

Article

Factors Influencing the Flood-Risk Cognition of Peasant Households Based on Structural Equation Models: A Case Study of Rural Areas in Southwestern China

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Abstract

Against the backdrop of recurrent flood hazards, flood-risk cognition has become an important factor influencing disaster prevention decisions. The flood-risk cognition level of peasant households is related to rural sustainable development and land use patterns in the corresponding region. In this study, a structural equation model (SEM)-based empirical analysis of the flood-risk cognition features and the influencing factors was carried out based on survey data obtained from 685 peasant households with flood threats in southwestern China. The results showed the following: (1) The overall flood-risk cognition of these households was moderate to high. Although 70.22% of the respondents showed a positive attitude toward flood prevention, their pre-disaster preparedness awareness remained insufficient. (2) Pre-disaster preparedness awareness, in-disaster response awareness, and post-disaster restoration awareness had significant positive effects on flood-risk cognition. Specifically, post-disaster restoration awareness mediated the effect of disaster response awareness on flood-risk cognition, disaster response awareness mediated the effect of pre-disaster preparedness awareness on flood-risk cognition, and pre-disaster preparedness awareness moderated the relationship between post-disaster restoration awareness and flood-risk cognition. (3) Clarity of defence knowledge, familiarity with secondary disasters of floods, willingness to evacuate under flood threats, self-ability to solve life difficulties, and mitigation attitudes were important factors influencing flood-risk cognition. (4) Female households outperformed males in flood-risk cognition, and households in Jingyang District showed optimal flood-risk cognition. These findings are significant for the promotion of education regarding disaster prevention and for optimising risk assurance policies in rural areas in southwestern China.

Keywords: flood disasters; rural areas; risk cognition; influencing factors; SEM



Academic Editors: Francesco De Pascale and Leonardo Mercatanti

Received: 9 June 2026

Revised: 1 July 2026

Accepted: 9 July 2026

Published: 14 July 2026

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1. Introduction

Amid the rapidly worsening global climate crisis, extreme weather events are becoming more frequent, and climatic anomalies are gradually intensifying. This is accompanied by a continuous increase in the frequency of natural disasters, each causing different degrees of destruction. Among them, flood disasters are characterised by wide coverage and a long period of influence. They have become one of the most impactful natural disasters, threatening social stability and economic development. Statistics indicate that, between

1990 and 2024, flood disasters impacted approximately 3.249 billion people globally, causing 231,800 deaths and over 0.14 billion dollars in economic losses. Flood disasters can destroy infrastructure and cause enormous economic losses, especially to agricultural production. In particular, crop flooding, cultivated land degradation, and reduced planting and breeding industries account for more than 70% of agricultural losses caused by natural disasters each year. As a result, large areas of crops are damaged, limiting stable agricultural development and reducing food safety. In response to increasing flood risks, governments have strengthened whole-process disaster risk governance, covering pre-disaster prevention, in-disaster emergency response, and post-disaster recovery [1]. In China, these efforts include early-warning systems and risk education before disasters, as well as agricultural insurance and livelihood recovery support after disasters [2]. However, despite these policy efforts, gaps remain between institutional provision and farmers' understanding, participation, and behavioural response [3]. Peasant households play a key role in agricultural production and agricultural disaster control, and their risk cognition levels influence their disaster prevention decisions and response behaviours. Improving the flood-risk cognition levels of peasant households is a key approach to lowering agricultural disaster losses and improving basic prevention efforts. At present, most scholars define the flood-risk cognition of peasant households as their subjective judgement and psychological perception of the possibility and potential damage of flood disasters. The perception of disaster events relates to peasant households' judgements of their likelihood and intensity [4]. The assessment of response ability relates to their judgement of their disaster-prevention level and the effectiveness of external relief [5]. Their perception of livelihood risks depends on their awareness of the threat that floods pose to agricultural production, property, and the safety of peasant households [6].

This study defines the flood-risk cognition of peasant households in relation to the disaster time sequence—that is, the comprehensive judgement of peasant households regarding the possibility of flood disasters, the consequences of disasters, and peasant households' disaster resilience, covering the dynamic cognitive features before, during, and after flood disasters. It argues that peasant households can be prompted to adopt positive disaster-control behaviours and adaptive strategies by increasing their flood-risk cognition. Awareness of flood risks makes rural neighbourhoods more tenacious, strengthens the protection of their personal and property rights, and protects sustainable agricultural development [7].

Flood-risk cognition is important because it relates to national food security and rural sustainable development. The flood-risk cognition of peasant households is sensitive to multiple factors. Specifically, external information acquisition and individual features both play important roles. Existing studies have demonstrated that government publicity helps peasant households acquire disaster information, thereby raising their basic flood-risk cognition levels. Nevertheless, peasant households usually receive risk information passively and generally lack awareness of how to improve their own risk-cognition level [8]. Therefore, peasant households' flood-risk cognition becomes a core factor influencing disaster control. To prevent disasters and to optimise disaster prevention and management, the corresponding cognitive features and influencing factors of peasant households need to be clarified.

On this basis, the life-cycle theory of disasters was chosen as the core analytical framework of this study. The factors influencing the flood-risk cognition of peasant households were divided into three classes based on their cognitive and behavioural features throughout the flood-disaster life cycle—namely, pre-disaster preparation, in-disaster responses, and post-disaster restoration. During pre-disaster preparation, influencing factors include individual and family factors (e.g., gender, age, education background, and management

scale of cultivated land) [9,10], disaster experience and cognition (e.g., frequency of disaster experience in the past and degree of damage) [11,12], and information acquisition and social capital (e.g., warning channels and disaster-control publicity) [13,14].

During in-disaster responses, the influencing factors include the immediate impacts of disasters (e.g., flooding depth and duration) [15,16], emergency responses and collective actions (e.g., self-rescue, mutual rescue, and primary rescue) [17,18], and real-time information transmission (e.g., disaster notice and hedging guidance) [19,20]. For post-disaster restoration, the influencing factors mainly include post-disaster loss and livelihood impacts (e.g., area of total crop failure and degree of damage) [21,22], policy support and aid guarantee (e.g., disaster relief subsidy and insurance claims) [23,24], and post-disaster learning and cognition reconstruction (e.g., disaster-prevention training and risk education) [25,26].

While surveys and semi-structured interviews are the dominant methods used in the existing studies [21], structural equation modelling (SEM) has recently been extensively applied [27]. As Logit and Probit models cannot be fitted into non-linear relationships, measuring the mediating effects of variables using these models is difficult [28]. By contrast, SEM not only handles multiple variables and accounts for measurement errors but depicts direct and indirect effects among variables [29]. It is more suited to analysing the complications of latent variables in flood-risk cognition. Further, multi-group SEM can handle parameter constraints and effect comparisons between groups and can be used to test group heterogeneity and the cross-group applicability of theoretical models.

From a regional perspective, current studies on flood disasters have mainly focused on regions with frequent hydrometeorological events, such as in Asia and Africa. Most of these regions comprise developing countries with a high dependence on agriculture and weak economic bases [30,31]. Unlike developed countries, which focus more on urban flood control than rural [32], developing countries focus on peasant households' flood responses and risk cognition in vulnerable rural areas [33]. China is a developing agricultural power that faces serious flood threats. Agriculture and the livelihoods of peasant households in southwestern China, in particular, encounter significant threats from rugged terrain, wide variation in precipitation, sudden floods, and frequent secondary disasters. The region experiences frequent severe floods, with the annual average proportion of affected counties and cities over 50%, while the probability of local flood disasters has reached 95% [34]. Frequent disasters have destroyed large swathes of farmland and reduced crop production. However, the existing studies in China have mainly focused on the eastern coastal regions; few empirical studies have examined the flood-risk cognition of peasant households in southwestern China [33]. Therefore, there is an urgent need to explore the factors influencing flood-risk cognition among peasant households in southwestern China to improve their adaptive ability and to facilitate sustainable development and rural revitalisation.

To this end, SEM was used to build a model based on survey data from 685 peasant households. The core factors influencing this group's flood-risk cognition were then analysed. This study has the following aims: (1) to build a SEM model of the factors influencing the flood-risk cognition of peasant households based on protection motivation theory (PMT), the life-cycle theory of disasters, and flood features in southwestern China; (2) to examine three categories of factors influencing the flood-risk cognition of peasant households in southwestern China—namely, pre-disaster preparation, in-disaster responses, and post-disaster restoration; (3) to provide empirical evidence to optimise disaster-control policies, to strengthen the response ability of peasant households to disasters, and to facilitate rural revitalisation and sustainable agricultural development in the investigated region.

2. Materials and Methods

2.1. Study Region

This study was set in Sichuan Province, a representative region in southwestern China. (Figure 1), located at $97^{\circ}21' \sim 108^{\circ}12' \text{ E}$, $26^{\circ}03' \sim 34^{\circ}19' \text{ N}$. There is a significant altitude difference in Sichuan Province, ranging from 188 m to 7556 m. Multiple landforms include plains, hills, and mountains. These terrain differences indicate significant regional differences in agricultural livelihoods. Peasant households in the plains and on hills mainly derive their livelihoods from traditional planting industries, while those in mountainous and plateau areas derive theirs from farming and grazing. Agricultural production mainly focuses on rain-fed agriculture, and regions with sufficient water resources are supplemented by supporting irrigation agriculture [35].

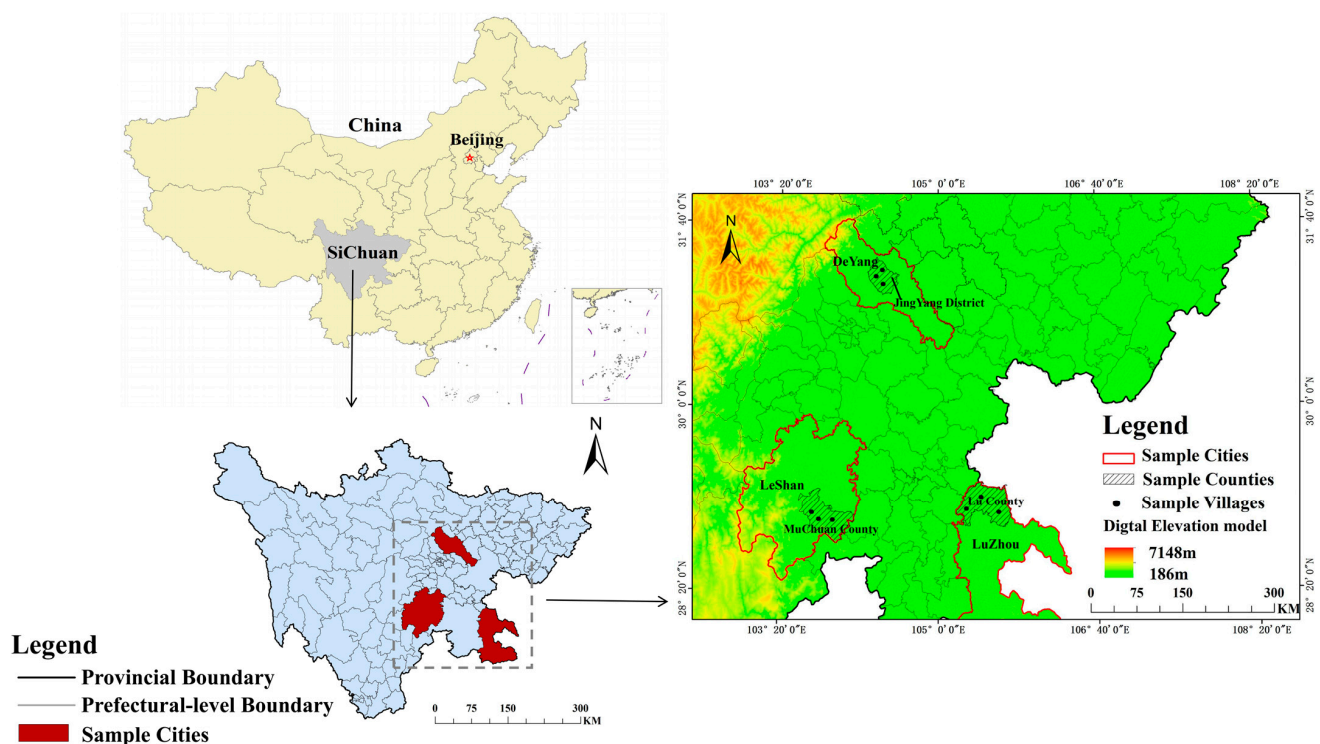


Figure 1. Study area and sampling site distribution.

Sichuan Province is one of the 13 grain-producing provinces in China, where large-scale grains, such as rice and corn, are planted. The province plays an important role in assuring regional and national food safety [36,37]. In 2024, the sowing area of food crops in Sichuan Province was 6.406 million hectares, and the total yield was 36.338 million tons. The province has a subtropical humid monsoon climate and an imbalanced spatial and temporal distribution of precipitation. The major flood period occurs from June to September, with precipitation during this period accounting for 70–80% of annual precipitation. There are also short periods of severe convection and frequent strong precipitation, making the various terrain regions prone to flooding in summer and autumn [38,39]. Meanwhile, the crop-growth cycle and the flood season overlap. Thus, flood disasters commonly cause large-scale waterlogging of farmland and reduced crop production, threatening agricultural production [40].

Given climate change, extreme precipitation events in Sichuan Province are increasing, accompanied by increased frequency and intensity of flood disasters [41]. From 2020 to 2024, the annual average number of counties in the province affected by disasters exceeded 150. Floods in rural areas accounted for 65% of the total flood-related losses in the province,

impacting the livelihoods of peasant households and agricultural production [42]. To mitigate flood risks, Sichuan Province has adopted several measures, including monitoring, early-warning systems, and comprehensive governance. Although these measures have helped to some extent to reduce macroscopic disasters, uncertainty about extreme flood disasters, the inadequacy of traditional engineering controls, and poor administrative management remain. Basic disaster-control resilience is inadequate. Hence, there is a pressing need to analyse flood-risk cognition among farm households and its determinants in the high-risk agricultural areas within Sichuan Province.

2.2. Data Sources

The analysis presented in this paper is based on primary data collected from a household survey implemented in Sichuan Province in 2024 covering basic family features, historical disaster conditions, and disaster-control behaviours. The survey was administered in a hierarchical, equal-probability, random-sampling mode. Samples were collected level-by-level, according to “county–town–administrative village–peasant households”. Firstly, by considering the occurrences of flood disasters and the economic development levels of the regions, the regionally representative plain area (Jingyang District), hill area (Lu County), and mountainous area (Muchuan County) were chosen as the study areas, according to the catalogue of mountainous counties and hill counties published by the Agricultural Mechanization Management Department, Agricultural and Rural Ministry in 2019.

Secondly, 9 sample towns and 54 sample administrative villages were identified, based on their economic development and spatial distance from the centres of districts, counties, and towns. Finally, 10–15 peasant households in each village were chosen as survey objects using the random-number table method. The chosen villages and peasant household samples all agreed with the corresponding territory features of the counties.

Before the survey, the research team recruited and trained 22 students as researchers. Pre-surveys were carried out in one village in a plain area, a hill area, and a mountainous area. The survey structure and questions were optimised according to the pre-survey results. The official survey was carried out from 30 June to 7 July 2024. Primary data were collected through face-to-face interviews with each respondent individually. A total of 54 village-level surveys and 685 surveys with peasant households were conducted. The sample distribution was balanced among survey districts and counties within the region: 242 surveys in Jingyang District, 223 in Lu County, and 220 in Muchuan County.

2.3. Methodology

2.3.1. Theoretical Analysis and Research Hypotheses

Within the academic domains of disaster risk management and community risk awareness, scholars have built a mature, multivariate research framework and theoretical model. Through long-term theoretical exploration and empirical testing, this framework provides key theoretical support for understanding the mechanism for disaster risk cognition and behavioural intentions [43]. At present, the mainstream research frameworks and theories regarding disaster risk cognition are the psychological measurement paradigm, cultural risk theory, and PMT [43]. These theories, which are complementary and adopt diverse research perspectives, constitute a complete theoretical system to study disaster risk cognition.

Specifically, PMT is extensively applied to disaster risk management and emergency preparation; it is an important theoretical model for investigating risk management from the perspective of social cognition [44]. Originating in the 1970s, PMT was first conceptualised to account for the influence of “fear appeals” on individual attitudinal change—i.e., using fear to motivate individuals to take protective action. Over time, it has been adapted

to the domain of disaster risk management and has been widely employed in empirical investigations in this field [45]. However, studies based on simple PMT have obvious limitations [46] because they emphasise static cognition and behavioural correlation analyses. PMT is difficult to adapt to the dynamic evolution of flood disasters and cannot capture the heterogeneity of individual cognitive features and behavioural selections at different disaster stages. Hence, it requires the life-cycle theory of disasters, which is based on a time series of disaster evolution. It divides the disaster process into three mutually correlated core phases—specifically, pre-disaster, in-disaster, and post-disaster—and emphasises differences at each stage in terms of risk features and information demand, providing theoretical support for a time-series analysis of influencing factors.

The complementarity of PMT and the disaster life-cycle theory provides a useful perspective for understanding the factors influencing peasant households' flood-risk cognition. PMT is one of the most widely applied cognitive frameworks for explaining individual protective behaviour under risk conditions. It conceptualises protection motivation as the outcome of two interrelated cognitive processes: threat appraisal and coping appraisal [47]. Empirical studies in environmental risk and flood contexts have shown that threat appraisal (perceived severity and vulnerability) and coping appraisal (self-efficacy and response efficacy) are closely associated with protective decision-making. However, their relative effects may vary across different contexts [6,7,48]. Recent studies have further suggested that these appraisal processes evolve with disaster experience and environmental feedback rather than remaining static [8].

Building on this perspective, the present study conceptualises the disaster life cycle as a temporal framework for understanding PMT processes. Rather than redefining the original PMT constructs, this framework assumes that different appraisal processes become more salient at different stages of the disaster cycle. Specifically, threat appraisal is emphasised before disasters, when households primarily assess the likelihood and potential consequences of flood hazards; coping appraisal becomes more salient during disasters as households evaluate their response capability and the effectiveness of available protective actions; and protection motivation is evident after disasters through the intention to restore livelihoods, to improve preparedness, and to strengthen future resilience.

Specifically, threat assessment is primarily reflected in pre-disaster preparedness awareness, because preparedness decisions are largely initiated by individuals' perceptions of flood probability and severity. Pre-disaster preparedness awareness, therefore, captures peasant households' anticipatory risk judgements, disaster expectations, and willingness to undertake preparatory actions before hazard occurrence. The response assessment is primarily reflected in disaster response awareness, as peasant households evaluate how well they can respond to an emergency and the effectiveness of disaster-mitigation measures during a flood. Finally, post-disaster restoration awareness represents the stage-specific manifestation of protection motivation during the post-disaster phase, reflecting peasant households' willingness to restore production and daily life, to optimise disaster prevention strategies, and to enhance disaster resilience based on disaster-loss cognition and self-restoration assessment (Figure 2) [49]. It is argued that individual pre-disaster preparedness awareness, in-disaster responses, and post-disaster restoration significantly affect flood-risk cognition [50,51]. They are interrelated and contribute to the complete flood-risk cognition of peasant households, from prediction to response and then to reflection.

Therefore, using PMT as the core analytical framework and integrating the life-cycle theory of disasters, this study hypothesised the following:

H1: *Pre-disaster preparedness awareness positively promotes the flood-risk cognition of peasant households.*

H2: Disaster response awareness positively promotes the flood-risk cognition of peasant households.

H3: Post-disaster restoration awareness positively promotes the flood-risk cognition of peasant households.

H4: Pre-disaster preparedness awareness has a direct positive effect on disaster response awareness.

H5: Disaster response awareness has a direct positive effect on post-disaster restoration awareness.

H6: Pre-disaster preparedness awareness has a direct positive effect on post-disaster restoration awareness.

H7: Post-disaster restoration awareness mediates the effect of disaster response awareness on flood-risk cognition.

H8: Disaster response awareness mediates the effect of pre-disaster preparedness awareness on flood-risk cognition.

H9: Pre-disaster preparedness awareness mediates the effect of post-disaster restoration awareness on flood-risk cognition.

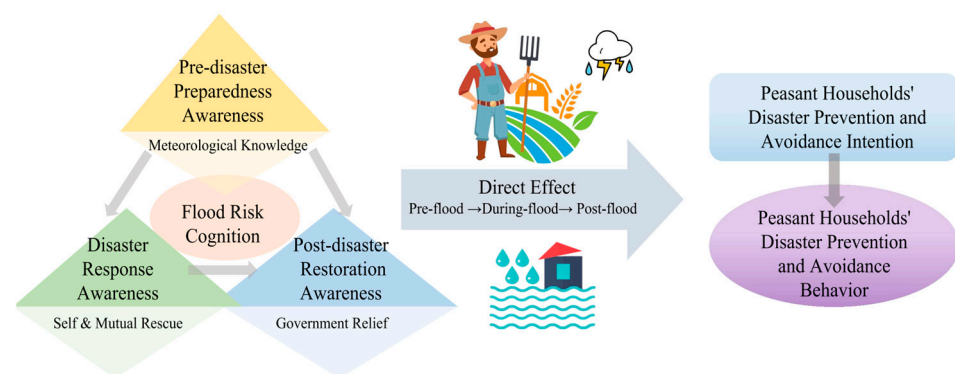


Figure 2. Theoretical analysis framework.

2.3.2. Validity and Reliability of the Survey

Validity and reliability are core evaluation dimensions for scale-type survey data and are prerequisite conditions for SEM analysis: reliability embodies the internal consistency and stability of survey measurement outcomes, while validity verifies the measurement accuracy and fitness of intended research constructs.

Cronbach's α coefficient tests the overall validity of a scale, and its calculation formula can be expressed as follows:

$$\alpha = \frac{k}{k-1} \left(1 - \frac{\sum_{i=1}^k \sigma_i^2}{\sigma_x^2} \right) \quad (1)$$

where k is the number of questions in the scale, σ_i^2 is the variance of scores for Question i , and σ_x^2 is the variance of total scores. Here, validity was considered good if $\alpha > 0.7$.

The KMO (Kaiser–Meyer–Olkin) test is the core prerequisite indicator of factor analysis, and its calculation formula can be expressed as follows:

$$KMO = \frac{\sum_{i \neq j} r_{ij}^2}{\sum_{i \neq j} r_{ij}^2 + \sum_{i \neq j} p_{ij}^2} \quad (2)$$

where r_{ij} denotes the bivariate Pearson's correlation between variables i and j , and p_{ij} represents their corresponding partial correlation coefficient. The numerator represents the sum of squares of the zero-order correlation coefficients for all variable pairs, while the denominator equals this value plus the sum of squares of the corresponding partial correlation coefficients.

The KMO test results were judged according to the Kaiser standards. If $KMO \geq 0.8$, the data were considered applicable to factor analysis with ideal reliability performance. If KMO ranged between 0.7 and 0.79, the data reliability was considered good. If KMO ranged between 0.6 and 0.69, the dataset demonstrated adequate factorability, indicating that it was suitable for exploratory factor analysis. Data with KMO ranging between 0.5 and 0.59 were considered not suitable for factor analysis. Data with KMO lower than 0.5 were considered very unsuitable for factor analysis.

2.3.3. SEM

(1) SEM construction

SEM is a comprehensive research method based on multivariate statistical analysis theory. It aims to systematically explore and analyse the internal structures and correlation mechanisms of complicated data containing multiple variables. The SEM framework is composed of two core sub-models, namely the measurement model and the structural model.

The measurement model is designed to establish the measurement associations between latent constructs and their respective observed indicators. Its mathematical characterisation can be expressed as follows:

$$X = \Lambda_x \xi + \delta \quad (3)$$

$$Y = \Lambda_y \eta + \varepsilon \quad (4)$$

In the settings of the measurement model, the error term (ε) is determined as mutually independent from the endogenous latent variable (η), the exogenous latent variable (ξ), and another error term (δ). The error term (δ) also maintains statistical independence from η, ξ, ε .

The terms Λ_x and Λ_y are the factor loads of the exogenous observed indicator (X) and endogenous observed indicator (Y) on the corresponding latent variables, which quantify the contributions of indicators to latent variables, while δ is the measurement error for X , and ε is that for Y . Similarly, ξ denotes the exogenous latent variable, while η stands for the endogenous latent variable.

SEM depicts the complicated interactions of two or more latent variables. It can be expressed as follows:

$$\eta = B\eta + \Gamma\xi + \zeta \quad (5)$$

The matrix B (dimensions: $n \times n$) characterises the mutual effect among endogenous latent variables (η). The net effect exerted by exogenous latent variables (ξ) on endogenous latent variables (η) is characterised by matrix Γ . Meanwhile, ζ represents the SEM residual, capturing unmodeled variation.

(2) Selection of Indicator Variables and Model Construction

The core variables were determined based on studies of PMT and flood-risk cognition (Table 1) [52]. To guarantee the scientific measurement and stability of the latent variables, flood-risk cognition was characterised by three core dimensions, i.e., Possibility of Disaster Occurrence (Y1), Threat of the Disaster (Y2), and Attitude to Defence (Y3). By considering the temporal evolutionary characteristics of floods from “warning before

disasters—emergency during disasters—restoration after disasters” in southwestern China as well as the findings of Chinese studies [53] and practical situations of the study area, the core independent variables were summarised into the following three dimensions with reference to studies of PMT [54] and the classical empirical results of flood-risk cognition [33]: (1) Pre-disaster preparedness awareness, including (A1–A4): A1, Meteorological Disaster Knowledge and Skills; A2, Familiarity with Secondary Disasters of Rainstorm Floods; A3, Knowledge of Flood Defence; and A4, Clarity of Early Warning Signals. There are complicated terrains and concentrated precipitation during flood seasons in southwestern China. Therefore, pre-disaster preparation is the key to loss reduction. The pre-disaster knowledge reserve and action willingness of peasant households determine their prediction ability of flood possibility and are prerequisites for the formation of risk cognition. (2) Disaster response awareness, including (B1–B4): B1, Willingness to Evacuate under Flood Threat; B2, Willingness to Relocate under Flood Threat; B3, Mastery of Self-rescue and Mutual Rescue Knowledge; and B4, Clarity of Escape Routes. Flood disasters are characterised by abruptness and destructive effects. The disaster response cognition and self-rescue ability of peasant households affect their judgement as to the effectiveness of disaster responses, thus influencing their cognition of flood threat. Disaster response awareness is the core middle link that shapes the risk cognition of peasant households. (3) Post-disaster restoration awareness, including (C1–C4): C1, Disease Prevention Awareness; C2, Self-reliance in Resolving Household Basic Living Difficulties; C3, Demand for Government Assistance; and C4, Demand for Social Assistance. Peasant households’ livelihoods in southwestern China rely heavily on cultivated land, and floods cause farmland damage and livelihood impacts. The post-disaster risk assurance and assistance demand of peasant households reflects their cognition of flood consequences and restoration difficulties. Post-disaster restoration awareness exerts profound effects on the judgement of flood risks and is the post-support dimension after the formation of risk cognition.

Based on previous research hypotheses and theoretical frameworks, a theoretical model of the factors influencing peasant households’ flood-risk cognition was built using AMOS 26.0 (Figure 3).

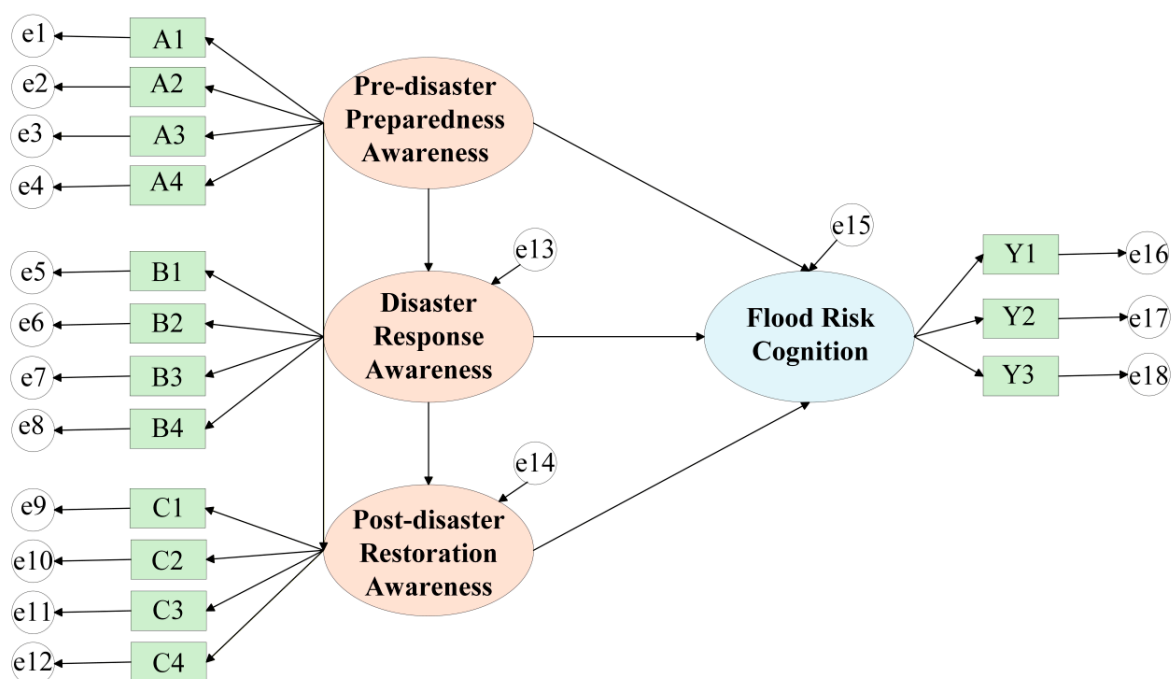


Figure 3. Initial structural equation model.

Table 1. Descriptive statistics of the observed variables for flood-risk cognition.

Latent Variables	Observed Variables	Definition	Mean	^b SE
Pre-disaster Preparedness Awareness	A1: Meteorological disaster knowledge and skills	Attach great importance to learning and accumulating meteorological disaster knowledge and skills. ⁱ	3.178	1.132
	A2: Familiarity with secondary disasters of rainstorm floods	Degree of familiarity with secondary disasters induced by rainstorm and flood events. ⁱ	3.261	1.090
	A3: Knowledge of flood defence	Level of understanding of rainstorm flood prevention. ⁱ	3.285	1.093
	A4: Clarity of early warning signals	Level of clarity regarding emergency disaster early warning signals. ⁱ	3.507	1.143
Disaster Response Awareness	B1: Willingness to evacuate under flood threat	Willingness to temporarily evacuate in response to flood disaster threats. ⁱⁱ	4.120	1.016
	B2: Willingness to relocate under flood threat	Willingness to permanently relocate under the threat of flood disasters. ⁱⁱ	3.820	1.098
	B3: Mastery of self-rescue and mutual rescue knowledge	Level of mastery of flood disaster self-rescue and mutual rescue knowledge. ⁱ	3.546	1.232
	B4: Clarity of escape routes	Degree of clarity regarding emergency evacuation routes under disaster conditions. ⁱ	3.723	1.147
Post-disaster Restoration Awareness	C1: Disease prevention awareness	Disease prevention awareness after flood disasters. ⁱ	3.349	1.072
	C2: Self-reliance in resolving household basic living difficulties	Degree to which household basic living difficulties can be resolved through self-efforts. ⁱ	3.362	1.098
	C3: Demand for government assistance	Demand for seeking help from the government after floods. ⁱ	2.629	1.022
	C4: Demand for social assistance	Demand for seeking help from society after floods. ⁱ	3.791	0.982
Flood Risk Cognition	Y1: Possibility of disaster occurrence	Within the next decade, households' housing and land may be affected by potential disasters. ⁱ	3.372	1.257
	Y2: Perceived threat	In the event of flooding, roads will be destroyed, and villages will be rendered isolated. ⁱ	2.771	1.262
	Y3: Mitigation attitude	Possess the capability to fulfil all necessary tasks for evacuation. ⁱ	4.091	0.948

Notes: ⁱ. 5-point Likert scale (1 = strongly disagree, 5 = strongly agree); ⁱⁱ. 5-point Likert scale (1 = very unwilling, 5 = very willing); ^b SE = standard deviation.

(3) Modification Method of SEM

In this study, the modification indicator (*MI*) was applied to optimise the initial SEM. Modification indices (*MI*) are employed to quantify the expected reduction in the chi-square statistic for model fit when a single parameter constraint is relaxed. The calculation formula can be expressed as follows:

$$MI = X_c^2 - X_u^2 \quad (6)$$

where X_c^2 is the Chi-squared value of the constraint model, that is, the fitting Chi-square of the current model when constraints are applied to a parameter, and X_u^2 is the Chi-squared value of the non-constrained/free model, that is, the Chi-squared value of the refitting model after the parameter constraint is released and free estimation is allowed. During model modification, the significance level was set at $p < 0.05$ (corresponding to the *MI* critical value of 3.84), and parameter constraints with high *MI* values and conforming to

theoretical logic were chosen for release gradually until the core fitting indicators of the model reached the ideal level (Figure 4), aiming to avoid over-modification.

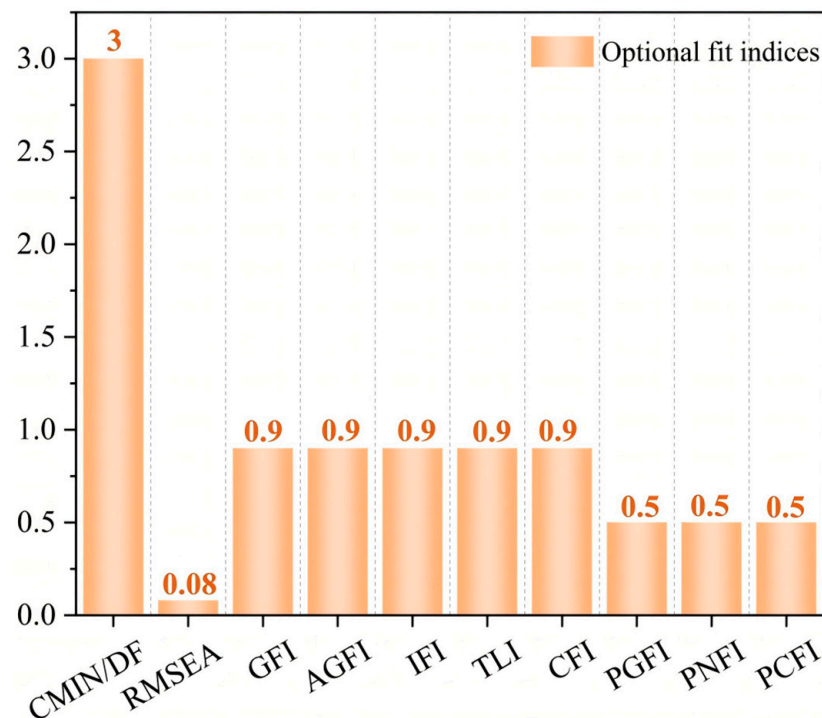


Figure 4. Model fitting criteria. CMIN/DF = $\chi^2/\text{df} < 3$; RMSEA = Root mean square error of approximation < 0.08 ; GFI = Goodness-of-fit index > 0.9 ; AGFI = Adjusted goodness-of-fit index > 0.9 ; IFI = Incremental fit index > 0.9 ; TLI = Tucker–Lewis index > 0.9 ; CFI = Comparative fit index > 0.9 ; PGFI = Parsimony goodness-of-fit index > 0.5 ; PNFI = Parsimony-adjusted NFI > 0.5 ; PCFI = Parsimony-adjusted CFI > 0.5 .

(4) Multi-group SEM

Multi-group SEM extends conventional SEM by testing the cross-group equivalence of model parameters, thereby enabling the analysis of moderating effects within the SEM framework (Jöreskog, 1971; Sörbom, 1974). It is widely used to assess measurement equivalence and the stability of structural paths across subpopulations. Because the present study focused exclusively on path-coefficient comparisons and did not conduct latent mean comparisons, the invariance testing sequence was restricted to four hierarchical levels of covariance-structure constraints, applied successively from the least restrictive to the most restrictive. The judgement criteria for each level are summarised in Table 2; the multi-group invariance test divided the constraint degree into four levels from low to high:

- (1) Configural invariance (Baseline): no equality constraints; only an identical factor structure was imposed across groups. This model had to achieve acceptable overall fit: $\text{CFI} \geq 0.90$, $\text{TLI} \geq 0.90$, $\text{RMSEA} \leq 0.08$. This can be expressed as follows:

$$\sum_g = \Lambda_g \Phi_g \Lambda_g^T + \Theta_{\varepsilon g} \quad (7)$$

- (2) Measurement weights: based on configural invariance, the factor loadings of different groups of observed variables on latent variables were constrained to be equal to verify the cross-group measurement consistency of the latent variables. This can be expressed as follows:

$$\sum_g = \Lambda \Phi_g \Lambda^T + \Theta_{\varepsilon g} \quad (8)$$

- (3) Structural covariance invariance: building on the confirmed measurement weight invariance, latent variable variance–covariance matrices were constrained to equality across groups to assess the cross-group consistency of intercorrelations among latent constructs. This can be expressed as follows:

$$\Sigma_g = \Lambda\Phi\Lambda^T + \Theta_{\varepsilon g} \quad (9)$$

- (4) Measurement residuals: based on structural covariance invariance, the variance–covariance matrices of the measurement errors were constrained to be equal across groups to verify the cross-group stability of the measurement errors. This can be expressed as follows:

$$\Sigma_g = \Lambda\Phi\Lambda^T + \Theta_{\varepsilon} \quad (10)$$

where Σ_g is the covariance matrix of observed variables of group g (g represents different sampling groups), Λ is the factor load matrix of observed variables on the latent variables, Φ_g and Φ are the variance–covariance matrices of the latent variables under free estimation and equal cross-group constraint, respectively, and $\Theta_{\varepsilon g}$ and Θ_{ε} are the variance–covariance matrices of the measurement residuals under free estimation and equal cross-group constraint, respectively.

Table 2. Criteria for multi-group invariance test.

Criteria for Invariance	DELTA-NFI	DELTA-RFI	DELTA-IFI	DELTA-TLI	DELTA-CFI	DELTA-RMSEA
Measurement weights	≤0.02	≤0.02	≤0.02	≤0.02	≤0.01	≤0.015
Structural covariances	≤0.02	≤0.02	≤0.02	≤0.02	≤0.01	≤0.015
Measurement residuals	≤0.02	≤0.02	≤0.02	≤0.02	≤0.01	≤0.015

Note: All fitting indicators of the DELTA series are absolute values of differences between successive nested models.

3. Results

3.1. Statistical Description of Survey Participants

A final sample of 685 valid questionnaires was retained for data analysis (Table 3). There was a slight male predominance among the participants. Most participants were above 60 years old, indicating that the sample was concentrated on the middle-aged and elderly. This aligns with the demographic composition of the study area. Further, most participants had a low level of education, only completing primary school.

Generally speaking, the dimensions of peasant households' flood-risk cognition exhibited clear levels (Table 1): Y3 showed the highest scores (mean = 4.091), followed by Y1 (mean = 3.372) and Y2 (mean = 2.771), successively, indicating that peasant households generally were predisposed towards emergency evacuation, but they still had insufficient understanding of the practical consequences of floods, such as isolated villages and facility damage. In terms of gender, there were stable differences between the groups (Figure 5): the scores for female peasant households ($n = 273$) were systematically higher than those for male peasant households ($n = 412$) for all dimensions of flood-risk cognition. This might be related to the higher rural permanent residence rate, greater contact with local disaster scenes, and females' higher awareness of flood risk. On the regional dimension, there was significant spatial heterogeneity (Figure 6): the comprehensive flood-risk cognition of peasant households in Jingyang District was the best, and peasant households in Muchuan County were the most positive towards disaster reduction and self-rescue. The flood-risk cognition levels of peasant households in Lu County were the lowest for all dimensions. Such regional differences might relate to differing primary disaster-prevention and publicity initiatives, as well as a resource-allocation imbalance. Generally speaking, the dimensions of peasant households' flood-risk cognition in the study

area revealed imbalanced development and significant differences in gender and location among the groups.

Table 3. Demographic profiles of the participants.

Variable	Definition	Min	Max	Mean	^b SE
Flood experience	0 = No experience, 1 = Have experienced flood	0	1	0.898	0.303
Gender	0 = Male, 1 = Female	0	1	0.601	0.490
Age	Age (years)	17	94	61.241	12.434
Education level	Years of education	0	16	5.825	3.741
Village position	1 = Ordinary villager, 2 = Village Party Secretary/Director, 3 = Village committee member, 4 = Group leader, 5 = Member of supervisory/council board of cooperative or collective economic organisation	1	5	1.257	0.818
Self-assessed health	1 = Very good, 2 = Good, 3 = Fair, 4 = Poor, 5 = Very poor	1	5	2.352	1.010
Number of labour force	Number of labourers aged 16–64	0	13	2.149	1.574
Area of cultivated land in operation	Area of cultivated land currently operated (mu)	0	11	2.397	1.445

Note: ^b SE = Standard Deviation.

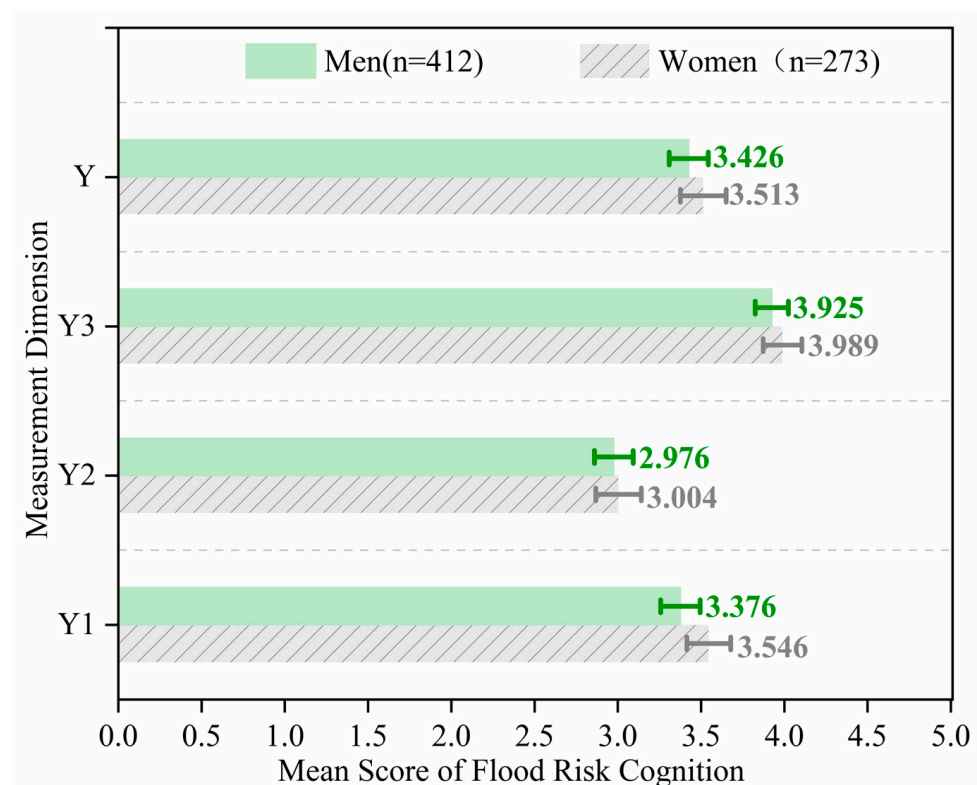


Figure 5. Descriptive statistics for gender and risk cognition. Note: Female respondents consistently scored higher across all flood-risk cognition dimensions, suggesting gender-based differences in risk cognition. Error bars represent 95% confidence intervals.

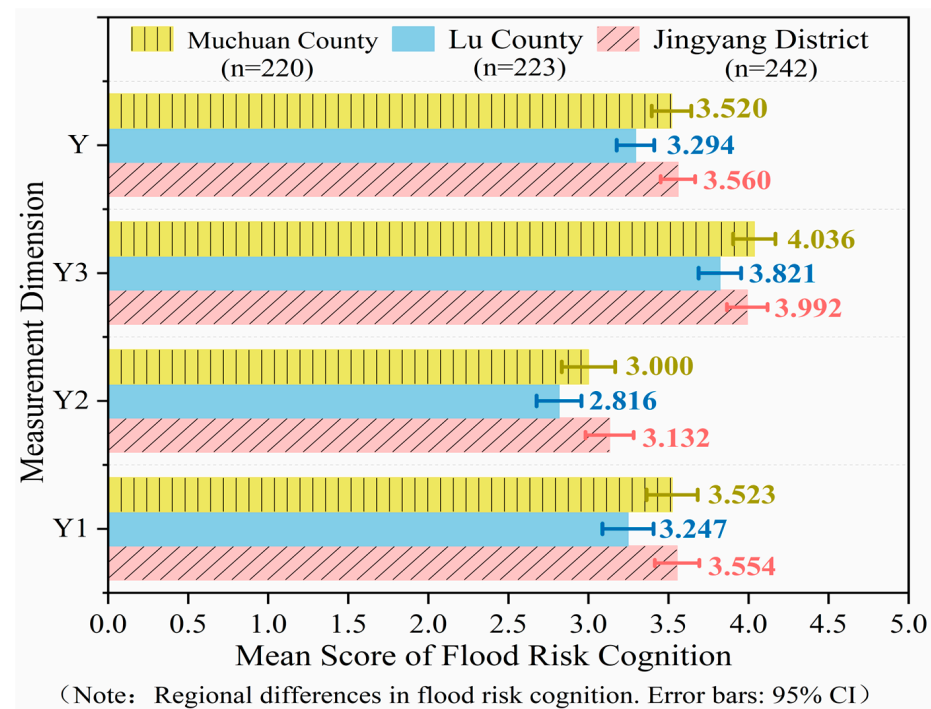


Figure 6. Descriptive statistics for region and risk cognition. Note: Respondents from Lu County consistently scored lower across all flood-risk cognition dimensions, suggesting region-based differences in risk cognition. Error bars represent 95% confidence intervals.

3.2. Reliability and Validity of Measures

In this study, the full scale achieved a Cronbach's α of 0.876, and all dimensions had reliability coefficients between 0.7 and 0.9, demonstrating satisfactory internal consistency. Moreover, a validity test was carried out. The KMO values for the total scale and the different dimensions were higher than 0.6, and Bartlett's test of sphericity (Sig) was lower than 0.05. The data met the prerequisites for factor analysis (Table 4). Finally, four common factors were extracted. The cumulative variance contribution rate achieved a satisfactory standard, thereby verifying the favourable structural validity of the survey (Table 5).

Table 4. Evaluation of survey reliability and validity.

Latent Variables	Observed Variables	Cronbach's Alpha	KMO	Bartlett's Test of Sphericity		
				Approximate Chi-Square	Degree of Freedom	p-Value
Pre-disaster Preparedness Awareness	A1 A2 A3 A4	0.775	0.769	738.443	6	0.000
Disaster Response Awareness	B1 B2 B3 B4	0.716	0.649	629.265	6	0.000
Post-disaster Restoration Awareness	C1 C2 C3 C4	0.725	0.745	528.491	6	0.000
Flood Risk Cognition	Y1 Y2 Y3	0.715	0.658	409.775	3	0.000
Overall		0.876	0.894	3542.903	105	0.000

Table 5. Matrix of varimax-rotated factor loadings.

		Factor			
		1	2	3	4
Pre-disaster Preparedness Awareness	A1	0.128	0.727	0.080	0.118
	A2	0.168	0.748	0.234	0.120
	A3	0.140	0.752	0.286	0.118
	A4	0.167	0.420	0.622	0.076

Table 5. Cont.

		Factor			
		1	2	3	4
Disaster Response Awareness	B1	0.219	0.108	0.289	0.737
	B2	0.103	0.131	0.135	0.838
	B3	0.115	0.105	0.812	0.188
	B4	0.135	0.150	0.814	0.145
Post-disaster Restoration Awareness	C1	0.430	0.582	0.046	0.035
	C2	0.628	0.300	0.221	0.014
	C3	0.724	0.021	0.179	0.154
	C4	0.785	0.083	0.133	0.042
Flood Risk Cognition	Y1	0.522	0.339	−0.159	0.370
	Y2	0.556	0.348	0.006	0.211
	Y3	0.513	0.383	0.196	0.334
Cumulative variance contribution rate		61.627%			

3.3. Results of SEM Analysis

3.3.1. Model Fit and Modification Outcomes

As shown in the model fit statistics (Figure 7), the model's CMIN/DF indicator was higher than the reference value. As a result, gradual modification was required using the MI method. Ultimately, two theoretically justified error covariance paths (e11↔e12 and e16↔e17) were added. Both covariances were positive and statistically significant. The covariance between e11 and e12 reflects the shared unobserved determinants of peasant households' demand for government and social assistance during post-disaster recovery, as both indicators capture help-seeking tendencies under common recovery conditions. The covariance between e16 and e17 reflects the common cognitive basis underlying perceived flood probability and perceived hazard severity, which are jointly shaped by prior flood experience and individual risk preferences. This covariance is theoretically consistent with the threat appraisal component of PMT.

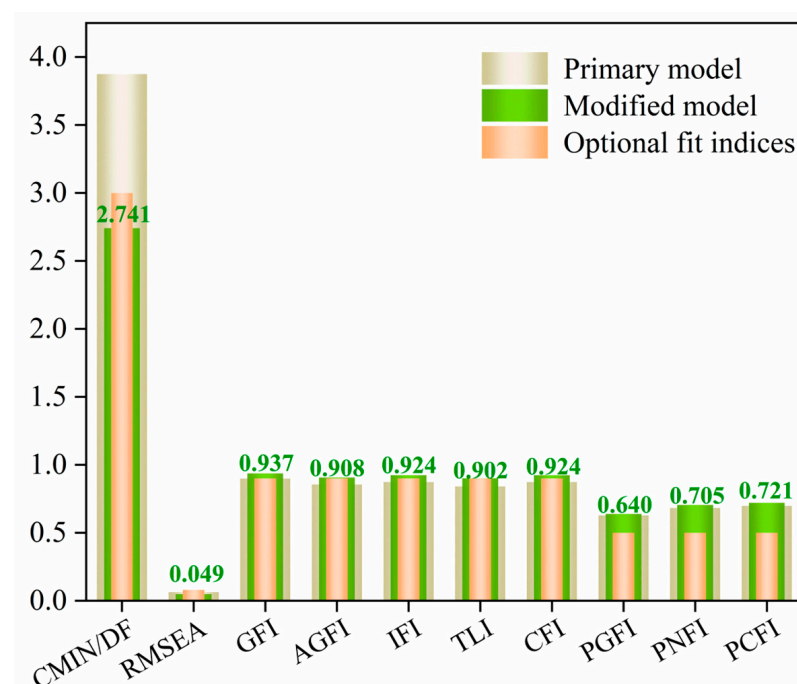


Figure 7. Model fit indices.

The PGFI and PNFI of the modified model (Figure 8) were higher than the ideal standards (0.5), while the IFI, CFI, and GFI were higher than the ideal standards (0.9), and RMSEA was 0.049, meeting the requirement (≤ 0.08). Generally speaking, the modified full-sample model presented high goodness of fit, indicating that the scale had good structural validity and explanatory power. This laid a solid foundation for the subsequent multi-group analysis.

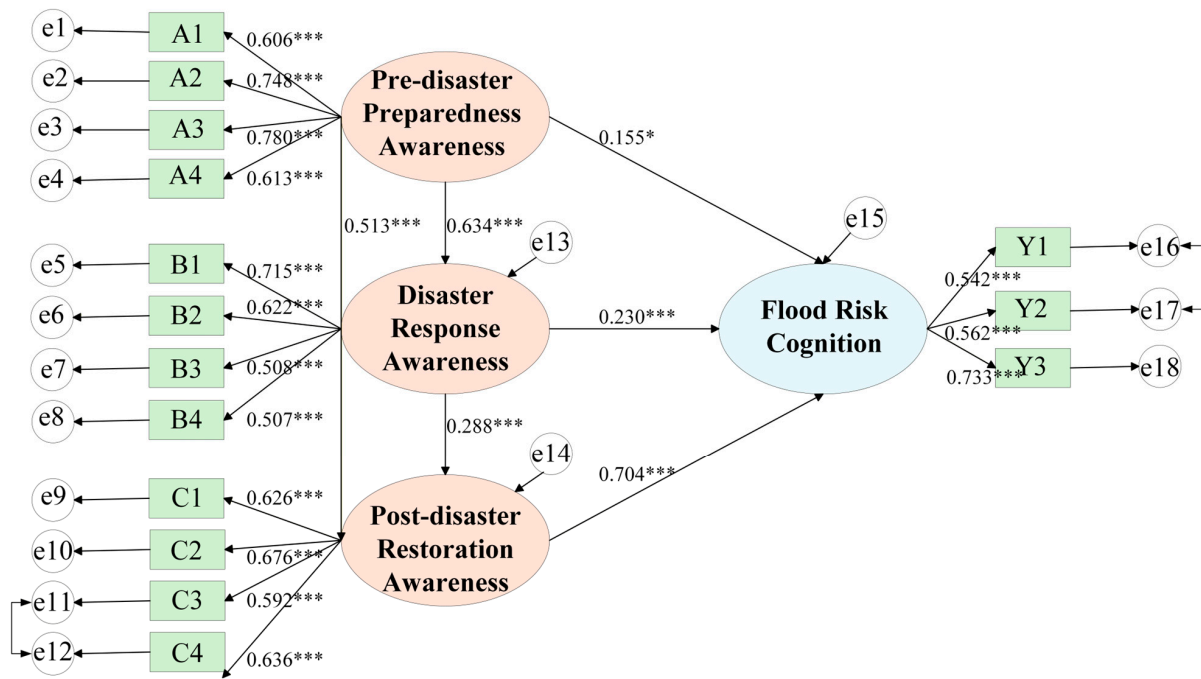


Figure 8. Revised path of model (full sample). Single-headed arrows indicate directional effects (hypothesised paths among latent variables and factor loadings from latent to observed variables); double-headed arrows denote residual error correlations. *** $p < 0.001$; * $p < 0.05$.

3.3.2. Recognition and Analysis of Important Influencing Factors

In this study, the following important influencing factors were identified (Table 6). In the pre-disaster preparedness awareness dimension, A3 and A2 achieved the highest factor loads (0.780 and 0.748, respectively), indicating their importance. This may be attributed to the fact that peasant households with long-term residence in flood-prone areas possess relevant experience and a deep understanding of disaster precursors and secondary hazards. The factor load of A4 was relatively low (0.613). This may reflect that peasant households acquire fragmented and poorly-targeted disaster prevention information, which is difficult to translate into systematic pre-disaster preparedness behaviours. In the dimension of disaster response awareness, the factor load of B1 was the highest, indicating that willingness to evacuate under flood threats is an important factor influencing the disaster response awareness of peasant households. This might be because evacuation is the primary emergency measure to minimise casualties and immediate losses in a flood. By contrast, the clarity of escape routes (B4) had the lowest factor load (0.507). This was perhaps due to peasant households paying little attention to escape routes in daily life from an overreliance on their risk-avoidance experiences. In the post-disaster restoration awareness dimension, C2 was relatively high (0.676), highlighting its importance. This might be because post-disaster restoration of peasant households primarily relies on their own ability to resolve difficulties. By contrast, the factor load of C3 was the lowest (0.592) because peasant households rely more on themselves and their families during post-disaster restoration, resulting in individual differences in expectations for government assistance. In the flood-risk cognition

dimension, Y3 (0.733) was significantly different from Y1 (0.542). Peasant households' concern about flood losses had a core influence on their flood-risk cognition, owing to rich personal experiences of flood-induced production losses and loss of life. Judgement of the probability of flood disasters is often influenced by experience and information asymmetry, resulting in strong subjectivity and weak correlations with objective flood-risk cognition.

Table 6. Fitting results of measurement model (full sample).

Items			NSE	^a SE	CR	^b SE
Pre-disaster preparedness awareness	→	A4	1.021	0.082	12.513	0.613 ***
Pre-disaster preparedness awareness	→	A3	1.243	0.083	14.890	0.780 ***
Pre-disaster preparedness awareness	→	A2	1.188	0.083	14.316	0.748 ***
Pre-disaster preparedness awareness	→	A1	1.000			0.606 ***
Post-disaster restoration awareness	→	C4	0.931	0.074	12.651	0.636 ***
Post-disaster restoration awareness	→	C3	0.902	0.076	11.899	0.592 ***
Post-disaster restoration awareness	→	C2	1.106	0.081	13.576	0.676 ***
Post-disaster restoration awareness	→	C1	1.000			0.626 ***
Disaster response awareness	→	B4	0.801	0.083	9.629	0.507 ***
Disaster response awareness	→	B3	0.862	0.086	10.031	0.508 ***
Disaster response awareness	→	B2	0.940	0.072	13.057	0.622 ***
Disaster response awareness	→	B1	1.000			0.715 ***
Flood risk cognition	→	Y3	1.156	0.088	13.178	0.733 ***
Flood risk cognition	→	Y2	1.036	0.074	13.910	0.562 ***
Flood risk cognition	→	Y1	1.000			0.542 ***

Note: Arrows indicate directional factor loading paths from latent variables to observed items. Significance levels: *** $p < 0.001$. NSE = non-standardised estimate; ^a SE = standard error, CR = critical ratio, ^b SE = standardised estimate.

3.3.3. Hypothesis Testing

(1) Modification results of the full-sample structural model

The structural model reflects the relationship between latent variables. The standardised route coefficients and fitting results of the structural model are shown in Table 7. The table shows that pre-disaster preparedness awareness had a significantly positive effect on flood-risk cognition (the standardised route coefficient was 0.155, $p < 0.05$), indicating that peasant households had more profound risk cognition of potential threats and losses when they had deeper knowledge of flood defence and greater familiarity with secondary disasters, thus verifying H1. Disaster response awareness had a significant positive effect on flood-risk cognition (the standardised route coefficient was 0.230, $p < 0.001$). Aside from basic cognition of flood disasters, this indicates that positive evacuation, emergency risk avoidance, self-rescue, and mutual rescue of peasant households under threat are associated with improved flood-risk cognition, thus verifying H2. Post-disaster restoration awareness had a significant positive effect on flood-risk cognition (the standardised route coefficient was 0.704, $p < 0.001$), and its direct effect was far stronger than preparedness awareness or disaster response. This indicates that peasant households with clearer planning, measures, and expectations of post-disaster restoration had a deeper understanding of flood risks and higher flood-risk cognition, thus verifying H3. Pre-disaster preparedness awareness had a significant positive effect on flood-risk cognition (the standardised route coefficient was 0.634, $p < 0.001$), indicating that preparedness strengthened the households' awareness of disaster response through knowledge, materials, and scheme support; thus, H4 is verified. The influencing path coefficient for disaster response awareness and pre-disaster preparedness awareness passed statistical significance testing at the 0.001 level, with corresponding standardised path estimates of 0.288 and 0.513. This indicates that the subjective willingness and action-planning awareness of peasant households towards post-disaster restoration were positively affected by their awareness of how to respond to

a disaster and their degree of preparation for a disaster, respectively; hence, H5 and H6 are verified.

Table 7. Structural model fit results.

		Paths	NSE	^a SE	CR	^b SE	Verified
H1	Flood Risk Cognition	← Pre-disaster Preparedness Awareness	0.145	0.070	2.081	0.155 *	Yes
H2	Flood Risk Cognition	← Disaster Response Awareness	0.203	0.061	3.314	0.230 ***	Yes
H3	Flood Risk Cognition	← Post-disaster Restoration Awareness	0.673	0.086	7.789	0.704 ***	Yes
H4	Disaster Response Awareness	← Pre-disaster Preparedness Awareness	0.672	0.065	10.399	0.634 ***	Yes
H5	Post-disaster restoration Awareness	← Disaster Response Awareness	0.265	0.065	4.072	0.288 ***	Yes
H6	Post-disaster restoration Awareness	← Pre-disaster Preparedness Awareness	0.501	0.076	6.631	0.513 ***	Yes

Note: Arrows indicate hypothesised directional paths: the variable on the left is the dependent variable, and the variable on the right is the independent variable. Significance levels: *** $p < 0.001$, * $p < 0.05$. NSE = non-standardised estimate; ^a SE = standard error, CR = critical ratio, ^b SE = standardised estimate.

This study examined the intrinsic relationships between latent constructs by evaluating their direct, indirect, and total effects. As shown in Table 8, the total effects of pre-disaster preparedness awareness, disaster response awareness, and post-disaster restoration awareness on the flood-risk cognition of peasant households were 0.790, 0.432, and 0.704, respectively. The indirect effects of pre-disaster preparedness awareness and disaster response awareness on the flood-risk cognition of peasant households were 0.635 and 0.202, respectively. The direct effects of pre-disaster preparedness awareness on disaster response awareness and post-disaster restoration awareness were 0.634 and 0.513, respectively. The indirect effect on post-disaster restoration awareness was 0.182. The direct effect of disaster response awareness on post-disaster restoration awareness was 0.288. This indicates that pre-disaster preparedness awareness had a significantly positive effect on post-disaster restoration awareness. Moreover, pre-disaster preparedness awareness appears to indirectly raise the flood-risk cognition level of peasant households by influencing the relationship between post-disaster restoration awareness and flood-risk cognition, at least to some extent; hence, H6 and H9 are verified.

Table 8. Integrated evaluation of overall effects among variables.

Variables	Pre-Disaster Preparedness Awareness			Disaster Response Awareness			Post-Disaster Restoration Awareness		
	Direct Effects	Indirect Effects	Total Effects	Direct Effects	Indirect Effects	Total Effects	Direct Effects	Indirect Effects	Total Effects
Disaster Response Awareness	0.634		0.634						
Post-disaster Restoration Awareness	0.513	0.182	0.695	0.288		0.288			
Flood Risk Cognition	0.155	0.635	0.790	0.230	0.202	0.432	0.704		0.704

Disaster response awareness and post-disaster restoration awareness were both important factors influencing flood-risk cognition. To investigate their mediating effect, the bootstrap method (5000 bootstrap resamples were drawn with a 95% confidence level) was applied using AMOS 26.0 [50]. According to the mediating effect analysis, the confidence interval of the indirect mediating effect of post-disaster restoration awareness between

disaster response awareness and flood-risk cognition was [0.092, 0.321], excluding 0. This indicates a significant mediating effect; thus, H7 is verified.

Additionally, the mediating effect of disaster response awareness between pre-disaster preparedness awareness and flood-risk cognition had a confidence interval of [0.494, 0.816], excluding 0, indicating a significant mediating effect; hence, H8 is verified. Further, the indirect effect of pre-disaster preparedness awareness on flood-risk cognition was stronger than that of disaster response awareness.

(2) Hypothesis verification of the group structural model

Furthermore, a multi-group SEM analysis based on gender was conducted. The inter-group invariance and measurement model effectiveness were also tested. The inter-group invariance test conformed to statistical standards (Table 9). Based on the results (Tables 10–12), this study built a life-cycle framework of peasant households' flood-risk cognition covering pre-disaster preparedness, in-disaster response, and post-disaster restoration. The framework was verified in both male and female samples, and its core logic showed good applicability. Accordingly, H3, H4, and H6 are true for both male and female groups.

Table 9. Invariance test table.

Criteria for Invariance	DELTA-NFI	DELTA-RFI	DELTA-IFI	DELTA-TLI	DELTA-CFI	DELTA-RMSEA
Measurement weights	0.005	0.004	0.001	0.005	0.001	0.002
Structural covariances	0.002	0.002	0.002	0.001	0.002	0
Measurement residuals	0.006	0.009	0.001	0.009	0	0.002

Table 10. Fitting results of measurement model (females).

Items			NSE	^a SE	CR	^b SE
Pre-disaster preparedness awareness	→	A4	1.056	0.141	7.507	0.598 ***
Pre-disaster preparedness awareness	→	A3	1.210	0.133	9.097	0.752 ***
Pre-disaster preparedness awareness	→	A2	1.203	0.136	8.824	0.728 ***
Pre-disaster preparedness awareness	→	A1	1.000			0.596 ***
Post-disaster restoration awareness	→	C4	0.866	0.113	7.694	0.613 ***
Post-disaster restoration awareness	→	C3	0.799	0.115	6.948	0.5428 **
Post-disaster restoration awareness	→	C2	1.124	0.135	8.341	0.673 ***
Post-disaster restoration awareness	→	C1	1.000			0.624 ***
Disaster response awareness	→	B4	1.126	0.171	6.602	0.669 ***
Disaster response awareness	→	B3	1.016	0.168	6.041	0.584 ***
Disaster response awareness	→	B2	0.951	0.109	8.720	0.596 ***
Disaster response awareness	→	B1	1.000			0.726 ***
Flood risk cognition	→	Y3	1.283	0.177	7.243	0.693 ***
Flood risk cognition	→	Y2	1.191	0.148	8.027	0.547 ***
Flood risk cognition	→	Y1	1.000			0.476 ***

Note: Arrows indicate directional factor loading paths from latent variables to observed items. Significance levels: *** $p < 0.001$, ** $p < 0.01$. NSE = non-standardised estimate; ^a SE = standard error, CR = critical ratio, ^b SE = standardised estimate.

As shown in the measurement model factor loadings (Tables 10 and 11), all observed variables in both groups had good validity and stability. It can be seen from the inter-group features of the observed variables that the factor load results also verified the gender differentiation of flood-risk cognition: for female participants, the factor loadings of the observed variables on the dimension of disaster response awareness were higher, indicating that females were more sensitive to the effects of disaster response awareness on cognition. For males, the factor loadings for the observed variables of pre-disaster preparedness awareness, post-disaster restoration awareness, and flood-risk cognition were

higher. This showed stronger judgement consistency (compared to females) in relevant content cognition.

Table 11. Fitting results of measurement model (males).

Items			NSE	^a SE	CR	^b SE
Pre-disaster preparedness awareness	→	A4	1.024	0.102	10.035	0.636 ***
Pre-disaster preparedness awareness	→	A3	1.271	0.109	11.717	0.796 ***
Pre-disaster preparedness awareness	→	A2	1.188	0.106	11.214	0.759 ***
Pre-disaster preparedness awareness	→	A1	1.000			0.606 ***
Post-disaster restoration awareness	→	C4	0.976	0.099	9.876	0.647 ***
Post-disaster restoration awareness	→	C3	0.976	0.103	9.480	0.629 ***
Post-disaster restoration awareness	→	C2	1.116	0.106	10.514	0.681 ***
Post-disaster restoration awareness	→	C1	1.000			0.619 ***
Disaster response awareness	→	B4	0.649	0.099	6.536	0.420 ***
Disaster response awareness	→	B3	0.800	0.106	7.541	0.467 ***
Disaster response awareness	→	B2	0.947	0.098	9.635	0.632 ***
Disaster response awareness	→	B1	1.000			0.690 ***
Flood risk cognition	→	Y3	1.117	0.102	10.994	0.764 ***
Flood risk cognition	→	Y2	0.964	0.086	11.174	0.565 **
Flood risk cognition	→	Y1	1.000			0.575 ***

Note: Arrows indicate directional factor loading paths from latent variables to observed items. Significance levels: *** $p < 0.001$, ** $p < 0.01$. NSE = non-standardised estimate; ^a SE = standard error, CR = critical ratio, ^b SE = standardised estimate.

Table 12. Factors Influencing flood-risk Cognition.

				Group 1 (Females)		Verified	Group 2 (Males)		Verified
				^b SE	^a SE		^b SE	^a SE	
H1	Flood Risk Cognition	←	Pre-disaster Preparedness Awareness	0.228	0.130	No	0.127	0.086	No
H2	Flood Risk Cognition	←	Disaster Response Awareness	0.190	0.091	No	0.281 **	0.095	Yes
H3	Flood Risk Cognition	←	Post-disaster Restoration Awareness	0.707 ***	0.133	Yes	0.658 ***	0.119	Yes
H4	Disaster Response Awareness	←	Pre-disaster Preparedness Awareness	0.708 ***	0.107	Yes	0.608 ***	0.082	Yes
H5	Post-disaster Restoration Awareness	←	Disaster Response Awareness	0.052	0.118	No	0.415 ***	0.087	Yes
H6	Post-disaster Restoration Awareness	←	Pre-disaster Preparedness Awareness	0.691 ***	0.147	Yes	0.430 ***	0.092	Yes

Note: Arrows indicate hypothesised directional paths: the variable on the left is the dependent variable, and the variable on the right is the independent variable. Significance levels: *** $p < 0.001$, ** $p < 0.01$. NSE = non-standardised estimate; ^a SE = standard error, ^b SE = standardised estimate.

Such gender differences arise from the division of labour in rural households and the gender division in disaster participation in mountainous areas: females are generally responsible for internal disaster prevention and post-disaster livelihood maintenance; thus, for them, pre-disaster preparedness is closer to post-disaster restoration. As males generally participate in the frontline emergency responses, disaster experience emerged as the most salient factor influencing their risk judgement. Hence, although the full life-cycle risk cognition framework was applied to both male and female samples, gender differences had a significant influence. These findings provide an important reference for distinguishing the flood-risk cognition features of peasant households.

On this basis, the sub-sample structural model was tested (Table 12). After the influencing intensities of paths were further compared, gender was a significant influence on flood-risk cognition. Compared to male samples, the positive effects of pre-disaster preparedness awareness on disaster response awareness and post-disaster restoration awareness were stronger for female samples. The two path coefficients, 0.708 and 0.691, reached 0.001 significance level. For males, only disaster response awareness had a significantly positive effect on post-disaster restoration awareness; the path coefficient was 0.415

($p < 0.001$). With respect to common features, post-disaster restoration awareness was an important influential path on flood-risk cognition for both males and females. Pre-disaster preparedness awareness had direct effects on the flood-risk cognition of male and female participants, but the effects were relatively weak.

The empirical results provide robust evidence of a structured, stage-dependant mechanism underlying flood-risk cognition among peasant households. The SEM analysis confirms significant direct and indirect effects among the three cognition dimensions, as well as notable gender heterogeneity in pathway strengths. While these findings establish the statistical relationships among variables, further theoretical interpretation is required to explain the underlying cognitive and behavioural mechanisms within the integrated framework of PMT and disaster life-cycle theory.

4. Discussion

4.1. Contributions and Innovations

In this study, the interrelationships between the characteristics of three dimensions of peasant households' flood-risk cognition and their individual and basic household characteristics in Sichuan Province were analysed based on survey data from 685 peasant households. Moreover, a SEM framework was built based on PMT and the life-cycle theory of disasters to analyse the factors influencing flood-risk cognition.

Building on prior research, this study makes the following key contributions: (1) It addressed the limitations of existing studies within a single application of PMT, integrating the life-cycle theory of disasters, building an innovative flood-risk cognition theoretical framework comprising three dimensions (i.e., pre-disaster, in-disaster, and post-disaster) from the microscopic perspective of peasant households, and perfecting the analytical system of rural flood-risk cognition in southwestern China. (2) The direct and mediating effects of flood-risk cognition and its influencing factors were examined using field survey data from peasant households in typical flood-prone regions of southwestern China, and the gender differences in flood-risk cognition were determined. (3) It provides a complementary perspective to the conventional "cognition drives behaviour" paradigm, developing an analytical framework based on the core logic that "awareness shapes cognition". While existing studies have examined the effect of risk cognition on disaster prevention behaviours, they have largely overlooked the mediating mechanisms involved. By contrast, this study conducted an empirical test of multi-dimensional awareness (e.g., pre-disaster preparedness, in-disaster responses, and post-disaster restoration) on the formation of flood-risk cognition from the perspective of the full life cycle of disasters, thereby revealing the prerequisites for cognition formation. Hence, the research results of this study exhibit similarities and differences when compared to existing studies on flood-risk cognition.

4.2. Discussion and Analysis of the Important Factors Influencing Flood-Risk Cognition

This study demonstrated that peasant households' knowledge of flood defence, familiarity with secondary disasters from rainstorm floods, willingness to evacuate under flood threat, self-reliance in resolving basic household living difficulties, and mitigation attitude all had significant positive effects on their flood-risk cognition. These are the core factors influencing peasant households' risk cognition. Knowing flood defence and having secondary disaster cognition are prerequisites for peasant households to build flood-risk cognition. Together, they contribute to the flood-risk cognition framework of peasant households [55].

In view of the formation mechanism of flood-risk cognition, positive acquisition of disaster knowledge is a common pathway for individuals to recognise risks and to develop

cognition. Building the flood-risk cognition system of peasant households is essentially an information integration and cognition-deepening process based on knowledge of how to prevent disasters and of secondary disaster cognition [10]. This aligns with the view that disaster knowledge forms the foundation of flood-risk cognition among peasant households. However, this study's conclusions have more to say. Research on peasant households in river basins that experience frequent disasters [56] has indicated that disaster knowledge disconnected from the local scene can cause information fatigue and a paralysed mentality among peasant households, and the driving effect of risk cognition was insignificant. This indicates that only practical disaster-prevention knowledge that accords with local disasters can noticeably improve the flood-risk cognition of peasant households.

Furthermore, this study demonstrated that willingness to evacuate and the independent post-disaster restoration efficacy of peasant households can strengthen flood-risk cognition. Peasant households with a clear willingness to avoid risks and strong confidence in their independent post-disaster restoration have more comprehensive flood-risk cognition. This enables them to avoid two types of extreme cognition bias: risk ignorance and excessive panic. Nevertheless, current studies have primarily centred on the one-way driving effect of flood-risk cognition on risk avoidance and self-rescue behaviours [57]. This study extended this in the time dimension, and the core logic was highly consistent with the disaster resilience theory proposed by Paton and Buergelt [58]. Aside from the three dimensions of disaster awareness across the full life cycle, the psychological judgement of peasant households about the potential hazards of floods was a core factor influencing their flood-risk cognition. These findings are consistent with Botzen et al. [8], who reported that mitigation attitude was the core internal factor influencing the formation of flood-risk cognition. By contrast, Terpstra's [13] study in mature flood-prevention areas in Europe and America found that a perfect government security system weakened the relationship between mitigation attitude and risk cognition. This reveals that variations in policy contexts bring about disparate impacts on flood-risk cognition.

4.3. Gender Differences in the Effects of Disaster Response Awareness on Post-Disaster Restoration Awareness and Flood-Risk Cognition

According to the full-sample data in the present study, disaster response awareness has significant positive effects on post-disaster restoration awareness and understanding of flood risks. To further explore potential group differences in the influencing paths, multi-group analyses were carried out with gender as the grouping variable. The results revealed obvious differentiation in the paths among the groups. Male respondents' disaster response awareness significantly influenced their post-disaster restoration awareness and flood-risk cognition. However, these two core paths did not reach significance among female respondents. This might be because, under the division of labour in rural households and social participation in China, males are often involved in flood emergency decisions and post-disaster reconstruction and planning. The formation of their awareness of disasters is endogenous; males predict disasters based on systematic cognition of flood risks [59]. Hence, improving their disaster awareness would strengthen their flood-risk cognition. This finding is consistent with the research conclusions of Khan and Soomro [60], who examined flood responses in rural areas of South Asia.

Additionally, males with strong awareness often have strong emergency-resource acquisition ability and higher family decision-making power. Their disaster response planning could extend to the post-disaster restoration stage, thereby realising the direct positive effect of disaster response awareness on post-disaster restoration awareness [61]. For rural females, willingness to make disaster response decisions is driven by exogenous factors (e.g., overall family decision) rather than their own risk cognition [62]. Ao et al. investigated responses to flood disasters in rural areas [63] and found that females' decisions

to evacuate and their response behaviours were first related to the care demands of family members rather than their own judgement of flood risks. The endogenous relationship between the response intention and risk cognition of females was significantly weaker than males. This was the core reason that disaster awareness among female respondents did not significantly affect their flood-risk cognition in this study.

Moreover, rural females have low resource availability and decision-making power. Bradshaw [64] demonstrated that core resources for post-disaster restoration tend to be concentrated among male household heads; females undertake heavy caring duties for the whole family and exhibit narrow social participation during post-disaster restoration. This implies that, although females have strong disaster response awareness, it is difficult to transform this into post-disaster restoration confidence, resulting in a significantly positive effect of disaster response awareness on post-disaster restoration awareness.

Furthermore, Faruk and Maharjan [6] found that females' flood-risk cognition level was significantly higher than that of males, a conclusion that is not inconsistent with the research conclusion here. However, this study found that females' higher flood-risk cognition was mainly attributed to risk concerns from family care responsibilities rather than to cognition strengthening brought about by disaster response behaviour.

4.4. Limitations of This Study and Implications for Further Research

This study has several limitations for future research to address. First, it used cross-sectional questionnaire data collected at a single time point. The pre-disaster, in-disaster, and post-disaster cognitive dimensions were measured based on the respondents' retrospective perceptions rather than longitudinal observations. Future longitudinal studies are needed to more accurately verify the dynamic evolution of flood-risk cognition throughout the disaster cycle.

Second, the findings are primarily applicable to mountainous rural areas in southwestern China with similar topographic and demographic characteristics. Although the proposed analytical framework can be replicated in other regions, its empirical applicability and external validity should be further examined in areas with different disaster types, socio-demographic characteristics, and institutional contexts. Finally, variables such as rural digital literacy and disaster memory attenuation were not included in this study. Future research could incorporate these contextual variables to improve the explanatory power and comprehensiveness of the proposed framework.

5. Conclusions

Using effective survey data from 685 peasant households, SEM was used to build a model based on PMT and the disaster life cycle to explore the characteristics and factors influencing peasant households' flood-risk cognition in southwestern China. Several major conclusions can be drawn, as follows: (1) Peasant household respondents generally demonstrated moderate or higher flood-risk cognition, showing three dimensions of characteristics, including "positive attitude toward defence, clear possibility cognition, and blinded threat cognition". (2) An action path from pre-disaster preparedness awareness → in-disaster response awareness → post-disaster restoration awareness was formed among latent variables, and it was significant in all peasant household respondents. Specifically, disaster response awareness exhibited a complete mediating effect between pre-disaster preparedness awareness and flood-risk cognition, while post-disaster restoration awareness played a partial mediating role between disaster response awareness and flood-risk cognition. (3) Clarity of defence knowledge, familiarity with secondary disasters of floods, willingness to evacuate under flood threats, self-efficacy to solve life difficulties, and mitigation attitudes were important factors influencing flood-risk cognition. (4) Female

peasant households outperformed males in flood-risk cognition. The flood-risk cognition of peasant households in Jingyang District was the best, and the peasant households in Muchuan County were the most positive toward disaster reduction and self-rescue. The flood-risk cognition levels of peasant households were the lowest in Lu County compared with the other two areas.

Based on the above conclusions, there are several study implications, which can be outlined as follows:

- (1) Overcoming structural shortages of peasant households' risk cognition and optimising primary disaster prevention and publicity logic: Disaster prevention publicity should focus on complementing peasant households' blind cognition of the long-term secondary damage associated with flood disasters, rather than simply focusing on motivating and advocating. Given the fragmented mountain terrain and the large share of low-educated, left-behind elderly in the sample, publicity should prioritise dialect audio broadcasts and door-to-door guidance over text-intensive materials. Meanwhile, flood-risk cognition among peasant households should be consolidated through the systematic dissemination of flood information, self-rescue training, and scientific guidance on willingness to relocate.
- (2) It is essential to set up an integrated cognition guidance system based on management of the full disaster life cycle: Primary disaster prevention should not conform to the traditional single pre-disaster publicity and education mode. Rather, an overall plan for the entire process from pre-disaster warning and publicity to disaster emergency guidance, and then to post-disaster cognition reshaping, should be adopted. For high-altitude villages with sparse road networks and delayed external rescue, a tiered village-to-household manual warning chain should be built to reduce terrain-induced information delay. More attention should be paid to post-disaster risk re-education and training in restoration. The flood-risk cognition of peasant households could be strengthened during post-disaster reconstruction and land-use optimisation. This would improve cognitive literacy throughout the different stages. Continuous door-to-door follow-up should be provided for elderly and low-educated respondents to consolidate long-term cognitive effects.
- (3) Promotion of a gender-based disaster prevention strategy: Disaster prevention policies should abandon a "one-size-fits-all" model. To take advantage of females' better overall risk-cognition sensitivity, females should be encouraged to volunteer for community disaster prevention and publicising of disaster risks. With high male out-migration in mountainous areas, female volunteers could cover left-behind elderly households by issuing daily risk reminders. At the same time, guidance for the cognitive characteristics of males should be optimised to improve the overall flood resilience of rural areas. Targeted training for males could be held during the Spring Festival and other peak periods to lift coverage during population outflows. These findings provide solid support for developing long-term, effective disaster control strategies and promoting sustainable rural development.
- (4) Local governments can leverage the mediating role of post-disaster restoration awareness and embed flood-risk training into the whole process of post-disaster reconstruction. During rural housing restoration and cultivated land reclamation, technical training on secondary disaster prevention and agricultural production resumption can be conducted simultaneously, and farmers' risk cognition can be strengthened alongside publicity of agricultural insurance claim settlements. Meanwhile, regular exchanges of disaster prevention experiences can be organised by village collectives during the post-disaster production recovery period to transform short-term post-disaster assistance demands into long-term disaster prevention capacity-building.

This would form a positive cycle of “post-disaster restoration–cognitive upgrading–pre-disaster defence”.

Author Contributions: Conceptualization, Y.S. and Y.W.; methodology, Y.W. and Y.S.; formal analysis, Y.W. and Y.S.; investigation, Y.S. and Y.W.; data curation, J.Z. and R.C.; supervision, J.Z.; writing—original draft preparation, Y.W. and Y.S.; writing—review and editing, J.Z. and R.C. All authors have read and agreed to the published version of the manuscript.

Funding: The research was funded by the National Natural Science Foundation of China (Grant No.41671529), Sichuan Provincial Key Laboratory of Intelligent Emergency Management (grand no. 2025ZHYJGL-12), Power Construction of China (grant no. P60224), and Sichuan Province Territorial Space Planning Preparation (2019–2035) and Related Topical Studies (grant no. Y9D2850).

Institutional Review Board Statement: Ethical review and approval were waived for this study by the Institution Committee due to Article 32 of the Ethical Review Measures for Human-Related Life Science and Medical Research.

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: The geographic information data came from the National Science and Technology Infrastructure Platform, the National Earth System Science Data Center (<http://www.geodata.cn>, accessed on 20 April 2026), and the Geospatial Data Cloud (<http://www.gscloud.cn>, accessed on 20 April 2026).

Acknowledgments: We thank the academic editors and anonymous reviewers for their kind suggestions and valuable comments.

Conflicts of Interest: Author Ruiyin Chen was employed by the company POWERCHINA Chengdu Engineering Corporation Limited. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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