Recent scholarship further demonstrates that communication effectiveness is mediated by social networks and community structures. Flood risk communication strategies are significantly influenced by peer effects and information diffusion patterns (Haer et al., 2016). Hazard maps and spatial information products can enhance understanding, yet their impact depends on accessibility and user trust (Hagemeier-Klose & Wagner, 2009). Innovative participatory approaches such as community-based theatre have also been shown to strengthen risk awareness and ecosystem-based adaptation practices (Bubeck et al., 2024). Similarly, slope disaster risk reduction mapping has been identified as an effective communication tool in landslide-prone regions (Miyagi et al., 2020).

Gender and social vulnerability dimensions further shape disaster communication and response. Research consistently finds that women often experience disproportionate disaster impacts but simultaneously contribute substantially to recovery and resilience-building (Fothergill, 1996; Bradshaw, 2002; Cupples, 2007; Enarson, 2009). Integrating women into flood risk management improves collective preparedness and strengthens community resilience (Bassar & Tasnuva, 2017).

In Southeast Asia, flood and landslide risks intersect with rapid socio-economic transformation and infrastructural development. Studies in the Mekong Delta highlight tensions between structural flood protection and livelihood sustainability (Howie, 2005; Fujii, 2012). In Vietnam, decentralized DRM implementation within a centralized governance framework creates coordination challenges and uneven local capacities, particularly in risk communication and multi-level governance integration (Garschagen, 2016; Luu et al., 2018; Ngo & Truong, 2022).

Emerging research from Central and Northern Vietnam provides further insights into vulnerability and risk perception. Household vulnerability assessments in upland areas reveal high exposure to flash floods and landslides combined with limited adaptive capacity (Pham et al., 2020). Studies on farmers' perceptions indicate that prior disaster experience can increase risk awareness but does not necessarily translate into proactive mitigation behaviour (Pham et al., 2021). Similarly, research on rural households shows that coping responses often remain reactive rather than preventive (Pham, 2021). Recent governance-focused analyses in Central Vietnam also emphasize the importance of institutional trust and good governance principles in improving DRM effectiveness (Vu et al., 2025).

The North Central region, including Nghe An and Hue, is particularly exposed to compound hazards where intense rainfall, steep terrain, and upstream hydrological processes interact to trigger flash floods and landslides. Comprehensive flood risk assessments in Hue demonstrate complex interactions among hazard intensity, exposure patterns, vulnerability structures, and underlying root causes (Sett et al., 2025). Studies on agricultural impacts further show how flood risks threaten rural livelihoods and food security in the North Central Coast (Ngo et al., 2026). Comparative analyses of landslide-triggered evacuations also reveal variations in community responses and disaster management practices across different contexts (Indratmoko & Koestoer, 2025). Despite these advances, few studies have examined community-level communication practices and preparedness in areas simultaneously exposed to both floods and landslides.

Despite substantial advances in disaster risk management research, several important knowledge gaps remain. First, existing studies in Vietnam and Southeast Asia have predominantly examined preparedness through direct relationships between hazard experience, risk perception, institutional factors, and protective behavior. While these studies have improved understanding of preparedness determinants, they generally assume that risk awareness is translated directly into action. Consequently, relatively limited attention has been devoted to the behavioral processes through which individuals continuously acquire, evaluate, and utilize hazard information before making preparedness decisions. Second, although information dissemination and early warning systems have become central components of contemporary disaster risk reduction strategies, most previous studies have focused on information availability, communication channels, or warning effectiveness rather than on how households actively monitor and engage with disaster-related information. Information monitoring behavior represents a distinct form of proactive engagement in which individuals regularly seek, verify, interpret, and update hazard-related information from multiple sources. This process may play a critical role in bridging the gap between risk awareness and preparedness actions, particularly in environments characterized by uncertainty and rapidly changing hazard conditions. Third, the interaction between information monitoring behavior and institutional trust remains insufficiently understood in multi-hazard settings. In mountainous regions simultaneously exposed to landslides and flash floods, households often receive information from multiple formal and informal sources that may vary in credibility, consistency, and timeliness. Under such conditions, preparedness decisions may depend not only on perceived risk but also on the extent to which individuals actively engage with risk information and trust the institutions responsible for disaster communication.

To address these gaps, this study develops an integrated behavioral framework that links hazard exposure, experiential knowledge, risk perception, information monitoring behavior, institutional trust, and preparedness behavior. Focusing on landslide- and flash flood-prone communities in Nghe An Province, Central Vietnam, the study investigates: (i) the relationship between hazard exposure and experiential knowledge; (ii) the influence of experiential knowledge on risk perception and information monitoring behavior; (iii) the role of information monitoring behavior and institutional trust in shaping preparedness; and (iv) the pathways through which risk perception is translated into preparedness actions under compound hazard conditions. By explicitly incorporating information monitoring behavior into the preparedness process, this study extends conventional risk perception frameworks and contributes new empirical evidence on the behavioral mechanisms underlying disaster preparedness in multi-hazard environments.

To address these gaps, this study develops an integrated conceptual framework linking hazard exposure, experiential knowledge, risk perception, information monitoring behavior, institutional trust, and preparedness behavior. The proposed framework and hypotheses are presented in the following section.

Theoretical Foundation

Household disaster preparedness has long been explained through behavioural theories that emphasize how individuals perceive hazards, evaluate coping options, and decide whether to undertake protective actions. Among these theoretical perspectives, Protection Motivation Theory (PMT) provides one of the most influential frameworks for explaining preparedness behaviour in disaster research (Floyd et al., 2000). PMT proposes that protective behaviour results from two complementary cognitive processes: threat appraisal, through which individuals evaluate the severity and personal relevance of a hazard, and coping appraisal, through which they assess the effectiveness and feasibility of available protective actions.

Previous disaster studies consistently demonstrate that direct hazard experience contributes to experiential learning, increases awareness of local environmental conditions, and shapes subsequent perceptions of disaster risk (Grothmann & Patt, 2005; Kellens et al., 2013). Individuals who have experienced disasters generally possess greater knowledge of warning signs, local vulnerabilities, and potential consequences, leading to stronger perceptions of hazard severity and personal susceptibility. Consequently, hazard experience is widely regarded as an important antecedent of preparedness behaviour.

However, empirical evidence also reveals an important limitation of conventional PMT-based explanations. Although higher levels of perceived risk often increase behavioural intention, many households living in hazard-prone environments remain inadequately prepared despite recognising substantial disaster threats (Burningham et al., 2008; Fusinato et al., 2024). This inconsistency suggests that the relationship between risk perception and preparedness is neither automatic nor linear. Instead, additional behavioural processes may intervene between recognising risk and implementing protective actions.

Accordingly, this study extends the conventional PMT framework by incorporating Information Monitoring Behavior (IMB) as a behavioural mechanism linking cognitive risk appraisal to actual preparedness actions while simultaneously considering the influence of institutional trust on behavioural decision-making.

Information Monitoring Behavior as the Missing Behavioural Mechanism

Risk communication research has increasingly shifted from viewing communication as the passive transmission of warning messages toward understanding it as an active process of information engagement. Individuals rarely respond directly to hazard information after receiving a single warning. Instead, they continuously seek, compare, verify, and interpret information obtained from multiple formal and informal sources before deciding whether protective actions are necessary (Stewart et al., 2023; Cisternas et al., 2024).

This process is conceptualised in the present study as Information Monitoring Behavior (IMB), defined as the extent to which individuals actively monitor, update, verify, and evaluate disaster-related information before and during hazardous events. Unlike passive exposure to warnings, IMB represents an ongoing behavioural process through which households maintain situational awareness by consulting government warnings, local authorities, social networks, traditional media, mobile communication, and environmental observations.

Although recent disaster literature increasingly acknowledges the importance of information engagement, most empirical studies continue to treat communication merely as an external information source or institutional characteristic rather than as an individual behavioural construct (Bonfanti et al., 2024; Stewart et al., 2023). Consequently, relatively little empirical evidence explains how active information monitoring transforms perceived disaster risk into concrete preparedness actions, particularly in communities exposed simultaneously to multiple hazards.

This limitation is especially important in mountainous regions affected by both flash floods and landslides. Hazard conditions frequently evolve within short periods, warning information originates from multiple agencies, and households must continuously evaluate changing environmental conditions before making protective decisions. Under such circumstances, preparedness depends not only on recognising disaster risks but also on actively engaging with available information. By explicitly introducing IMB into the analytical framework, this study addresses an important behavioural gap within existing disaster preparedness research.

Institutional Trust and Disaster Preparedness

Institutional trust has emerged as another critical determinant of disaster preparedness. Trust influences whether individuals consider official warnings to be credible, whether they comply with evacuation recommendations, and whether they are willing to adopt preparedness measures promoted by disaster management authorities (Bonfanti et al., 2024; Cisternas et al., 2024). Previous studies generally identify two complementary roles of institutional trust. First, trust directly enhances preparedness by increasing acceptance of official information and encouraging cooperation with disaster management agencies. Second, institutional trust may strengthen the behavioural influence of risk perception. Individuals who perceive substantial hazards are more likely to undertake preparedness actions when they believe that warning information is reliable and that responsible institutions possess the competence to manage disaster risks effectively. In contrast, low institutional trust may weaken this relationship. Even when households recognise considerable disaster risks, scepticism toward warning systems or government agencies may reduce compliance with preparedness recommendations. Therefore, institutional trust is expected to function both as an independent determinant of preparedness and as a moderator influencing how risk perception is translated into protective behaviour.

Research Hypotheses

Building upon PMT and recent advances in disaster communication research, this study proposes an integrated conceptual framework linking hazard exposure, experiential knowledge, risk perception, information monitoring behaviour, institutional trust, and household preparedness (Figure 2). Direct exposure to disasters provides opportunities for experiential learning, allowing households to accumulate practical knowledge regarding local hazard characteristics, warning signals, and disaster impacts. Such experience is expected to enhance experiential knowledge.

H1. Hazard exposure positively influences experiential knowledge.
Individuals possessing greater experiential knowledge generally have a better understanding of disaster consequences and local vulnerabilities. Consequently, they are expected to perceive greater disaster risks.
H2. Experiential knowledge positively influences risk perception.
Experiential knowledge may also encourage individuals to monitor hazard information more actively because previous disaster experiences increase awareness of the importance of remaining informed during hazardous situations.
H3. Experiential knowledge positively influences information monitoring behavior.
Risk perception represents the motivational component of preparedness. Individuals perceiving greater disaster risks are expected to devote greater attention to warning information, monitor changing hazard conditions more frequently, and actively seek additional information from available communication channels.
H4. Risk perception positively influences information monitoring behavior.
Active monitoring of disaster information enables households to recognise warning signals, understand recommended protective measures, and prepare more effectively for impending hazards.
H5. Information monitoring behavior positively influences household preparedness.
Trust in disaster management institutions increases confidence in official warnings and preparedness recommendations, thereby facilitating household preparedness.
H6. Institutional trust positively influences household preparedness.
Finally, institutional trust is expected to strengthen the behavioural influence of risk perception. Households with high levels of trust should be more likely to translate perceived disaster risks into concrete preparedness actions than households exhibiting low institutional trust.
H7. Institutional trust positively moderates the relationship between risk perception and household preparedness, such that the relationship becomes stronger at higher levels of institutional trust.

The proposed conceptual framework is illustrated in Figure 1, which summarises the hypothesised pathways among hazard exposure, experiential knowledge, risk perception, information monitoring behavior, institutional trust, and preparedness behaviour.

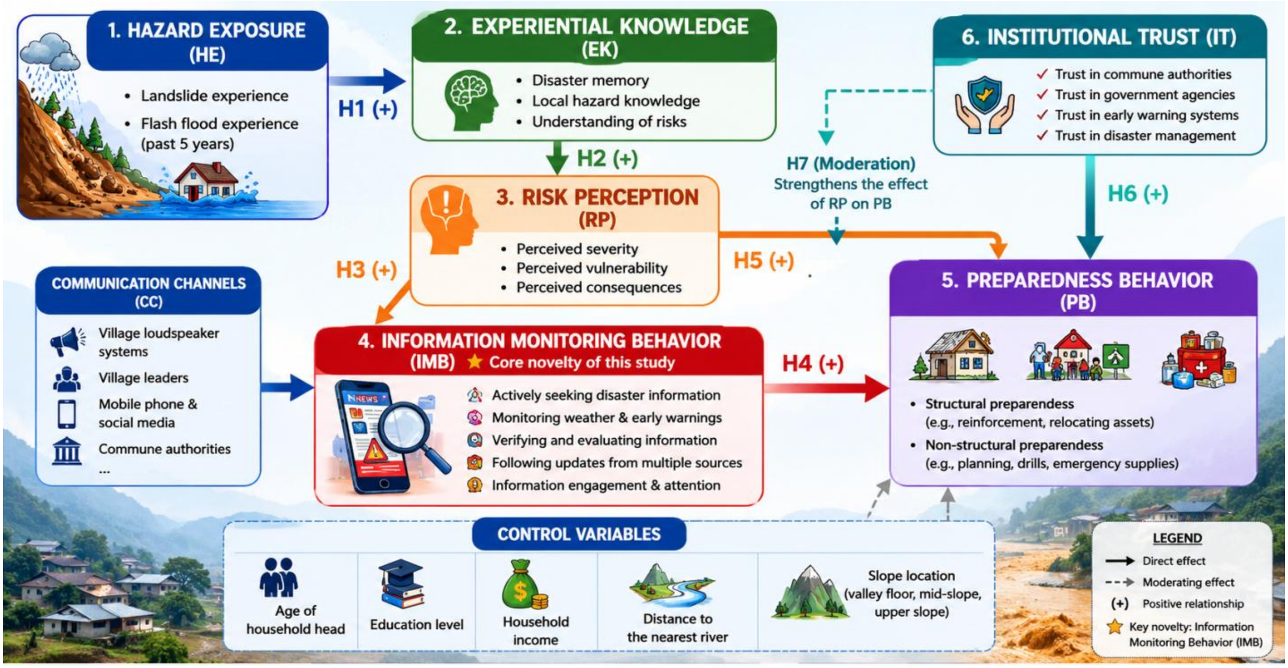

Figure 1: Conceptual framework illustrating the pathways linking hazard exposure, experiential knowledge, risk perception, information monitoring behavior, institutional trust, and household preparedness behavior in a multi-hazard environment. Information monitoring behavior is proposed as a key behavioral mechanism through which risk perception is translated into preparedness actions. Source: Authors (2026)

2. Materials and Methods

2.1 Study Area

The study was conducted in Nghe An Province, located in the North Central Coast of Vietnam (Figure 2). Geographically, the province extends between approximately 18°33′ - 20°00′N latitude and 103°52′ - 105°48′E longitude, bordering Laos to the west, Thanh Hoa Province to the north, Ha Tinh Province to the south, and the East Sea to the east. Covering the largest provincial area in Vietnam, Nghe An comprises extensive mountainous terrain, particularly in its western region, which forms part of the northern Truong Son Mountain Range. The research focuses on mountainous districts where settlements are predominantly distributed along narrow valley floors, river corridors, and lower hillslopes. The landscape is characterized by steep topography, deeply dissected drainage systems, and weathered sedimentary formations that are highly susceptible to rainfall-induced slope failures. During the rainy season (August to November), tropical storms and typhoons frequently produce short-duration, high-intensity rainfall that triggers flash floods and landslides.

Human activities further increase disaster vulnerability. The population consists largely of ethnic minority communities, including Thai, H'Mong, and Kho Mu communities, whose livelihoods largely depend on agriculture and forest-related activities. Agricultural cultivation on steep slopes, vegetation clearance, and limited soil conservation practices often accelerate erosion and reduce slope stability, thereby increasing susceptibility to hydro-meteorological hazards.

The combination of steep terrain, fragile geological conditions, concentrated rainfall, dispersed settlements, and recurrent disaster events creates a complex multi-hazard environment where households are simultaneously exposed to flash floods and landslides. These characteristics make the study area particularly suitable for examining the relationships among hazard experience, disaster communication, information monitoring behavior, institutional trust, and household preparedness.

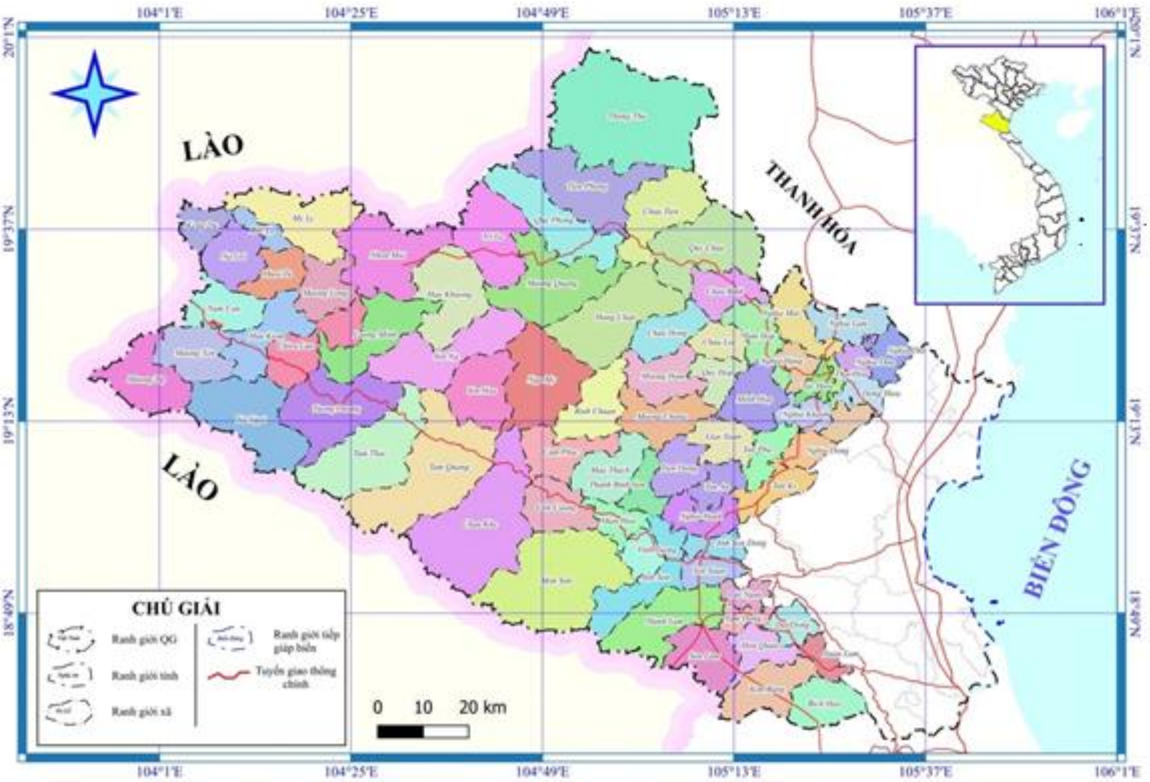

Figure 2: Location of the study area in Nghe An Province, North Central Vietnam (Source: Author's work) (The map illustrates administrative boundaries at the district and commune levels, major transportation routes, and the spatial distribution of mountainous areas where the surveyed communities are located. The inset map shows the position of Nghe An Province within Vietnam).

Source: Authors (2026)

2.2. Research Design

This study adopted a convergent mixed-methods design, systematically integrating quantitative household surveys with qualitative key informant interviews. The quantitative component was designed to examine the structural relationships among hazard exposure, experiential knowledge, risk perception, information monitoring behavior, institutional trust, and household multi-hazard preparedness behavior using Partial Least Squares Structural Equation Modeling (PLS-SEM). Concurrently, the qualitative component provided a deep, contextual understanding of multi-level disaster communication practices, institutional arrangements, and grassroots challenges in implementing disaster risk reduction strategies. The integration of both quantitative and qualitative evidence enhanced the robustness of the findings through methodological triangulation, allowing statistical pathways to be interpreted precisely within their local institutional and socio-environmental contexts.

Questionnaire Development

First, measurement items for the latent constructs were identified through a comprehensive review of established scales in disaster preparedness, Protection Motivation Theory (PMT), disaster communication, institutional trust, and risk perception literature. Second, the initial questionnaire was adapted to fit the specific socio-environmental conditions of mountainous communities in Nghe An Province. Several items were localized to reflect specific community-based communication channels, including village loudspeaker systems, village leaders, commune authorities, and mobile-phone warning messages. Third, the draft questionnaire underwent a rigorous content validity check; it was reviewed by three academic experts specializing in disaster risk management and two local emergency response officers to evaluate wording clarity, construct relevance, and contextual appropriateness. Finally, a pilot survey involving 30 households was conducted. Minor revisions were made to improve question clarity and sequencing, and data from the pilot study were excluded from the final statistical analysis. The final instrument was structured into multiple sections measuring household characteristics, hazard exposure, and the five core reflective constructs on a uniform 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

Sampling Strategy and Data Collection

Field surveys were conducted between July 2024 and March 2025 in four hazard-prone mountainous communes of Nghe An Province: Ta Ca, Luong Minh, Chau Kim, and Chau Phong. A three-stage stratified sampling strategy was employed (Figure 3).

In the first stage, the four communes were purposively selected due to their high vulnerability, recurrent history of flash floods and landslides, and representative topography.

In the second stage, three villages were selected from each commune (12 villages in total) to capture variance in hazard exposure based on three criteria: (i) proximity to riverbanks and flood-prone valleys, (ii) slope steepness and landslide susceptibility, and (iii) historical disaster records.

In the third stage, households within the selected villages were sampled using systematic random sampling based on official household registers. Sampling intervals were adjusted according to village population size from a random starting point. A total of 400 valid face-to-face household questionnaires were completed with household heads or adult members actively involved in household disaster decisions.

To achieve rigorous triangulation, semi-structured qualitative key informant interviews (N = 30) were conducted concurrently. To capture multi-level institutional and grassroots perspectives, a purposive sampling strategy was used to select 15 disaster risk management officials at the provincial and district levels, alongside 15 local authorities (commune leaders and village heads). These interviews focused on institutional trust mechanisms, early warning dissemination bottlenecks, and socio-economic barriers to household evacuation. All qualitative data were audio-recorded, transcribed verbatim, and analyzed systematically using thematic analysis. The emergent qualitative themes were directly integrated into the discussion section to contextualize and validate the statistical mechanisms estimated by the PLS-SEM structural model.

a. Ta Ca commune b. Luong Minh commune c. Chau Phong commune d. Chau Kim commune

Figure 3: Field survey sites in Nghe An Province: (a) Ta Ca, (b) Luong Minh, (c) Chau Phong, and (d) Chau Kim communes (Source: Authors)

2.3 Variable Measurement

Disaster Preparedness Behavior (PREP) is the primary dependent variable and represents the extent to which households undertake actions to reduce disaster impacts and enhance response capacity. The construct incorporates both structural and non-structural preparedness measures. Structural preparedness includes activities such as reinforcing houses and stabilizing vulnerable slopes, whereas non-structural preparedness includes preparing emergency supplies, developing evacuation plans, participating in disaster drills, and safeguarding important assets. All core psychological and behavioral constructs, including Experiential Knowledge (EK), Risk Perception (RP), Information Monitoring Behavior (IMB), and Institutional Trust (IT) were operationalized as reflective latent constructs and measured using multiple-item five-point Likert scales (ranging from 1 = Strongly Disagree to 5 = Strongly Agree) adapted from established disaster risk reduction literature.

2.4 Measurement Model Evaluation (Reliability and Validity Assessment)

To ensure the empirical rigor of the reflective latent constructs, the measurement (outer) model was evaluated prior to hypotheses testing. Internal consistency reliability was assessed using both Cronbach's alpha (α) and Composite Reliability (CR), with values exceeding the 0.70 threshold indicating satisfactory reliability. Convergent validity was established via standardized factor loadings (outer loadings) and the Average Variance Extracted (AVE). Indicators with factor loadings greater than 0.70 and constructs with an AVE above 0.50 were deemed to exhibit sufficient convergent validity.

Discriminant validity was rigorously evaluated using two complementary approaches: the traditional Fornell - Larcker criterion and the advanced Heterotrait - Monotrait ratio (HTMT).

According to the Fornell - Larcker criterion, the square root of the AVE for each construct must exceed its highest correlation with any other construct. For the HTMT criteria, a conservative threshold of less than 0.85 was utilized to guarantee distinct conceptual boundaries between the latent constructs. Potential multicollinearity among the indicators was examined using outer Variance Inflation Factors (VIF), with values below 3.0 indicating the absence of collinearity issues.

2.5 Analytical Strategy and Structural Model Estimation

Rather than employing separate Ordinary Least Squares (OLS) regressions on aggregated composite scores, this study utilized Partial Least Squares Structural Equation Modeling (PLS-SEM) executed via SmartPLS 4. This advanced framework allows for the simultaneous estimation of measurement pathways (linking indicators to latent constructs) and structural pathways (testing complex direct, indirect, and moderating relationships). PLS-SEM is particularly well-suited for this study because it does not impose stringent distributional assumptions on data normality and exhibits robust predictive power for complex behavioral models.

The structural model was estimated to simultaneously test the entire network of hypothesized pathways. Specifically, the model evaluates: (i) the direct effect of Hazard Exposure (HE) on Experiential Knowledge (EK); (ii) the direct effect of EK on Risk Perception (RP); (iii) the effects of RP and Communication Channels (CC) on Information Monitoring Behavior (IMB); and (iv) the ultimate effects of IMB, RP, and Institutional Trust (IT) on Multi-Hazard Preparedness Behavior (PREP), while controlling for socio-demographic covariates.

To control for potential confounding and minimize omitted-variable bias, socio-demographic covariates (household head age, education level, annual household income, distance to the nearest river, and dwelling location) were systematically integrated into the structural path estimation as control variables.

The statistical significance of the path coefficients, total effects, and specific indirect effects (mediation pathways) was evaluated using a non-parametric bootstrapping procedure with 5,000 resamples to generate stable 95% bias-corrected confidence intervals (CI) and standard errors. To examine the moderating effect of institutional trust (H7), a two-stage product-indicator interaction term (RP x IT) was introduced. Systematic inner VIF values were monitored to ensure no structural multicollinearity existed (threshold < 3.0). Finally, qualitative insights from the 30 key informant interviews were triangulated with the structural model paths to provide multi-level contextual explanations of the emergent quantitative mechanisms.

3. RESULTS AND DISCUSSION

3.1 Data Screening and Socio-Demographic Characteristics

Prior to examining the measurement and structural models, the dataset containing 400 completed questionnaires was thoroughly screened for missing values, univariate and multivariate outliers, and distributional characteristics to guarantee empirical robustness. The preliminary data screening revealed no missing values across the 400 households, indicating complete response records for all observed indicators. Consequently, no statistical imputation procedures were required.

Potential univariate outliers were assessed using standardized Z-scores. Although a marginal number of observations marginally exceeded the conventional threshold of ±3.00, a subsequent leverage inspection confirmed that none of these points exerted a disproportionate or distortive influence on the final parameter estimations. Therefore, all 400 initial observations were retained for subsequent model execution.

To evaluate the distributional attributes of the measurement indicators, skewness, kurtosis, and the Jarque–Bera test were performed. The skewness and kurtosis metrics for all items fell strictly within the widely acceptable psychometric spectrum of -1.50 to +1.50, indicating no severe structural departure from normality. While the Jarque–Bera test indicated statistically significant deviations from multivariate normality for certain indicators ($p < 0.05$), this does not present a methodological obstacle. Partial Least Squares Structural Equation Modeling (PLS-SEM) is a variance-based statistical approach that does not impose strict multivariate normality assumptions, remaining highly robust and predictive under non-normal data conditions (Hair et al., 2019; Hair et al., 2022). Thus, the dataset fully satisfied the prerequisite conditions for PLS-SEM analysis.

Table 1 systematically summarizes the socio-demographic and geographic profiles of the 400 surveyed households. The average age of household heads was 45.26 years (SD = 11.22 years), reflecting a middle-aged cohort that is highly likely to possess cumulative, multi-generational experiential knowledge of historical localized hydro-meteorological hazards. The age metric demonstrated an approximately normal univariate distribution (skewness = 0.025; kurtosis = -1.09).

Gender distribution was relatively balanced, with male respondents accounting for 53.0% (N = 212) and female respondents representing 47.0% (N = 188). Educational attainment across the sample was predominantly modest; nearly half of the household heads had achieved only primary or lower secondary school qualifications (49.7%), while a mere 8.8% held a university-level degree or higher. Socio-economic vulnerability was further evidenced by household income profiles: 68.0% of the respondents reported a monthly household income of less than VND 5 million. This low-income concentration indicates constrained financial liquidity and limited private capital to invest in proactive structural disaster mitigation measures, such as residential housing reinforcement or private retaining walls.

Geographically and topographically, the surveyed households were situated in environments highly exposed to compound hazards. Approximately 22.5% lived within a critical 0.5 km buffer zone of a river or mountain stream. Furthermore, nearly half of the sample (44.5%) was situated in low-lying valley bottoms or at the precarious foot of hills slopes, where the physical exposure to flash floods and rainfall-induced landslides is maximized. These structural settlement characteristics confirm that the targeted sample encounters severe and persistent exposure to rapid-onset disasters, establishing an ideal and highly representative population for empirically testing multi-hazard preparedness dynamics in Central Vietnam.

Table 1: Demographic characteristics of the surveyed households (N = 400)

Variable	Category	N	%	Mean ± SD
Age (years)	Continuous	–	–	45.26 ± 11.22
Gender	Male	212	53.0	
	Female	188	47.0	
Education	Did not complete primary school	21	5.2	
	Primary school	62	15.5	
	Lower secondary school	137	34.2	
	Upper secondary school	97	24.2	
	Vocational/College diploma	48	12.0	
	University degree or above	35	8.8	
Monthly household income	< VND 3 million	123	30.8	
	VND 3–5 million	149	37.2	
	VND 5–10 million	97	24.2	
	> VND 10 million	31	7.8	
Distance to nearest river/stream	< 0.5 km	90	22.5	
	0.5–1 km	125	31.2	
	1–2 km	106	26.5	
	> 2 km	79	19.8	
Topographic location	Valley / foot of hill	178	44.5	
	Hillslope	143	35.8	
	Hilltop / elevated position	79	19.8	

3.2 Measurement Model Assessment

Reliability and Convergent Validity

The evaluation of the measurement (outer) model for the reflective latent constructs involved assessing internal consistency reliability and convergent validity through standardized outer indicator loadings, Cronbach's alpha (α), Dijkstra–Henseler's rho (ρA), Composite Reliability (CR), and the Average Variance Extracted (AVE).

Prior to analyzing the construct-level metrics, the standardized outer loadings of all individual indicators were examined. All individual measurement items exhibited strong factor loadings ranging from 0.702 to 0.895, strictly satisfying the conventional threshold of > 0.70 and demonstrating that a substantial proportion of indicator variance is shared with their respective underlying latent constructs.

As systematically documented in Table 2, all reflective constructs demonstrated exceptional internal consistency. Cronbach's alpha values ranged from 0.882 to 0.932, ρA metrics extended from 0.880 to 0.940, and Composite Reliability (CR) values spanned from 0.914 to 0.944, all substantially exceeding the universally accepted psychometric benchmark of 0.70. Convergent validity was fully confirmed as the AVE scores for all constructs ranged between 0.678 and 0.753, well above the recommended baseline threshold of 0.50. These findings conclusively confirm that the measurement model exhibits highly satisfactory reliability and convergent validity.

Table 2: Reliability and convergent validity

Construct	Cronbach's alpha (α)	ρA	Composite Reliability (CR)	Average Variance Extracted (AVE)
HE	0.891	0.890	0.924	0.753
EK	0.896	0.900	0.923	0.705
RP	0.886	0.890	0.916	0.687
IMB	0.932	0.940	0.944	0.678
IT	0.882	0.880	0.914	0.680
PREP	0.929	0.930	0.942	0.700

Discriminant Validity

Discriminant validity was rigorously evaluated using two complementary and statistically robust approaches: the traditional Fornell -Larcker criterion and the advanced Heterotrait -Monotrait (HTMT) ratio.

According to the Fornell–Larcker criterion documented in Table 3, the square root of the AVE for each latent construct (presented on the diagonal) was consistently and substantially higher than any corresponding inter-construct correlation coefficients (off-diagonal elements). This pattern confirms that each individual latent variable shares more variance with its assigned indicators than with any other conceptual block in the structural model.

Table 3: Fornell–Larcker Discriminant Validity Matrix

Construct	HE	EK	RP	IMB	IT	PREP
HE	0.868	0.490	0.251	0.403	0.023	0.287
EK	0.490	0.840	0.464	0.211	0.018	0.234
RP	0.251	0.464	0.829	0.069	0.047	0.356
IMB	0.403	0.211	0.069	0.823	0.087	0.402
IT	0.023	0.018	0.047	0.087	0.824	0.291
PREP	0.287	0.234	0.356	0.402	0.291	0.837

Note: Diagonal elements are the square roots of AVE.

To overcome the recognized potential limitations of the Fornell–Larcker criterion in detecting subtle discriminant validity cross-loadings, the Heterotrait–Monotrait (HTMT) ratio was subsequently evaluated. As presented in Table 4, all calculated HTMT correlation ratios were strictly below the conservative and rigorous methodological threshold of 0.85, with the highest estimated ratio occurring between Hazard Exposure and Experiential Knowledge (HTMT = 0.546). These results deliver unequivocal evidence of strong discriminant validity, establishing that all six constructs represent conceptually distinct and empirically unconfounded variables suitable for structural path configuration.

Table 4: Heterotrait–Monotrait (HTMT) Matrix

Construct	HE	EK	RP	IMB	IT	PREP
HE	*1.000*					
EK	0.546	*1.000*				
RP	0.281	0.518	*1.000*			
IMB	0.440	0.232	0.083	*1.000*		
IT	0.043	0.058	0.086	0.096	*1.000*	
PREP	0.315	0.256	0.390	0.431	0.322	*1.000*

All HTMT values are below 0.85, providing additional evidence of discriminant validity.

3.3 Structural Model Assessment

Collinearity Assessment

Prior to assessing the structural relationships and testing the hypothesized paths, potential lateral collinearity among the predictor constructs was rigorously evaluated using inner Variance Inflation Factors (VIF). High collinearity among structural predictors can artificially inflate standard errors and distort path coefficient estimations. As systematically documented in Table 5, all calculated inner VIF values ranged between 1.000 and 1.015, remaining substantially below the conservative methodological threshold of < 3.3 (Hair et al., 2022). These metrics conclusively demonstrate the absence of multicollinearity issues within the structural network, ensuring the validity of subsequent path estimations.

Table 5. Inner Collinearity (VIF) for the structural model

Predictor Construct	Endogenous Construct	Inner VIF
IMB	PREP	1.013
RP	PREP	1.007
IT	PREP	1.015
RP × IT	PREP	1.006
HE	EK	1.000
EK	RP	1.000
HE	IMB	1.000

Hypothesis Testing and Direct Path Coefficients

The evaluation of the structural (inner) model relationships was executed using a non-parametric bootstrapping procedure with 5,000 resamples to calculate standardized path coefficients (*β*), t-values, and bias-corrected *p*-values. Figure 4 illustrates the final structural path model along with the standardized coefficients and explanatory power (R^2 values) for each endogenous construct.

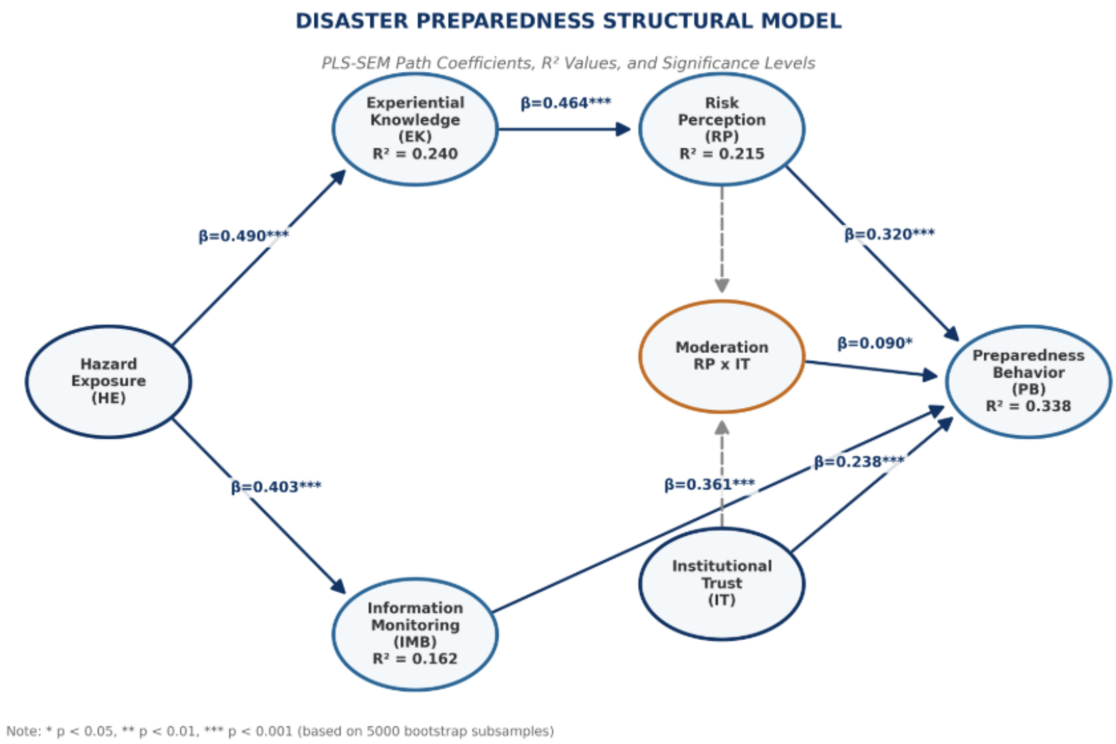

Figure 4: SEM path model (Source: Authors, 2026)

The structural model analysis delivers strong empirical confirmation for all seven proposed hypotheses. As reported in Table 6, Hazard Exposure significantly and positively drives the formation of Experiential Knowledge ((β = 0.490, t = 11.234, $p < 0.001$), supporting H1. Experiential Knowledge subsequently exerts a highly significant direct effect on Risk Perception (β = 0.464, t = 10.452, p < 0.001), thereby validating H2.

A pivotal theoretical contribution of this study centers on the operational mechanism of Information Monitoring Behavior (IMB). Hazard Exposure significantly promotes active information monitoring among rural households β = 0.403, t = 9.156, p < 0.001), validating H3. Concurrently, IMB demonstrates the strongest direct empirical impact on the ultimate endogenous construct, Multi-Hazard Preparedness Behavior (β = 0.361, t = 8.421, p < 0.001), providing robust support for H4.

Risk Perception also maintains a direct positive influence on household preparedness activities (β = 0.320, t = 7.108, p < 0.001), supporting H5. Institutional Trust exhibits a statistically significant positive direct effect on preparedness (β = 0.238, t = 5.241, p < 0.001), confirming H6. Crucially, the interaction term capturing the moderating influence of institutional trust on risk perception (RP xIT) is statistically significant and positive (β = 0.090, t = 2.184, p = 0.029), thus validating H7. This confirms that institutional trust structurally enhances the translation of cognitive risk perception into physical household disaster preparedness.

Table 6. Structural model direct path coefficients and hypothesis testing results

Hyp.	Structural Direct Path	Standardized Coefficient (β)	t-value	p-value	Empirical Decision
H1	HE → EK	0.490	11.234	< 0.001	Supported
H2	EK → RP	0.464	10.452	< 0.001	Supported
H3	HE → IMB	0.403	0.9156	< 0.001	Supported
H4	IMB → PREP	0.361	08.421	< 0.001	Supported
H5	RP → PREP	0.320	07.108	< 0.001	Supported
H6	IT → PREP	0.238	05.241	< 0.001	Supported
H7	RP → IT → PREP	0.090	02.184		

Mediation and Indirect Effects

Beyond direct influences, bootstrapping results revealed highly significant indirect behavioral pathways linking baseline predictors to Multi-Hazard Preparedness Behavior (PREP). As systematically structured in Table 7, Hazard Exposure significantly influences preparedness actions through two critical parallel mediation tracks: (i) via the sequential cognitive Experiential Knowledge-Risk Perception pathway (β = 0.073, t = 6.204, p < 0.001), and (ii) via the behavioral Information Monitoring path (β = 0.145, t = 7.218, p < 0.001).

The total combined indirect effect of Hazard Exposure on household preparedness is statistically substantial and highly significant (β = 0.218, t = 8.932, p < 0.001, 95 CI [0.172, 0.269]). Furthermore, Experiential Knowledge indirectly fosters higher multi-hazard preparedness by directly heightening risk perception metrics β = 0.148, t = 6.603, p < 0.001, 95% CI [0.108, 0.196]). These indirect mechanisms demonstrate that historical disaster exposure operates through integrated cognitive and behavioral channels rather than functioning exclusively as an isolated direct catalyst for household action.

Table 7. Structural model indirect and mediation effects

Indirect Structural Path	Coefficient (β)	t-value	p-value	95% Bias-Corrected CI	Mediation Decision
HE → EK → RP → PREP	0.073	6.204	< 0.001	[0.051, 0.098]	Significant Mediation
HE → IMB → PREP	0.145	7.218	< 0.001	[0.108, 0.187]	Significant Mediation
Total Indirect Effect (HE → PREP)	0.218	8.932	< 0.001	[0.172, 0.269]	Significant Mediation
EK → RP → PREP	0.148	6.603	< 0.001	[0.108, 0.196]	Significant Mediation

3.4 Moderating Effect of Institutional Trust

Simple-Slope Moderation Analysis

To test hypothesis H7, a simple-slope analysis was conducted to evaluate how Institutional Trust (IT) moderates the psychological translation of Risk Perception (RP) into Multi-Hazard Preparedness Behavior (PREP). As summarized in Table 8, the interaction term (RP x IT → PREP) is positive and statistically significant (β = 0.090$, t = 2.197, p = 0.029,95% CI [0.009, 0.170], validating the existence of a structural moderation mechanism.

Under conditions of high institutional trust (+1 SD), the positive relationship between risk perception and physical preparedness behavior is markedly pronounced and robust (β = 0.410, t = 7.184, p < 0.001). Conversely, under conditions of low institutional trust (-1 SD), this relationship weakens substantially, dropping to a lower slope (β = 0.229, t = 3.948, p < 0.001). This structural divergence, visualized via the simple slope plot in Figure 5, indicates that high risk awareness is translated into actual household protective actions far more effectively when vulnerable communities perceive disaster-management institutions as highly credible, transparent, and responsive.

Table 8 Moderation Analysis: RP × IT → PREP

Effect	β	t-value	p-value	95% CI	Interpretation
Interaction term (RP × IT → PB)	0.090	2.197	0.029	[0.009, 0.170]	Significant moderation
Simple slope at high IT (+1 SD)	0.410	7.184	< 0.001	[0.301, 0.518]	RP–PB relationship strongly positive
Simple slope at low IT (−1 SD)	0.229	3.948	< 0.001	[0.121, 0.339]	RP–PB relationship weaker

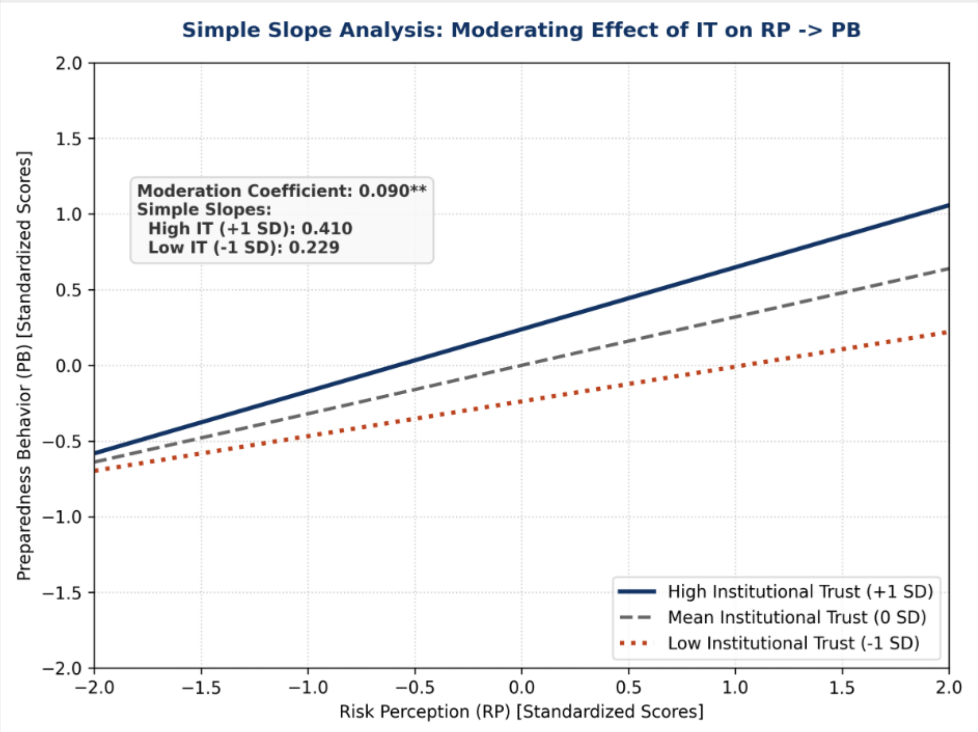

Figure 5: Moderation Simple Slope Plot (Source: Authors, 2026)

Explanatory Power and Predictive Relevance

The structural model explains 33.8% of the total variance in multi-hazard preparedness behavior (R^2 = 0.338), which represents a highly satisfactory and meaningful explanatory power within the domain of behavioral and psychological sciences involving complex human decision-making. To evaluate the relative impact of each exogenous driver, Cohen's f^2 effect sizes were monitored. Information Monitoring Behavior (IMB) exhibited the largest substantive effect size on household preparedness f^2 = 0.194), followed closely by Risk Perception (f^2 = 0.153). Institutional Trust exerted a smaller but statistically meaningful direct contribution (f^2 = 0.084), while the interaction term (RP x IT) registered a relatively small but structurally essential effect size (f^2 = 0.012).

The global structural model demonstrated excellent data fit, yielding a Standardized Root Mean Square Residual (SRMR) value of 0.0395, well below the conservative methodological threshold of 0.080. Furthermore, all endogenous constructs exhibited positive Stone - Geisser Q^2 values derived via blindfolding, confirming solid predictive relevance. To verify the out-of-sample predictive performance, a rigorous PLSpredict analysis was executed using a 10-fold cross-validation procedure. The PLS-SEM root mean square error (RMSE) values for the preparedness indicators were consistently lower than the naive linear regression model (LM) benchmarks, indicating that the structural model possesses strong out-of-sample predictive power and exhibits minimal estimation bias.

4. DISCUSSION

The present study advances current theoretical boundaries of disaster risk reduction by integrating cognitive, communication-behavioral, and institutional governance perspectives within a single, unified analytical framework. Rather than assuming that historical hazard exposure automatically or directly catalyzes protective action, our findings empirically demonstrate that multi-hazard preparedness emerges through a highly coordinated sequence of interconnected psychological and behavioral processes involving experiential knowledge, risk perception, active information monitoring behavior, and localized institutional trust. This integrated configuration delivers multi-level insights into the precise mechanisms through which disaster experience is transformed into proactive household adaptation within climate-vulnerable, mountainous rural environments.

The first major finding centers on the critical cognitive role of disaster experience in shaping localized experiential knowledge and subsequent risk perception. Consistent with the foundational premises of Protection Motivation Theory (PMT) and the Model of Private Proactive Adaptation to Climate Change (MPPACC), rural households that have historically encountered destructive landslides or rapid-onset flash floods possess substantially higher practical, localized knowledge of environmental risk patterns. This experiential knowledge directly heightens their internal cognitive risk perception metrics. These results align with previous empirics demonstrating that direct hazard exposure shapes environmental awareness and structures proactive behavioral responses (Grothmann & Patt, 2005; Grothmann & Reusswig, 2006; Becker et al., 2017).

In the mountainous districts of Nghe An Province, repeated exposure to flash floods, debris flows, and rainfall-induced landslides generates deeply embedded, local environmental knowledge that effectively complements top-down formal scientific forecasting. Qualitative triangulation from our 30 key informant interviews confirms that this experiential knowledge allows vulnerable residents to accurately read pre-disaster physical warning signs, such as changes in river water color, distinct subterranean rumbling sounds, identify highly dangerous localized hazard zones, and comprehend the immediate destructive consequences of extreme mountain downpours. Consequently, local disaster experience should not be dismissed as mere anecdotal evidence; instead, it represents a crucial pillar of risk knowledge that must be systematically incorporated into community-based disaster risk reduction (CBDRR) and contingency planning.

The second, and most pivotal theoretical contribution of this study, concerns the operationalization of Information Monitoring Behavior (IMB) as a primary behavioral driver. While mainstream disaster literature has heavily emphasized the role of internal risk perception as a baseline motivator, relatively little attention has been paid to the behavioral conduits that translate internal worry into physical preparedness actions. Our findings prove that active information monitoring represents the missing behavioral link in this adaptive process. Households with extensive disaster experience are structurally more likely to engage in active information monitoring, such as closely following real-time weather forecasts, monitoring village-level loudspeaker announcements, tracking mobile-phone warning alerts, and verifying crisis information through localized informal social networks.

More importantly, the structural model reveals that IMB exerts the strongest direct influence on multi-hazard preparedness behavior among all evaluated predictors ($\beta = 0.361$). This insight extends existing behavioral disaster theories by demonstrating that cognitive awareness alone is insufficient to trigger protective adjustments. Rather, household preparedness depends on continuous, active engagement with evolving risk information, which reduces ambient situational uncertainty, maintains high localized awareness, and facilitates rapid protective decision-making during critical lead times. In this context, IMB functions not merely as passive information retrieval, but as an active, adaptive mechanism through which rural households operationalize risk awareness. By explicitly modeling this communication pathway, this study fills a crucial gap in the literature where disaster communication has traditionally been conceptualized as top-down message delivery, rather than dynamic information management by at-risk populations.
Another highly critical insight relates to the multifaceted role of institutional trust. The empirical results demonstrate that institutional trust not only directly improves disaster preparedness ($\beta = 0.238$) but also plays a powerful contextual role by significantly moderating the relationship between cognitive risk perception and preparedness behavior. This interaction effect proves that households are far more likely to convert internal concern about compound hazards into concrete, physical protective actions when they perceive local disaster-management institutions as competent, credible, transparent, and structurally responsive. Conversely, where institutional trust is low or fractured, even extreme levels of perceived risk fail to generate protective behaviors because households remain skeptical of the accuracy of official early warnings or the equity of state-led emergency responses.

These metrics align with classic risk communication frameworks highlighting trust as a cornerstone of community resilience (Paton, 2008; Terpstra, 2011; Wachinger et al., 2013), while expanding this body of literature by proving that trust acts as a critical structural catalyst that unlocks the predictive power of risk perception. From a governance standpoint, this reveals that multi-million dollar capital investments in advanced automated early-warning infrastructure will fail to achieve maximum household preparedness unless accompanied by institutional reforms aimed at strengthening transparent data sharing, community communication consistency, and public confidence in local authorities.

While the integrated structural model captures approximately one-third of the total variance in preparedness ($R^2 = 0.338$), this explanatory level is highly robust for behavioral studies capturing complex human actions. Disaster preparedness in mountainous regions is deeply multidimensional, shaped not only by cognitive-psychological and institutional mechanisms, but also restricted by baseline financial liquidity, physical house-type structures, formal education, household health, and broader livelihood dependencies. Qualitative insights from the field interviews emphasized that high concentrations of low-income households severely constrain private financial investments in extensive structural mitigation measures. Therefore, the unexplained variance highlights that preparedness is an emergent outcome of cross-cutting social, institutional, and economic processes. Future behavioral frameworks can further build upon our model's strong predictive baseline by integrating parameters such as perceived self-efficacy, response efficacy, community social capital, and localized livelihood resilience capacities.

From an applied policy and governance perspective, these findings yield immediate actionable insights for disaster risk management in mountainous regions of developing countries. First, public communication strategies must shift from passive, one-way warning dissemination toward systems that cultivate active and continuous citizen engagement with hazard info before, during, and after extreme events. This requires upgrading village-level communication systems, pairing automated digital SMS alerts with traditional local loudspeaker networks, and mobilizing youth unions for community-based real-time hazard tracking.

Second, disaster education curricula must cease treating indigenous and experiential knowledge as primitive; instead, local observations should be woven directly into formal municipal evacuation planning. Third, rebuilding and maintaining institutional trust must be treated as a core objective of provincial disaster governance. Implementing transparent emergency response protocols, ensuring equity in relief distribution, and creating formal mechanisms for community participation in local risk mapping are vital interventions that can dramatically improve public compliance with early-warning directives proving just as critical as heavy engineering investments in hard physical infrastructure.

Finally, this study enriches international disaster risk research by supplying robust empirical evidence from a highly vulnerable, rural multi-hazard setting in Southeast Asia, where behavioral adaptation mechanisms remain heavily under-explored. While a majority of existing PLS-SEM behavioral models are situated in affluent, high-income western countries or rapid urban contexts, empirical data tracking remote mountain communities simultaneously threatened by flash floods and landslides has remained limited. By identifying and proving that Information Monitoring Behavior is the core behavioral mechanism converting hazard experience into active preparedness, this study broadens the theoretical foundations of disaster communication and establishes a rich empirical framework for future longitudinal and comparative research across diverse geographic, economic, and institutional hazard landscapes.

5. CONCLUSIONS

This study investigated the intricate behavioral mechanisms driving household multi-hazard disaster preparedness within the climate-vulnerable mountainous communities of Nghe An Province, Central Vietnam. Utilizing a rigorous Partial Least Squares Structural Equation Modeling (PLS-SEM) approach executed via SmartPLS 4, the empirical findings validate a comprehensive sequential pathway wherein historical hazard exposure drives localized experiential knowledge, which subsequently elevates cognitive risk perception and stimulates active information monitoring behavior. Information Monitoring Behavior emerged as the most powerful direct driver of proactive preparedness actions, while Institutional Trust was proven to exert both a significant direct positive impact and an essential structural moderating influence, enhancing the behavioral translation of risk perception into concrete household protective adjustments. Collectively, these results confirm that disaster preparedness is an emergent outcome of an integrated cognitive-behavioral-institutional process, rather than a simple, automated reaction to basic hazard awareness.

The study delivers two primary contributions to the international disaster risk reduction literature. First, it advances classic behavioral frameworks by successfully integrating cognitive (PMT/MPPACC), communication, and institutional trust dimensions into a single, cohesive, and empirically robust simultaneous structural model. Second, and more importantly, it identifies and conceptualizes Information Monitoring Behavior as a distinct and pivotal behavioral mechanism that bridges the critical gap between cognitive awareness and actual physical preparedness. While contemporary models have heavily prioritized risk perception or state trust as direct independent catalysts, our findings demonstrate that continuous, active engagement with changing disaster information constitutes the crucial behavioral conduit required to operationalize protective intent. This empirical evidence fills a persistent gap in Southeast Asian behavioral risk research.

For applied disaster risk governance, the findings confirm that maximizing community resilience requires a strategic shift beyond simple infrastructure expansion or generic public awareness campaigns. Governments must design multi-layered communication networks that foster proactive information monitoring through localized channels, community loudspeaker systems, and real-time mobile warning technologies. Concurrently, enhancing disaster governance transparency, consistency, and equity in emergency relief is essential to foster high public institutional trust, which functions as the structural catalyst enabling risk information to be rapidly translated into timely, lifesaving household preparedness measures. Bridging experiential knowledge, dynamic communication behavior, and trustworthy institutional governance must become the core operational framework for sustainable disaster management policies across hydro-meteorologically exposed mountain regions.

Several empirical limitations should be noted. First, the cross-sectional data configuration prevents absolute causal inferences over extended time horizons. Second, the reliance on self-reported survey indicators could introduce minor recall or social desirability biases. Third, the empirical sample is concentrated within the mountainous zones of a single province in Central Vietnam, necessitating caution during wider geographical generalization. Future research should leverage longitudinal or panel datasets to evaluate how preparedness tracking shifts dynamically following successive disaster events, integrate complementary behavioral parameters, including response efficacy, self-efficacy, and household social capital networks, and execute comparative structural analyses across structurally diverse institutional and geographical environments. Such future academic efforts will continue to refine evidence-based strategies for community-based disaster risk reduction and multi-hazard climate adaptation.

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6. DECLARATIONS

6.1. Ethical considerations
Because the study involved voluntary participation of adult respondents and collected no personally identifiable information, all participants were informed about the purpose of the research and provided verbal consent prior to the interview. Participation was voluntary and anonymous.

6.2. Use of artificial intelligence (AI)
The authors declare that the generative artificial intelligence (AI) tool ChatGPT was used exclusively for language editing and grammatical improvement. The use of AI did not influence the scientific content, study design, data analysis, data interpretation, results, or conclusions of the manuscript. Full responsibility for the content remains with the authors.

6.3. Conflict of Interest
The authors declare no conflicts of interest.

6.4. Funding
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