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Public Intention to Participate in Sustainable Geohazard Mitigation: An Empirical Study Based on an Extended Theory of Planned Behavior

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Abstract. Giving full play to the public's initiative for geological disaster reduction is critical for sustainable disaster reduction under a government-led top-down disaster governance approach. According to the public's intention to participate in geological disaster mitigation activities, this study introduces the analytical framework of the theory of planned behavior (TPB), with attitudes, subjective norms, and perceived behavioral control as the primary explanatory variables, with three added explanatory variables: risk perception, disaster experience, and participation perception.

Survey data obtained from 260 respondents in Jinchuan County, Sichuan Province, China, are analyzed using structural equation modeling and combined with multivariate hierarchical regression to test the explanatory power of the model. The results indicate that attitude, subjective normative, perceived behavioral control, and participatory cognition are significant predictors of public intention to participate. Disaster experience is negatively associated with public intention to participate. In addition, the extended TPB model contributes 50.7% to the explanation of the behavioral intention of public participation. Practical suggestions and theoretical guidance are provided for strengthening geohazard risk management and achieving sustainable disaster reduction. In particular, it is concluded that, while correctly guiding public awareness of disaster reduction activities, policymakers should continue developing participatory mechanisms, paying attention to two-way communication bridges between the public and the government, uniting social forces, and optimizing access to resources.

Keywords. Sustainable geohazard mitigation; public participation; theory of planned behavior; structural equation modeling.

1 Introduction

Frequent natural disaster events have caused great harm in many aspects, such as economic and social development, people's safety, and environmental ecosystems, among which geological disasters are more prominent in mountainous areas where the level of socioeconomic development is lagging and the natural ecological environment is fragile. 80% of southwest China's

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Sichuan Province is in a mountainous environment, and geological disasters such as flash floods seriously threaten people's lives and property safety (Gong et al., 2018). According to the National Bureau of Statistics of the People's Republic of China, a total of 160,640 geological disasters occurred from 2008 to 2019, causing 9525 casualties and CNY 51.9 billion direct economic losses.

Facing a severe disaster situation, there is an urgent need to enhance the capacity for sustainable disaster reduction. The introduction of The Sendai Framework for Disaster Risk Reduction (2015-2030) demonstrates that disaster risk reduction objectives should be linked to progress in global sustainable development (Anonymous, 2015; Peters & Peters, 2021). Effectively addressing risks and promoting sustainable development needs to be integrated with climate change adaptation (Seidler, Dietrich, Schweizer, Bawa, & Khaling, 2018), resilience strategies (Cwa & Sjc, 2020), resilient communities (Dube, 2020), etc. According to Stephan, Norf, and Fekete (2017) the design of disaster risk management measures in line with the concept of social and ecological sustainability contributes to the long-term reduction of social vulnerability and is a major trend for the future, based on disaster science and the sustainability impact of post-disaster measures.

As a fundamental force in disaster risk management, the public is increasingly becoming part of sustainable disaster reduction governance. The public actively participates in disaster reduction activities and learns self-help skills and disaster reduction knowledge, thus taking active measures for effective disaster reduction and household disaster prevention plans and proactively advising decision makers based on the actual situation. This two-way interaction helps decision makers acquire local knowledge and "the added benefit of sustainability and potential behavior change" (Roopnarine et al., 2021). Pearce (2003) argues that the organic combination of disaster management, community planning, and public participation can achieve sustainable disaster reduction and governance. The focus of disaster management has shifted from reactive prevention to proactive mitigation and from single actors to multiple participants. From a multistakeholder collaborative perspective, it is also clear that community-based disaster risk reduction is the foundation for the disaster management system pyramid and is critical to successful "sustainable disaster reduction" (D. Xu, Hazeltine, Xu, & Prasad, 2018).

It is worth acknowledging that, for the past 72 years, the Chinese government has been using different disaster management approaches to mobilize public participation in disaster reduction activities. Since the beginning of group monitoring and prevention endeavors in 1970, the public participation monitoring and warning system (PPMW) has facilitated the establishment of a three-tier monitoring network at the county, township, and village levels to reduce human casualties and management costs (Sheng-nan, Yu, Peng, Rong, & Pi-hua, 2020). The community established a disaster warning WeChat group to disseminate early warning information to residents. In terms of strengthening the construction of "disaster-resistant communities", China has held a "National Integrated Disaster Reduction Demonstration Community" competition for 11 consecutive years. Community grid-based management is precise to every household and person. The government actively carries out the geological disaster-related popularization of science activities to improve the residents' disaster reduction awareness and skills (Yuan, Zeng, Chu, Li, & Gong, 2014).

Although many countries and regions are beginning to recognize the critical role of public participation for sustainable disaster reduction, community residents currently have low levels of participation, poor risk awareness, and a lack of responsibility for

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disaster prevention and mitigation in the disaster risk management process (Rong & Peng, 2013), which is not conducive to sustainable disaster reduction. Direct or indirect disaster experiences can change individuals' emotions or feelings, which, according to studies of self-protective behavior on an individual or household basis, in turn affect their readiness to take action (Mertens et al., 2018). At the same time, residents in high-risk areas have a clear knowledge and perception of potential hazards and environmental risks, which also cannot be ignored in disaster preparedness research (Khan et al., 2020). Furthermore, it is necessary for people to appreciate the importance of participatory approaches for community catastrophe mitigation and their well-being (Zubir & Amirrol, 2012), as this will facilitate their cooperation with government endeavors. However, few studies consider how to increase public participation in disaster risk management that are still in the early stages of development, and they mostly focus on disasters of a greater impact and concern, such as earthquakes (Hua, Huang, Lindell, & Yu, 2020), droughts (Meadow, Crimmins, & Ferguson, 2013), and floods (Born, 2020; Lawrence, Quade, & Becker, 2014). Geological hazards such as mudslides and landslides, which have the greatest impact on residents of remote mountainous areas, are under-researched. Therefore, further research is needed to explore the role of the public in geological hazard mitigation management from the perspective of sustainable development, as well as the specific factors and influencing mechanisms that affect public participation.

Public participation is a socio-behavioral decision-making process that is usually studied using social psychological models from such theories as social cognitive theory (Lantz, 1978), the theory of reasoned behavior (Chang, 1998), and the theory of planned behavior (Icek, 1991). Of these, the theory of planned behavior (TPB) is widely used to explain the general decision-making process of individual behaviors, such as predicting recycling (Oztekin, Teksöz, Pamuk, Sahin, & Kilic, 2017) and urban smog reduction (Zhu, Yao, Guo, & Wang, 2020), with high explanatory and predictive power in terms of human behavior (Steinmetz, Knappstein, Ajzen, Schmidt, & Kabst, 2016). As the application of TPB progresses, an increasing number of studies have found that adding other variables to enrich the theoretical basis of TPB in different contexts significantly improves explanatory power. Shi, Wang & Zhao (2017) has confirmed that the extended TPB model has strong applicability in the willingness of residents to participate in the reduction of PM2.5 emissions. In the study of disaster preparedness behavior, an extended TPB that includes "community participation" and "community-agency trust" can increase the explanatory power of household preparedness in earthquake disasters (Zaremohzzabieh et al., 2021).

Therefore, based on the TPB, we consider risk perception and disaster experience factors from the perspective of risk and disaster reduction behavior, and consider the degree of public perception of participation activities from the perspective of participation behavior as three additional explanatory variables. An empirical study is conducted in Jinchuan County, Sichuan Province, where such geological hazards as flash floods and mudslides are serious issues. The main objectives of this study are as follows: 1) to identify the factors influencing public intention to participate in sustainable disaster mitigation management and ascertain their degree of influence; 2) to extend the application of the TPB in geological disaster risk management and test the explanatory and predictive power of the extended TPB model; and 3) to provide recommendations to decision makers for improving public participation. This study has practical implications for mobilizing public participation, improving regional sustainable disaster reduction capacity, and the development of a participatory disaster risk reduction management model.

2 Theoretical foundations and assumptions

The TPB can be used to explain human behavioral decision processes in specific situations (Icek, 1991), such as in health, protective, and learning behaviors. TPB considers behavioral intention to be an important predictor of behavior, and is influenced by three independent factors: behavioral attitude (BA), subjective norm (SN), and perceived behavioral control (PBC). The TPB has been successfully applied in public participation behavioral intention studies to air pollution control (Z. Xu, Shan, Li, & Zhang, 2020), afforestation and carbon reduction (Lin, Wu, Liu, & Lee, 2012), and community governance (H. Zhang & Zhang, 2015). However, it has not been fully tested for public participation behavior in disaster management, and only a few studies have explored its applicability in disaster mitigation settings (Ong et al., 2021). A particular issue is that geological hazards, due to the special characteristics of their nurturing environment and disaster-causing factors, differ from such natural disasters as floods and earthquakes in terms of behavioral intention to participate and risk management tools. Therefore, this paper combines the characteristics of geological disasters and public participation, and adds "risk perception", "disaster experience", and "participatory cognition" as additional explanatory variables to the basic TPB model. A theoretical framework of the factors influencing public intention to participate in disaster prevention and mitigation activities was constructed (Fig. 1).

2.1 Theory of planned behavior

2.1.1 Behavioral attitude

Behavioral attitude reflects the outcome of an individual's evaluation after considering the advantages and disadvantages of a particular behavior (Jong, Neulen, & Jansma, 2019). Prior research shows that attitudes have a positive effect on behavioral intentions. The more positive the behavioral attitude, the stronger the intention to adopt the behavior (de Groot & Steg, 2007). In the present study, the measure of attitude includes the perception of evaluating the advantages and disadvantages of the behavior, as well as the psychological feelings of the individual about performing the behavior, prompting hypothesis

H1: Behavioral attitude is positively correlated with the public's participation intentions.

2.1.2 Subjective norm

Subjective norm reflects social pressure from important people or groups around an individual, which may motivate people to perform or not perform a certain behavior (Fu, Liu, & Zhang, 2021; Icek, 1991). Subjective norm is measured by the degree to which individuals are surrounded by important people who approve of their behavioral performance. Most studies support the ability of subjective norm to forecast the intention to alleviate behavior (Slotter, Trainor, Davidson, Kruse, & Nozick,

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2020), and state that the higher the individual's perceived subjective norm, the more probable the behavior will be performed, and hence

H2: Subjective norm is positively correlated with the public's participation intention.

2.1.3 Perceived behavioral control

Ajzen (1985) has suggested that individual controlling of intention requires not only internal factors but also external conditions to be considered; therefore, he added perceived behavioral control to the Theory of Rational Behavior (TRA) to improve is explanatory power. Perceived behavioral control refers to an individual's perceived ease of performing a behavior, reflecting an assessment of its ability and a prediction of the difficulty of such obstacles as time, money, and distance (Icek, 1991). When an individual perceives that it can easily cope with the impediments, the more probable it is to perform the behavior(de Leeuw, Valois, Ajzen, & Schmidt, 2015; Gao, Wang, Li, & Li, 2017) , and hence

H3: Perceived behavioral control is positively correlated with the public's participation intention.

2.2 Risk perception

Risk perception usually refers to an individual's perception of the probability of a risky event occurring and its adverse consequences (Lindell & Hwang, 2008), and fear of risk has also been suggested as one of the representations of risk perception (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978). The impact of "risk perception" on public behavioral decisions has attracted much attention in past studies, and research confirms that improving residents' risk perception is key to community disaster management (Hernandez-Moreno & Alcantara-Ayala, 2017). Martin et al. (2009) found that the residents' level of risk perception affects their preparedness for natural disaster risk processes. Dash et al. (2007), through an empirical study, found risk preparedness and risk perception to be positively correlated, and the results of Miceli's (2008) study suggest that risk perception can provide reliable psychological indicators of people's actions and behaviors to reduce their vulnerability during disasters and environmental emergencies. Therefore, risk perception is measured dimensionally in the present study based on the risk perception model proposed by Slovic (1987), using fear level, consequence severity, probability factor, and control factor for

H4: Risk perception is positively correlated with the public's participation intentions.

2.3 Disaster experience

Residents living in geohazard-prone areas have often had direct or indirect experiences of disasters, and these experiences could have an impact on their lives, property, psychology, and livelihoods. Previous studies show that disaster experiences influence an individuals' level of disaster prevention and behavioral intentions; for example, people who have experienced floods are more likely to adopt disaster mitigation and prevention behaviors in the future (Lawrence et al., 2014), and residents who have experienced disasters have a higher willingness to invest in safety measures to reduce their personal losses (Entorf & Jensen, 2020; Seifert, Botzen, Kreibich, & Aerts, 2013). To explain this, some studies argue that disaster experience is a

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social learning process, and the relationship between the environment, behavior, and human thinking and cognition is an interactive decision (Zhou & Yan, 2019). Thus, in a severe natural disaster environment, individuals will recognize the severity of the consequences of a disaster and thus seek more information and knowledge to counteract its impact on their subsequent lives since the effects on people of risk events fade over time (Felgentreff, 2003). In the present paper, the assessment of disaster experiences on behavioral intentions is completed based on the damage to individuals' lives, health, and property (as well as the impact on their lives and psychology) from geological disasters that occurred in the region in the past decade. Thus, we have

H5: Disaster experience is positively correlated with the public's participation intentions.

2.4 Participatory cognition

In studies of environmental management and urban planning, it was found that public participation can better facilitate the implementation of decisions and provide opportunities for two-way communication between decision makers and the public (Gamper & Turcanu, 2009; Karlsson, Holgersson, Söderström, & Hedström, 2012). The degree of openness to participation and public perceptions of the participatory process has a significant impact on the level of environmental participation (X. Zhang, Jennings, & Zhao, 2018). In addition, individual behavioral motivation requires consideration of the degree of attention given to behaviors and events (Echavarren, Balžekienė, & Telešienė, 2019). Past research, through case studies, has found that behavioral responsibility values and a sense of belonging increase residents' attention to participatory activities, and thus their willingness to participate (Verma, Chandra, & Kumar, 2019). Therefore, the present paper includes "participatory cognition" to describe the public's understanding of disaster risk reduction activities and their concern over participation mechanisms (H. Huang, Hou, Qiu, Li, & Zhao, 2017; Ong et al., 2021). These mainly include knowledge of participation activities such as local disaster risk reduction policies and emergency plans, the time and content of the activities, and the form of participation; and the value and significance of such participation activities as influencing the democratic power of decision making (Najafi, Ardalan, Akbarisari, Noorbala, & Elmi, 2017) and the ongoing significance of public participation (MPH, MPH, & MSHS, 2017). Thus, the final hypothesis is

H6: Participation cognition is positively correlated with the public's participation intentions.

3 Method

3.1 Study area

Jinchuan County belongs to the Aba Tibetan and Qiang Autonomous Prefecture of Sichuan Province, located on the northwest plateau of Sichuan, at the eastern edge of the Qinghai-Tibet Plateau and upper reaches of the Dadu River (Fig. 2). Jinchuan County has 421 types of geological disaster sites, including 250 mudslides (accounting for 59.38%), 103 landslides (accounting for 24.47%), 61 collapse (accounting for 14.49%), and seven unstable slopes (accounting for 1.66%) – threatening

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the lives of 18,865 people and CNY 931.84 million (J. Zhang, 2016) of property security. On June 14, 2020, Jinchuan County experienced flooding and mudslide disasters, affecting a total of 19 townships, 1899 households, and 7598 people.

To reduce the damage of geological hazards and maintain the safety of people and property, the government of Jinchuan County – located in a geological disaster-prone area – has undertaken many disasters prevention and mitigation activities, such as the full-coverage survey work of geological hazard potential sites in Kaer Township and the comprehensive emergency drill for disaster prevention and mitigation in Kasa Township. Jinchuan County's Mulin Community was designated a "National Model Disaster Reduction Community" in 2020 and has played an exemplary role in calling for public participation in disaster reduction activities. Being more prominent in terms of public participation in sustainable disaster reduction, Jinchuan County was therefore chosen as the investigation area for this study.

3.2 Measurement tools

The questionnaire comprises three sections. The first introduces the background of the study and public participation in disaster risk reduction governance activities, including emergency drills, symposia, and preparation of emergency plans. The second involves the basic demographic characteristics, including age and education level. The third is the core of the questionnaire, measuring such latent variables as willingness to participate, attitude, subjective norms, perceived behavioral control, risk perception, disaster experience, and participatory cognition, with variables such as attitude measured with multiple indicators. The measurement items in the questionnaire were adapted and modified to fit the current research context and research topic based on the TPB and research related to public participation. Table 1 shows the related items and their references. A five-point Likert scale is used to measure all items, and all are described positively.

3.3 Data collection and analysis

The initial questionnaire prepared was sent to professional scholars, village supporters, and other cadres to pilot it before the main survey. Based on the results, some unclear statements and unreasonable wordings were revised and adjusted. The main survey was conducted in June 2021 in Jinchuan County, Shaer Township, Desheng Village, Danzamu Village, and Shangengzi Village in Sichuan Province. The investigators were systematically trained before the field questionnaires to understand the background and specific content of the research in detail. A total of 300 questionnaires were distributed, and 260 (86.7%) valid questionnaires were obtained after excluding questionnaires that were incompletely filled out or scored the same for each option.

Structural equation modeling (SEM) is a widely used multivariate statistical approach to test theoretical models and hypotheses while estimating modeling path coefficients and measurement errors (Fonseca, 2013). To achieve the research objectives, SEM is used on the survey data to analyze the factors influencing public participation in disaster risk reduction governance intentions included in the extended TPB model. The analysis is in three parts. The first is a confirmatory factor analysis (CFA) to assess the adequacy and fit of the measurement model (Anderson & Gerbing, 1988), the second is the

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hypothesis testing and path analysis of the model, and the third uses hierarchical regression to evaluate the predictive power of the basic TPB model and extended TPB model. All calculations are performed by SPSS 23.0 as well as AMOS 23.0.

4 Results

4.1 Demographic characteristics of the sample

Table 2 shows the respondents' demographics, with the following notable characteristics.

1) There are more females than males.
2) There are more at a significant age level, with most concentrated in the 46 to 60 years age group.
3) More than half have low education levels.
4) More than half belong to farming households.
5) Their monthly income is generally low, with one-third earning less than CNY 500 per month.
6) The vast majority have lived in the area for more than 20 years.

Overall, the range of social groups covered by the respondents and the sample size are consistent with the actual situation and are highly representative.

4.2 Structural reliability and validity

Cronbach's alpha and composite reliability (Meadow et al.) are used to measure the reliability of each construct in the questionnaire (Y. Huang et al., 2021) (Table 3). The overall Cronbach's alpha coefficient of the questionnaire is 0.786. The Cronbach's alpha coefficients range from 0.711 to 0.824 (generally required to be greater than 0.7). The combined validity (Meadow et al.) values range from 0.692 to 0.853 – generally close to or over 0.7 is considered acceptable (Fornell & Larcker, 1981), indicating that the questionnaire has good internal consistency with KMO=0.780 (generally required to be greater than 0.6), while Bartlett's test of sphericity=2100.573, and significance test $P<0.001$. These results indicate the data are suitable for factor analysis (Huan, Jinhe, Chang, Peng, & Guang, 2019). A CFA is used to assess the fit and validity of the constructed model.

1) Regarding structural validity (Table 4), $\chi^2/df=1.171$, RMSEA=0.026, RMR=0.027, GFI=0.927, AGFI=0.903, NFI=0.902, CFI=0.984, IFI=0.984, indicating a good model fit, as χ^2/df is not greater than 3; RMSEA and RMR are considered good below 0.08; and GFI, AGFI, CFI, NFI, and IFI are greater than 0.9 (Hu & Bentler, 1999).
2) Convergent validity is evaluated by standardized factor loading and average variance extraction (AVE). Table 3 shows that the standardized factor loadings range from 0.577 to 0.829. The AVE values range from 0.523 to 0.593, above the recommended threshold of 0.50 (Fornell & Larcker, 1981). This indicates that each observed variable had some explanatory power for its latent variable, with excellent convergence.
3) Discriminant validity, using AVE and correlation coefficients, are evaluated. The correlation coefficient between the factors is required to be lower than the square root of the AVE value for discriminant validity to be passed (Fornell &

Larcker, 1981). The results show that the correlation coefficients between the latent variables are less than the AVE's square root (Table 5), indicating good discriminant validity.

4.3 Hypothesis test

All three hypotheses related to the intention to participate are supported in the *basic* TPB theoretical model. First, the public's behavioral attitude makes a significant positive contribution to their intention to participate (β=0.273, p<0.01), and there is a strong correlation between the relationship, indicating that the more valuable members of the public perceive disaster reduction management activities to be to them, the stronger is their intention to participate. In particular, subjective norms have a strong positive effect (β=0.478, p<0.001), suggesting that social pressure and motivation to participate – or exemplary leadership by close family, friends, and government personnel – would promote individual intention to participate. In addition, perceived behavioral control also has a strong positive relationship (β=0.229, p<0.001), suggesting that the public's intention to participate is substantially increased when behaviors are perceived to be easier to perform.

Of the new factors added to the *extended* TPB model, the perception of the participation factor has a positive effect at a significant level of P<0.001 and contributes to the model to a high degree (β=0.253, P<0.001), which indicates that the more the public understands the participation process and the form of participation involved, the more positive is their willingness to participate. Surprisingly, disaster experience and intention to participate have a negative effect, but to a lesser extent (β=-0.183, p<0.05) – a result that is contrary to our hypothesis. In addition, the hypothesis of risk perception on intention to participate is not supported, and further analysis is needed. Table 6 (Fig. 3) shows the path results of the hypothesis testing.

4.4 Multiple hierarchical regression analysis

Multiple hierarchical regression analyses is used to assess the explanatory and predictive power of the basic and extended TPB model (Table 7). Multiple linearity tests are performed on the data by testing the independent variables' linear regression variance inflation factor (VIF) scores, which are calculated to be VIF<5, indicating the independent variables in the regression model are essentially free of multicollinearity.

Considering previous studies and the actual demographic characteristics of Jinchuan County, the control variables of age, education level, and monthly income are added (Zheng & Wu, 2020). The results show that these three control variables together explain 7.5% of the variance in participation intention. Then, the basic TPB model explains 46.0% of the variance – an increase of 38.5%. In other words, the basic TPB can effectively explain the public's intention to participate in geological hazard mitigation activities. The extended TPB model continues to add three new variables to the original model: risk perception, disaster experience, and participatory perception. Compared with the basic TPB model, it significantly increases the variance of participation intention (R^2=0.507) and the explanatory amount by 4.7%, indicating that the addition of new variables increases the explanatory amount of public participation behavioral intention, and the extended TPB model is more applicable to the prediction of public behavioral intention.

5 Discussion

5.1 Factors influencing intention to participate

The present study uses an extended TPB model to explain the behavioral willingness for public participation in sustainable disaster reduction. Consistent with previous studies is that individual willingness to participate is related to attitudes, subjective norms, perceived behavioral control, and participatory cognition. Not fully consistent with the previous hypothesis is that H4 does not pass the hypothesis test and the result for H5 is the opposite of the hypothesis. Of the four predictors that pass the hypothesis test:

1) Behavioral attitude has a significant positive effect on the public's intention to participate. Most previous studies conclude that attitude is the main predictor of behavioral intention and that, if individuals have a positive attitude toward a participation matter or issue, they would act corresponding with their attitude (Ajzen & Fishbein, 1977).
2) The findings indicate that subjective norm is the most important predictor of public willingness to participate, suggesting that social pressure (encouragement from family and friends, and appeals and support from organizations such as the government) is a positive force for the public. In the behavioral decision-making process, people are more likely to be influenced by the perceptions of others and more willing to take advice from those who matter most to them, which reflects a sense of trust in the organization and a sense of social belonging. This is especially the case with smaller communities, which inherently lack internal capacity, and therefore small group participation may be less enthusiastic or even neglected if they continue to lack sustained support from local government (Mathers, Dempsey, & Molin, 2015).
3) Perceived behavioral control plays a role in having a positive effect on willingness to participate. Previous studies also confirm that individuals are more likely to participate when they perceive easier execution behaviors and higher self-efficacy (Li, Zuo, Cai, & Zillante, 2018; Shi, Fan, & Zhao, 2017). In other words, people are more willing to participate in activities that are low-cost, less time-consuming, and less difficult to perform.
4) Participatory cognition is one of the core variables that influence the intention to participate. The higher the level of participatory cognition, the more positive the public's intention to engage in the behavior; from another perspective, participatory activities need to be widely noticed and understood by individuals. Weinstein (2000) found that people with a moderately high level of concern about tornado governance were 56% to 79% more likely to take preparedness actions than those with a moderately low level of concern.

Contrary to our hypothesis, however, there is no significant correlation between risk perception and public intention to engage in disaster reduction behaviors – despite such findings having emerged in past studies – although this does not mean that risk perception is not important for individual disaster reduction behaviors (Chen, 2016). First, most residents in the present study are farmers and less educated, which reflects the basic status of rural Sichuan. Members of this group tend to have only a vague perception of disaster risk and generally have a 'fluke mentality' compared to that with disasters that have not happened yet. Moreover, structural engineering measures invariably have an immediate protective effect compared to non-engineering measures, with a strong trust in engineering measures reducing the sense of responsibility for disaster reduction. After the

Wenchuan earthquake in 2008, for instance, the country paid more attention to the risk management of post-earthquake-derived geological hazards and implemented many structural engineering measures to address clear potential hazard sites (Fig. 4). In the study area, emergency shelter signs were profuse (Fig. 5). In the process of conducting the survey, ad hoc comments were often received indicating the generally high satisfaction of the public with the work of the government, such as in "the government's engineering measures make us feel well protected" and, despite a high perception of surrounding disaster risk, "our houses are safe." In addition, the image of disaster victims may make them subconsciously believe that they are the target of assistance, which accelerates the transfer of public responsibility for disaster reduction. The willingness to actively participate in disaster reduction activities is weak even if they perceive high risks in their environment (Terpstra, 2010).

To our surprise, it was found that disaster experience was negatively related to willingness to participate. This is inconsistent with previous hypotheses, but a similar situation has nevertheless been found in previous studies (Siegrist & Gutscher, 2008). The possible reason for this is the reverse psychological impact of past disaster experiences on disaster victims. On the one hand, disaster victims who have been severely affected by a disaster may show some fear and anxiety about trauma-related situations and activities during the post-disaster trauma phase, and some studies have shown that 20% of survivors develop psychological disorders that make it difficult to reintegrate into society (Augustijn-Beckers, Flacke, & Retsios, 2010). On the other hand, the loss situation of the subjects of this study was at a moderate level (Mean=1.585~2.477), so they felt more stubborn and lucky than fearful and helpless, believing that "they will not experience the same disaster in the same place twice in their lifetime" (Ardaya, Evers, & Ribbe, 2017). Several respondents refused to answer the questionnaire during the research process because of their past tragic experiences. Therefore, it may well be that the impact of disaster experience on the psychological aspects of the public still needs to be taken seriously.

5.2 Implications for participatory disaster risk reduction management

With the government's top-down disaster prevention and mitigation approach, the expected sustainable disaster reduction effect cannot be achieved if the public is not highly motivated to participate (Raikes, Smith, Baldwin, & Henstra, 2021). In addition, public participation in the disaster prevention and mitigation process can create a down-top surge effect to achieve multiple purposes:

- Help individuals take responsibility for disaster reduction and achieve a sense of "ownership": take the initiative to experience risk education, acquire self-rescue skills, and take responsibility for disaster preparedness.
- Promote mutual communication between the government and the public to build trust: understand the needs and suggestions of the public in promoting geological disaster prevention and mitigation activities to develop emergency plans that meet actual local conditions.
- People express their opinions and needs on an open and transparent platform, monitor government actions, and receive social attention: stakeholders are closely linked to reaching a consensus on disaster reduction to form an "up and down linked" participatory disaster risk management framework.

Future geohazard risk management's focus is to improve public participation enthusiasm based on the existing governance, improve the public participation system, and accelerate the construction of "disaster-resistant communities" to achieve the sustainability goal of minimizing and maximizing disaster mitigation costs and effects, respectively. The findings of the present study provide the following guidance for further strengthening participatory disaster risk management in geohazard-prone areas to achieve sustainable disaster reduction.

First, it is shown that public attitude and participatory perception positively impact on willingness to participate. If the members of the public feel that the participation process is beneficial and valuable to them, this will significantly increase their intention to participate. Therefore, managers need to provide adequate guidance of the public's perceptions of disaster prevention during the organization and implementation of activities. Policymakers can conduct abundant disaster prevention and mitigation activities to increase the public's awareness of disaster reduction activities, such as joint teams with professional knowledge and social organizations to conduct risk mapping and publicity, knowledge lectures, and the training of self-help and mutual help skills. Studies have confirmed that prior training can help people take appropriate actions in advance and prepare for emergencies (McBride, Becker, & Johnston, 2019). Encouraging public participation in the design and testing of emergency plans is the most natural and effective form of two-way interactive participation, helping the public to directly understand the functions of local government and the role of members of the public and assisting them in recognizing the social and disaster mitigation responsibilities they need to assume. It can effectively avoid the false sense of security that eventually leads to weak risk awareness due to the transfer of responsibility for disaster preparedness (Wachinger, Renn, Begg, & Kuhlicke, 2013).

Second, according to Chen and Tung (2014), subjective norms can positively influence individuals' behavioral decisions. Social pressure from family, friends, and government workers on individuals may cause them to consider that "everyone around me is taking action, so should I go?" or "everyone thinks I should get involved, so should I try?" before making behavioral decisions. Furthermore, according to traditional Chinese culture, collective interests tend to take priority over individual interests: thus, the government can build on current grid-based management by focusing on the group effect, and adopting incentives (e.g., distributing small gifts) to appeal to residents to participate in disaster reduction activities as a family unit.

Third, emergency management departments and social organizations need to focus on improving the public participation mechanism, optimizing how rural residents obtain information (e.g., exclusive one-to-one services for the elderly and WeChat group notifications for younger groups), and ensuring adequate participation in the participation process. Disseminating basic knowledge concerning geological disaster prevention and control to the public and providing a good resource environment for the public is necessary for increasing public awareness and participation. When members of the public understand the participation procedures and associated working arrangements, they can know how to cooperate with the government in the participation process and provide their opinions or suggestions for better feedback.

Fourth, the whole of society should pay attention to the psychological health of the residents and provide timely psychological counseling for affected people. Residents who have experienced disasters are prone to, possibly severe,

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psychological damage. People recognize severe consequences of disasters from their past disaster experiences, the great loss of life and property, and the sense of difficulty and powerlessness they feel before facing a destructive natural disaster. Therefore, managers need be mindful of providing post disaster reconstruction help to local disaster victims that is not limited to material help (such as housing and food) but should also provide post-disaster psychological counseling to help disaster victims adequately cope with negative emotional impacts. In implementing future disaster prevention and mitigation policies, it is important that affected people trust, and actively cooperate with, the government. Disaster-affected groups have the most profound understanding of disasters and the local situation, and their experience and local knowledge are valuable for decision makers to improve emergency plans and risk prevention accordingly.

6 Conclusions

Encouraging public participation as a means of forming a bottom-up complement to the traditional top-down geological disaster risk management model provides an important way for improving sustainable disaster reduction. In the present study, risk perception, disaster experience, and participation cognition were added to the basic TPB framework to analyze the factors influencing public intention to participate in disaster reduction in geological hazard-prone areas. A questionnaire survey is used to conduct empirical analysis in Jinchuan County, one of the most disaster-prone areas in China. The study results show attitude, subjective norms, perceived behavioral control, and participation cognition to be significantly and positively correlated with public intention to participate in the extended TPB framework. In contrast, disaster experience is negatively correlated, and risk perception is not significantly correlated with intention to participate. The multilevel regression reveals that the extended TPB model improves the explanatory power of the public's intention to participate in disaster prevention and mitigation compared to the basic model.

Combining the research results and the actual situation in the study area, it is found that the participatory disaster reduction framework contributes to the sustainable development of human society. However, the process requires the joint endeavors of the government, the public, and social groups to reach a “consensus on disaster reduction.” On the one hand, policymakers need to ensure that the public has a good sense of participation and to improve public motivation and disaster prevention capabilities, including diverse forms of activities, rich organizational content, effective publicity, and transparent and convenient participation channels. On the other hand, it is necessary to strengthen the participation mechanism, pay attention to the two-way communication bridge between the public and the government, unite social forces, optimize access to resources, and improve the disaster reduction capacity of individuals and communities to achieve sustainable disaster reduction. This study provides research support for enhancing individual awareness of participation in geohazard prevention and mitigation, improving group awareness of risk prevention, and promoting the overall trend of sustainable disaster reduction in the region. It provides theoretical guidance for mobilizing public and social forces to cooperate with the government to form a participatory disaster management mechanism with upward and downward linkages.

This study is limited by analyzing individual participation intentions as a whole and not considering whether cognitive differences and risk awareness differences exist between villages and towns with different disaster situations and levels of economic development. Subsequent studies could therefore distinguish and compare the effects of various cognitive differences and risk awareness differences on public participation in disaster prevention and mitigation, analyzing the effects of behavioral *intention* far from the actual behavioral decision. In addition, the research field of public participation behavior in the stage of geological disaster prevention and control is still in relatively lacking. Therefore, a further future research direction would be to continue to analyze the path of public participation behavior decisions under the premise of understanding the influence mechanism of participation intention.

Author contribution

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Declaration of conflicting interests

The authors declare that they have no conflict of interest.

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Table

Table 1. Questionnaire measurement items

Latent variable	Observed variable	Items	References
Participation intention	PI1	I am willing to participate in geohazard risk reduction governance activities, such as evacuation drills, under existing conditions.	(Gao et al., 2017)
	PI2	I intend to participate in geohazard risk reduction governance activities, such as evacuation drills, under existing conditions.	
Behavioral attitudes	BA1	I think it is important to participate in geohazard risk reduction governance activities.	(Icek, 1991) (Y. Huang, Aguilar, Yang, Qin, & Wen, 2021)
	BA2	I think it is valuable to participate in geohazard risk reduction governance activities.	
	BA3	I think it is wise to participate in geohazard risk reduction governance activities.	
Subjective norms	SN1	Family, friends, and neighbors think I should participate in geohazard risk reduction governance activities.	(Icek, 1991) (H. Zhang & Zhang, 2015)
	SN2	The neighborhood council, government, and civil society organizations think I should participate in geohazard risk reduction governance activities.	
	SN3	If family, friends, and neighbors are actively involved in these activities, it will encourage me to participate.	
	SN4	If neighborhood councils, government, and civil society organizations are actively involved in these activities, it will encourage me to participate.	
Perceived behavioral control	PBC1	It is easy for me to participate in geohazard risk reduction governance activities.	(Icek, 1991) (Ru, Qin, & Wang, 2019)
	PBC2	The cost of participation does not affect my willingness to participate.	
	PBC3	The cost of time spent does not affect my willingness to participate.	
	PBC4	The distance to the event location does not affect my willingness to participate.	
Risk perception	RP1	I feel scared when landslides, mudslides, and other geological disasters occur.	(Slovic, 1987)
	RP2	I think there is a high possibility of geological disaster in the place where I live.	
	RP3	I think the consequences of these geological disasters are serious.	

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	RP4	I think the damage caused by geological disasters cannot be controlled.	
Disaster experience	DE1	Loss of life and health caused by landslides, mudslides, and other geological disasters.	(Zhou & Yan, 2019)
	DE2	Loss of property caused by the occurrence of landslides, mudslides, and other geological disasters.	
	DE3	Impacts on your life caused by geological geohazards such as landslides and mudslides.	
Participatory cognition	PC1	I know the local emergency evacuation routes and evacuation sites.	(H. Zhang & Zhang, 2015) (Najafi et al., 2017)
	PC2	In the process of public participation in disaster reduction, I know how to properly reflect my views and suggestions to decision makers.	
	PC3	I know the basic forms and contents of local public participation in disaster reduction activities.	

Note 1: PI, BA, SN, PBC, RP, and PC were measured from strongly disagree (1) to strongly agree (5); DE was measured from very low (1) to very high (5).

Table 2. Demographic characteristics of the respondents

Characteristic	Category	Frequency	Percentage (%)
Gender	Male=0	113	43.5
	Female=1	147	56.5
Age	<18=1	2	0.8
	18-30=2	27	10.4
	31-45=3	49	18.8
	46-60=4	107	41.2
	60-80=5	75	28.8
Educational level	Primary school or below=1	76	29.2
	Junior high school=2	80	30.8
	Senior/vocational high school=3	38	14.6
	Technical school=4	41	15.8
	Undergraduate degree or above=5	25	9.6
Occupation	Student=1	10	3.8
	Farmer=2	137	52.7
	Civil servant=3	23	8.8
	Surveyor=4	6	2.3
	Staff=5	16	6.2
	Teacher=6	8	3.1
	Self-employed=7	16	6.2
	Retirement=8	34	13.1
	Other=9	10	3.8
Monthly income	<500 CNY=1	86	33.1

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	500-1500 CNY=2	53	20.4
	1500-3000 CNY=3	39	15.0
	3000-4000 CNY=4	27	10.4
	>4000 CNY=5	55	21.2
Duration of residence	<5 years=1	23	8.8
	5-10 years=2	27	10.4
	10-20 years=3	34	13.1
	>20 years=4	176	67.7

Table 3. Results of the reliability and validity tests

Latent variable	Observed variable	Mean	S.D.	Standardized factor loading	CR	AVE	Cronbach's alpha
Participation intention	PI1	4.635	0.490	0.730	0.692	0.529	0.719
	PI2	4.712	0.471	0.724			
Behavioral attitudes	BA1	4.835	0.402	0.754	0.768	0.530	0.711
	BA2	4.623	0.612	0.577			
	BA3	4.831	0.396	0.829			
Subjective norms	SN1	4.673	0.574	0.723	0.853	0.593	0.824
	SN2	4.765	0.537	0.796			
	SN3	4.788	0.487	0.778			
	SN4	4.731	0.531	0.780			
Perceived behavioral control	PBC1	4.381	0.827	0.686	0.813	0.523	0.811
	PBC2	4.331	0.775	0.642			
	PBC3	4.327	0.803	0.771			
	PBC4	4.442	0.756	0.783			
Risk perception	RP1	3.981	0.948	0.801	0.825	0.541	0.821
	RP2	3.842	1.130	0.742			
	RP3	4.304	0.977	0.714			
	RP4	4.073	1.065	0.680			
Disaster experience	DE1	1.931	0.952	0.827	0.786	0.552	0.779
	DE2	1.585	0.957	0.725			
	DE3	2.477	1.063	0.669			
Participatory cognition	PC1	4.319	0.811	0.651	0.788	0.555	0.784
	PC2	4.212	0.809	0.778			

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PC3	4.269	0.784	0.798

Table 4. Overall model fit indicators

Variable	Public participation intention	
	Basic TPB model	Extended TPB model
Chi-square value	120.673	242.325
Degrees of freedom	59	207
χ^2/df	2.045	1.171
Root mean square error of approximation (RMSEA)	0.064	0.026
Root mean square residual (RMR)	0.017	0.027
Goodness-of-fit index (GFI)	0.938	0.927
Adjusted goodness-of-fit index (AGFI)	0.905	0.903
The normed fit index (NFI)	0.912	0.902
Comparative fit index (CFI)	0.952	0.984
Incremental fit Index (IFI)	0.953	0.984

690 **Table 5. Discriminant validity of the latent variables**

Variable	Behavioral attitude	Subjective norm	Perceived behavioral control	Risk perception	Disaster experience	Participatory cognition	Participation intention
Behavioral attitude	**0.727**						
Subjective norm	0.642	**0.728**					
Perceived behavioral control	0.723	0.549	**0.770**				
Risk perception	0.443	0.233	0.243	**0.723**			
Disaster experience	0.093	0.221	0.011	0.020	**0.736**		

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Participatory cognition	-0.148	0.042	-0.033	-0.075	0.383	**0.743**	
Participation intention	0.564	0.440	0.445	0.258	0.002	0.085	**0.745**

Table 6. Standardized path coefficient results

Hypothesis	Standardized (β)	S.E.	t-value
Participation Intention <--- Behavioral Attitude	0.273**	0.091	3.159
Participation Intention <--- Subjective Norm	0.478***	0.074	5.409
Participation Intention <--- Perceived Behavioral Control	0.229***	0.040	3.335
Participation Intention <--- Risk Perception	0.101	0.036	1.404
Participation Intention <--- Disaster Experience	-0.183*	0.032	-2.483
Participation Intention <--- Participatory Cognition	0.253***	0.050	3.323

Note: *p < 0.05, **p < 0.01, ***p < 0.001.

Table 7. Hierarchical regression results

Variables	Control variables		Basic TPB model		Extended TPB model			
	β	t-Value	β	t-Value	β	t-Value	Collinearity statistics	
							Tolerance	VIF
Age	0.245***	3.670	0.107*	2.016	0.139**	2.700	0.745	1.342
Educational	-0.074	-0.876	-0.020	-0.305	-0.009	-0.134	0.469	2.131
Monthly income	0.060	0.773	0.060	0.991	0.043	0.734	0.571	1.751
BA			0.218***	3.855	0.161**	2.875	0.628	1.593
SN			0.437***	7.796	0.387***	6.891	0.625	1.599
PBC			0.175***	3.520	0.137**	2.818	0.838	1.194
RP					0.095	1.981	0.861	1.162
DE					-0.134**	-2.822	0.881	1.135
PC					0.203***	3.975	0.758	1.319
Model summary								
F	6.916***		35.916***		28.541***			
R^2	0.075		0.460		0.507			
ΔF	6.916***		60.124***		7.907***			

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ΔR^2	0.075	0.385	0.047

Note: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Figures

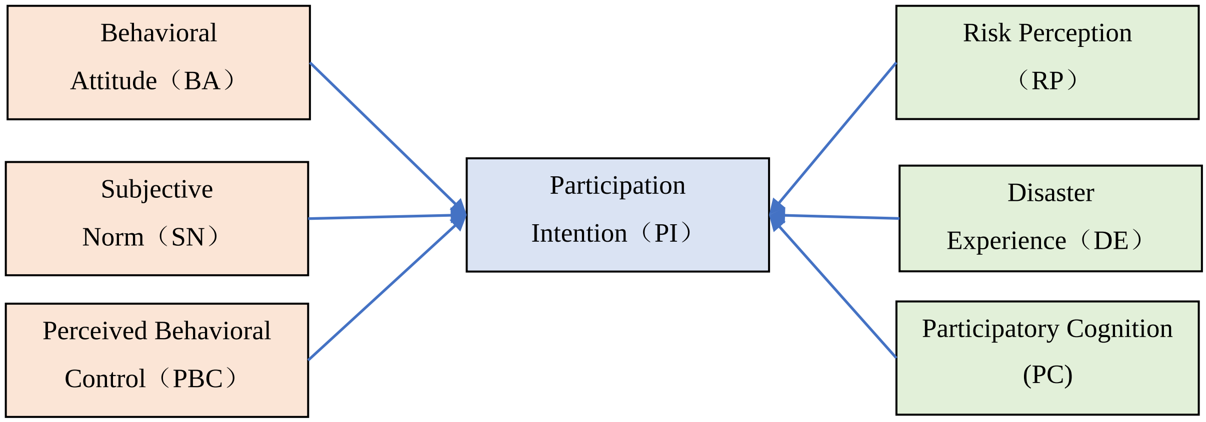

Figure 1: Conceptual model: expanding the TPB model

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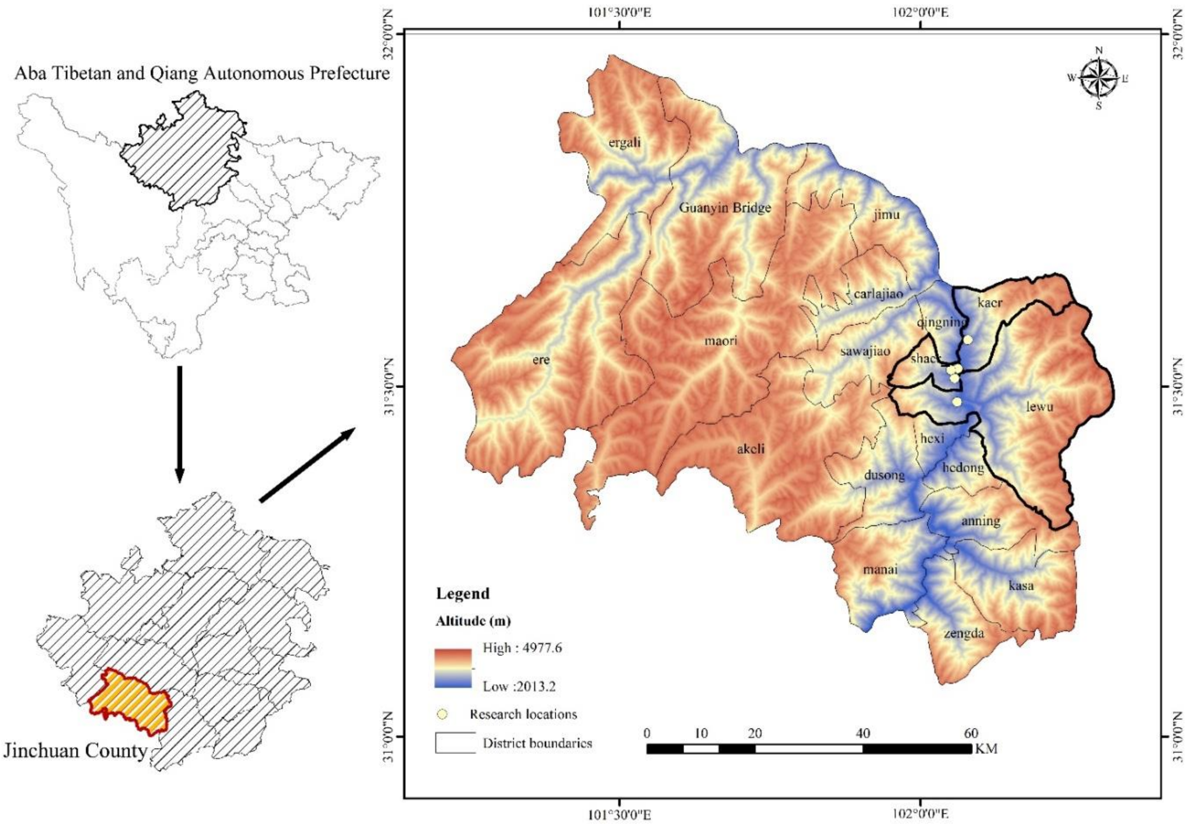
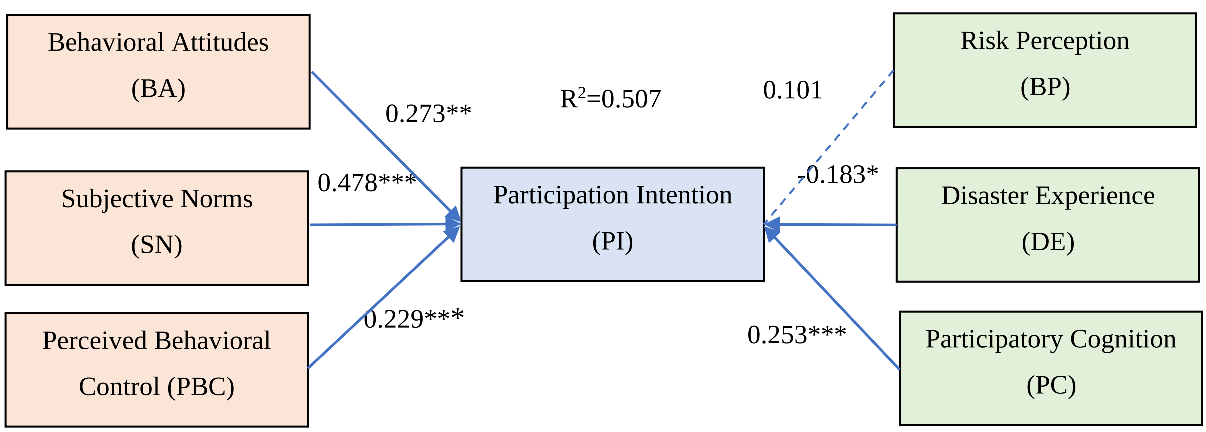


Figure 2: Site location of the study area



705 **Figure 3: Expanding the TPB model results (*p < 0.05, **p < 0.01, ***p < 0.001; the solid line is the significant path, but the dotted line is not)**

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(a) gravity retaining wall

(b) debris flow pre-warning device

(c) discharge chute for debris flow

(d) permeable type of retaining dam for debris flow

Figure 4: Structural engineering measures to prevent and control. (a) gravity retaining wall, (b) debris flow pre-warning device, (c) discharge chute for debris flow, (d) permeable type of retaining dam for debris flow

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(a) emergency evacuation route sign

(b) emergency shelter sign

Figure 5: Emergency shelter signage. (a) emergency evacuation route sign, (b) emergency shelter sign