

## Article

# The Impacts of Training on Farmers' Preparedness Behaviors of Earthquake Disaster—Evidence from Earthquake-Prone Settlements in Rural China

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**Abstract:** Earthquakes have strong negative impacts on the development of global economic society. Fortunately, these negative impacts can be reduced through earthquake-preparedness behaviors. However, existing studies mostly focus on the driving factors of disaster-preparedness behaviors among urban residents, while few studies consider such factors among rural residents. Based on survey data of earthquake-prone rural settlements in China, this study uses the probit model and the Poisson model to evaluate the quantitative impact of training on farmers' earthquake-preparedness behaviors. The results show that: (1) disaster prevention and mitigation training can encourage farmers to engage in earthquake disaster-preparedness behaviors; that is, compared with farmers who have not participated in training, farmers who have participated in training have a 21.39% higher probability of adopting earthquake disaster-preparedness behaviors. (2) Disaster prevention and mitigation training can improve the extent of farmers' adoption of earthquake disaster avoidance preparedness behaviors, namely, compared with farmers who have not participated in training, farmers who have participated in training adopt earthquake disaster-preparedness behaviors to a greater extent, presenting an increase of 0.75 items. Therefore, this study provides a helpful reference for improving disaster prevention and mitigation training policies for settlements at high risk of earthquakes.

**Keywords:** training; preparedness behavior of earthquake disaster; earthquake-prone settlements; rural China



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## 1. Introduction

Earthquake disasters are one of the most harmful geological disasters to the development of human society [1]. According to the Emergency Database (EM-DAT), from 2000 to 2020, 721,514 people died of earthquakes worldwide, and 118,344,432 people were affected by earthquakes [2]. The earthquake in the Sumatra-Andaman Islands in December 2004 had the highest magnitude and the largest number of deaths in the 21st century. The magnitude was as high as 9.3, causing more than 283,100 deaths [3–5]. The Great East Japan Earthquake, which occurred in the Pacific Ocean off the northeastern part of Japan in March 2011, caused the highest economic loss due to an earthquake in history, with a magnitude of 9.0 and an economic loss of more than 200 billion dollars [6]. Therefore, exploring how to reduce the negative effects of earthquakes has become a research hotspot.

Preparation behavior can help reduce the negative impacts of disasters [7–9]. In an earthquake disaster, Jaime [10] and Kusumastuti et al. [7] discovered that those who have participated in an earthquake evacuation drill in advance and mastered evacuation routes and emergency safety procedures are more likely to survive. In a landslide disaster, Xu et al. [11] showed that people who engage in any disaster preparation behaviors,

including learning disaster prevention knowledge, stocking emergency food, participating in government-organized training, strengthening houses, purchasing insurance, etc., can be less negatively affected. Kalubowila et al. [12] believed that people who know the warning signs of landslides and the highest potential time period for landslides in advance are less negatively affected. In flood disasters, Zaalberg et al. [13] pointed out that victims with flood disaster experience can better reduce the losses caused by flood disasters. Zaalberg and Midden [14] reported that people who have experienced a 3D interactive flood disaster simulation in advance of flood disasters can better reduce their risk, while Lokonon [15] thought that those who are willing to relocate can better avoid flood risks. For tsunami disasters, Plümper et al. [16] believed that the advance propaganda of tsunami education and evacuation drills can reduce the death rate caused by tsunamis. Witvorapong et al. [17] pointed out that people who pay close attention to disaster-related news, prepare emergency kits or make family emergency plans and are willing to relocate are less negatively affected. For a disaster involving volcanic eruption, Thorvaldsdóttir and Sigbjörnsson [18] indicated that when farmers obtain early warning information on volcanic eruptions and participate in evacuation preparations in advance, the damage caused by volcanic eruptions can be effectively reduced. For hurricanes, Peacock et al. [19] found that hurricane damage can be reduced when people strengthen their houses in advance. Bourque et al. [20] considered that effective coastal evacuation plans can reduce hurricane-related casualties. In view of the positive significance of disaster preparation behaviors, improving residents' earthquake-preparedness behavior is the key to reducing the negative impact of earthquake disasters.

Previous studies have enhanced the understanding of the driving factors of residents' disaster-preparedness behaviors. Fernandez et al. [21], Hoffmann and Muttarak [22], Goto and Picanço [23], and Grothmann and Reusswig [24] indicated that disaster risk perception capabilities can improve the disaster-preparedness behaviors of urban residents; Hong et al. [25], Kirschenbaum et al. [26] and Kusumastuti et al. [7] believed that disaster information acquisition is one of the key factors for urban residents' disaster preparedness decisions, enabling residents to judge the possibility and severity of disasters, learn the correct and effective disaster-preparedness behaviors based on the disaster information they obtain, and to change behavior decisions. Kim and Madison [27] and Onuma et al. [28] believed that disaster experience factors play an important role in urban residents' adoption of disaster-preparedness behaviors. Residents who have experienced more disasters have greater awareness of disaster preparedness and more targeted preparation behaviors. According to the studies by Samaddar et al. [29], Sandra et al. [30] and Armaş et al. [31], self-efficacy also has a significant influence on urban residents' disaster avoidance preparation behaviors. Samaddar et al. [29] found that there was a strong correlation between self-efficacy and preparedness willingness when studying flood avoidance preparedness intentions. Sandra et al. [30] considered that improving residents' self-efficacy in disaster situations is an important way to promote disaster preparedness. Training is the key way to improve residents' disaster avoidance preparedness behavior. However, few studies have evaluated the quantitative impact of training on residents' disaster-preparedness behavior. In addition, compared with urban areas, information in rural areas is relatively blocked, disaster prevention and mitigation facilities are backward, and economic poverty leads to social vulnerability, so rural residents are more negatively affected by disaster [32–38]. Therefore, it is urgent to explore the quantitative impact of training on the disaster-preparedness behaviors of rural residents.

China is the largest developing country in the world and one of the countries that is deeply threatened by earthquake disasters [38–41]. From 2004 to 2019, 164 earthquakes of magnitude 5 or above occurred in China, causing 486,659 casualties and direct economic losses of 113,652,498.3 million yuan [42]. For example, the Sichuan Province of China suffered successive large earthquakes of magnitude 7 or higher in 2008 and 2013 (the Wenchuan earthquake on 12 May 2008, and the Lushan earthquake on 20 April 2013), which aroused worldwide attention, and the more severely affected areas were mostly

rural [36–38]. The Chinese government has gradually realized the importance of building a resilient disaster prevention and mitigation system in rural areas, in which large-scale disaster prevention and mitigation training is the key link. However, there are few studies that quantitatively evaluate whether training improves residents' disaster-preparedness behavior and the extent to which it can be improved. Muttarak and Pothisiri [43] indicated that disaster-related education and training can improve individual disaster preparedness and reduce vulnerability to natural disasters. However, the effectiveness of this education may be limited to a subgroup of the population, such as highly educated individuals. In the experiment of Joffe et al. [44], the intervention group received controlled interventions, including face-to-face workshops. As a result, compared with the control group, the intervention group's earthquake-preparedness work increased significantly. Other research objects of disaster prevention and reduction training include management training for emergency rescue teams and disaster knowledge training for community managers. For the farmer groups in areas with high earthquake risk, there is no quantitative research to assess the specific impact of training on their earthquake-preparedness behaviors. Therefore, this study takes earthquake-prone rural settlements in Sichuan Province of China as case study areas to discuss the quantitative impact of training on the earthquake-preparedness behaviors of rural residents. The results will help provide references to improve the training policies of disaster prevention and mitigation for settlements at high-risk for earthquakes. The source of research ideas is shown in Figure 1.

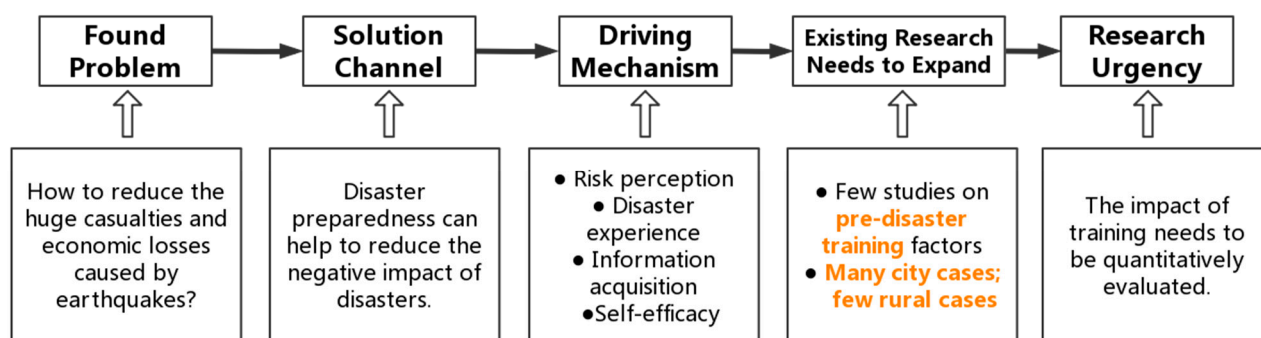


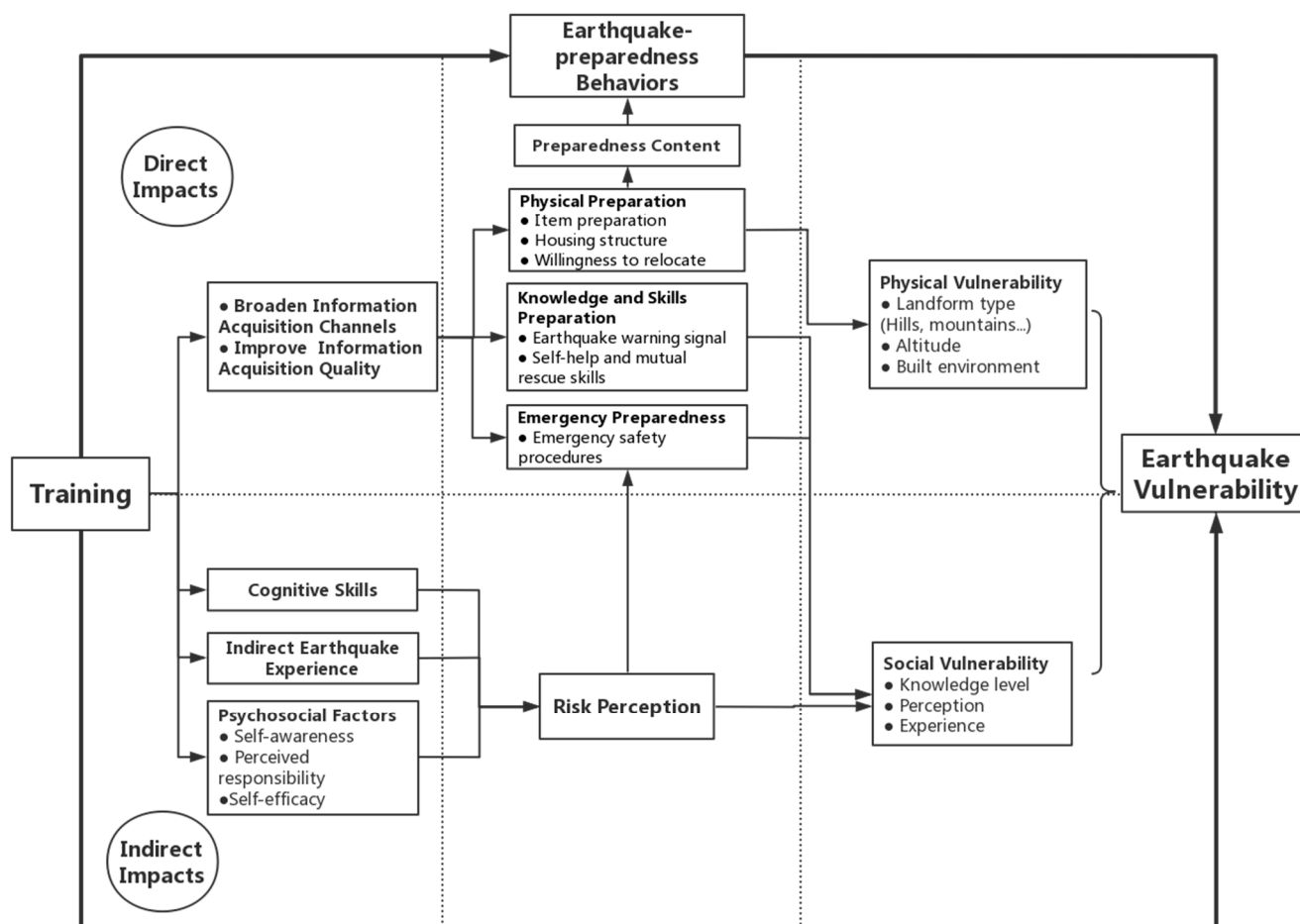
Figure 1. Source of research ideas.

## 2. Materials and Methods

### 2.1. Theoretical Analysis

Disaster avoidance preparedness behaviors can effectively improve residents' resilience in response to disasters [1,39,45–47]. Vulnerability is a measure of social resilience to disasters [32,34,48]. Reducing the vulnerability of individuals and society to disasters can improve the defense capabilities of disaster-bearing bodies, thus reducing the extent of earthquake damage [46,49]. In the hazard-of-place model of vulnerability, according to Cutter et al. [32], the social fabric includes community experience with disasters, and the community's ability to respond to, cope with, recover from, and adapt to disasters, which in turn are influenced by economic, demographic, and housing characteristics. Social and biophysical vulnerabilities interact to produce overall vulnerability; considerable past study has focused on the components of biophysical vulnerability and built environment vulnerability [50], however, up to now, there is still no consistent and stable indicator system for assessing social vulnerability. Inspired by the hazard-of-place model of vulnerability, we used physical vulnerability and social vulnerability to investigate residents' earthquake vulnerability. Based on the content of disaster preparedness and risk perception literature, this study selects three dimensions of landform type, altitude, and built environment, to describe physical vulnerability to an earthquake, and three dimensions of knowledge level, perception, and experience to describe social vulnerability to an earthquake. The interaction of physical and social vulnerability constitutes the overall earthquake vulnerability.

In addition, as shown in Figure 2, reasonable physical disaster preparedness can reduce physical vulnerability, while risk perception and earthquake experience can reduce social vulnerability to effectively improve residents' resilience to disasters.



**Figure 2.** Theoretical analysis framework of the impact of training on farmers' earthquake-preparedness behaviors.

Many studies believe that factors such as risk perception, disaster experience, government trust, information acquisition, and media exposure can help improve residents' preparedness behaviors for earthquake disasters; we discuss five of these. (1) Risk perception. Risk perception is one of the important driving factors for the behavioral decision-making of residents in disaster-prone areas [31,39,51,52]. The stronger the risk perception ability of the public is, the higher the degree of earthquake preparedness [1,8,36–38]. (2) Disaster experience. Residents in areas with frequent disasters are more conscious of predisaster preparedness than residents in other areas [38,39,53], and even nondestructive earthquake experiences inspire the public to prepare for earthquake disasters [54]. (3) Trust in governments. People with higher trust in their government have lower risk perception of potential earthquakes and correspondingly lower disaster preparedness [8,55,56]. (4) Information acquisition. Residents judge the possibility and severity of an earthquake based on received information, and thereby may change behavioral decisions. The timeliness and quality of information acquisition are particularly important [1,25,26,39,57,58]. (5) Media exposure. Media exposure can influence emergency preparedness behavior by increasing social pressure and self-efficacy [59], or by increasing risk perception [25].

However, disaster prevention and mitigation training for earthquakes can not only directly enable farmers to understand disaster-preparedness behaviors but also indirectly stimulate farmers' disaster-preparedness behaviors by enhancing risk perception.

Figure 2 shows the theoretical analytical framework of the impacts of training on farmers' earthquake-preparedness behaviors. Formal training and education are the main mechanisms facilitating individuals' acquisition of knowledge, skills, and abilities, which may affect their adaptability [60,61]. Training can influence personal attitudes, beliefs, practices, and behavioral decisions [62].

#### 2.1.1. Training Directly Affects Farmers' Disaster-Preparedness Behaviors

As shown in Figure 2, residents' disaster-preparedness behaviors can be divided into three dimensions: physical disaster preparedness, knowledge and skills preparedness, and emergency disaster preparedness [45]. According to the research of Cutter et al. [32], Yong et al. [63] and Morrissey [9], this study speculates that training may have an impact through these three dimensions.

- (1) Training may improve the quality of information obtained by farmers and increase their understanding of physical disaster preparedness for earthquakes, which can directly affect disaster avoidance preparedness behaviors. For example, training may enable farmers to be aware of the specific contents of physical preparations, begin to prepare earthquake emergency packages, purchase disaster insurance, regularly strengthen their houses, and change their attitudes toward relocation and willingness for evacuation [64–67].
- (2) Training may expand farmers' sources of information, directly increasing their knowledge and skills preparedness behaviors for earthquakes [60]. Common channels for farmers to obtain information include the government, relatives and friends, mass media, and social media [57]. Training broadens these channels to help farmers obtain high-quality disaster information, such as earthquake warning signals (abnormal performance of animals, strange sounds, unclear light in the sky), the location of high-risk hidden danger points of earthquakes, professional knowledge for survival when trapped, and scientific self-help and mutual rescue skills.
- (3) Training may also increase farmers' emergency knowledge reserves, directly affecting their earthquake preparedness. For example, training can help farmers understand the correct emergency safety procedures, such as sheltering themselves or running outside, avoiding window glass, staying close to water and away from fire, and avoiding trees, telephone poles, buildings, and mountains [7]. Training can also help farmers identify places of refuge and be familiar with the best escape routes for their families so that they can respond calmly and rationally when an earthquake hits.

#### 2.1.2. Training Indirectly Affects Farmers' Disaster-Preparedness Behaviors

As shown in Figure 2, training may change the individual farmer's or family's perception of disaster risks to indirectly stimulate earthquake-preparedness behaviors.

- (1) Training can improve farmers' cognitive skills and risk understanding [43,60,68], thereby affecting the risk perception of disasters. Akbar [69], Morrissey [9], Ooi et al. [70] and Dai et al. [71] found that training makes people more likely to perceive disaster probability and threat. Mileti and Sorensen [72] indicated that the abstract thinking obtained through training enables people to better perceive and process risk information. Muttarak and Lutz [60] proposed that people with higher levels of training have a better understanding of risk and are able to take effective actions against perceived threat.
- (2) Training may change the psychological structures and psychological predictors related to disasters [65], such as self-awareness, self-efficacy, and perceived responsibility for preparedness, and thereby affect farmers' risk perception of disasters. (i) Training helps farmers establish correct self-cognition and maintain moderate cognitive attitudes. Training may reduce the optimism bias of people with disaster experience and knowledge about disasters due to their self-confidence and optimism [73], and it can reduce people's excessive pessimism regarding disaster risk avoidability due to the influences of emotion. (ii) Training may improve the individual's perceived



sense of responsibility for preparedness. Publicizing the degree of disaster risk to farmers can appropriately increase farmers' anxiety and sense of urgency, thereby increasing their positive risk perception. (iii) Training may increase positive self-efficacy. Farmers' provisioned with feasible disaster avoidance preparation plans can enhance their confidence in avoiding or reducing damage through disaster-preparedness behaviors [31,74].

- (3) Training may increase farmers' indirect earthquake experience, thereby increasing the risk perception of earthquakes [25,28,39,75]. Earthquake simulation escape drills are a common method of disaster prevention and mitigation training, which can increase the indirect experience with earthquakes. Training can change vicarious experience (acquired through others), and Becker et al. [53] believe that knowing a person who has experienced personal loss or injury can provide vicarious experience and change risk perception.

In summary, training content and disaster-preparedness behaviors are diverse, and farmers may have different acceptance levels. Therefore, this study proposes the following research hypotheses:

**Hypothesis 1 (H1).** *Training can improve the possibility of farmers adopting earthquake-preparedness behaviors.*

**Hypothesis 2 (H2).** *Training can improve the extent to which farmers adopt earthquake-preparedness behaviors.*

## 2.2. Data

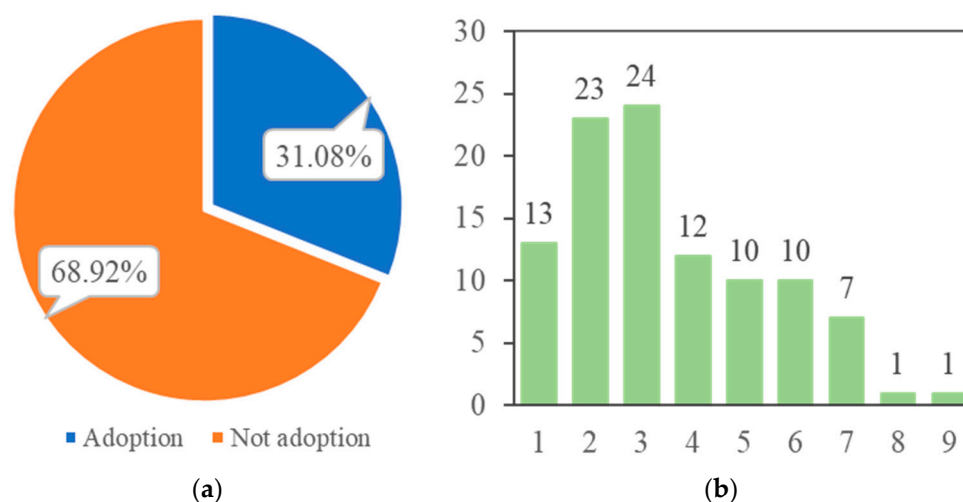
The Sichuan Province of China is located in the Eurasian seismic belt (one of the three major seismic belts in the world), and is one of the most earthquake-prone areas in the world [45]. In particular, magnitude 8.0 and magnitude 7.0 earthquakes occurred successively in 2008 and 2013, which aroused the attention of the world [38]. In this study, the Sichuan Province of China was selected as the sample frame. With reference to factors such as their difference in economic development level, the severity of their disasters, and their distances to earthquake centers, two sample counties were selected from the two earthquake-stricken areas of Wenchuan and Lushan; eight sample towns are selected from four sample counties, and sixteen sample villages are selected from eight sample towns. Finally, according to the preset random number table, 20–23 households were randomly selected from the families list of each sample village as sample rural households. The interviewer asked each farmer about the family's socioeconomic characteristics, participation in earthquake disaster prevention and mitigation training projects, and earthquake disaster-preparedness behaviors. During the process of data analysis, we cleaned up some questionnaires that were obviously not logical or of common sense, and finally obtained a total of 325 valid questionnaires. The details of sampling and data cleaning can be found in Xu et al. [38], Xu et al. [1], Xu et al. [52], and Xue et al. [36].

## 2.3. Variables

### 2.3.1. Dependent Variables

This study takes farmers' earthquake-preparedness behaviors as a dependent variable and discusses the impact of training on earthquake-preparedness behaviors. In the questionnaire, farmers were asked whether they had prepared any of the following nine items for earthquake disasters: water, food, emergency lights, radios, first aid kits and manuals, fire extinguishers, special supplies (such as medicine), important documents and cash, or clothes. Therefore, referring to the studies of Onuma et al. [28], Becker et al. [58], Becker et al. [53], Spittal et al. [76] and Kirschenbaum [77], this study divides earthquake disaster-preparedness behaviors into (i) whether the farmers undertook earthquake disaster-preparedness behaviors (1 = if the farmers prepared at least one of the above nine items to deal with the earthquake disaster; 0 otherwise); and (ii) the degree

of earthquake-preparedness behaviors (i.e., the number of items the farmers prepared for earthquake disasters). Through the analysis, we can see that few farmers adopted earthquake disaster-preparedness behaviors. As shown in Figure 3a, only 31.08% of the farmers in the sample adopted earthquake disaster-preparedness behaviors. The extent to which farmers adopted earthquake-preparedness behaviors was relatively low. As shown in Figure 3b, among the farmers who adopted earthquake disaster-preparedness behaviors, nearly 60% (60 households) of farmers prepared only three or fewer items to deal with earthquake disasters.



**Figure 3.** The situation of farmers' earthquake-preparedness behaviors. (a) Distribution of adopted and not adopted earthquake disaster-preparedness behaviors in the sample; (b) Frequency distribution of adopting disaster-preparedness behaviors in the sample.

### 2.3.2. Focus Variable

Training is the focus variable in this study. The traditional methods of earthquake disaster prevention and mitigation training for residents include earthquake escape skills seminars [62,78], earthquake simulation evacuation drills [58,63,67], earthquake demonstration with multimedia technology [69], the printing and distribution of science handbooks on earthquake disaster knowledge, earthquake knowledge competitions, etc. In recent years, with the development of VR technology and intelligent wearable technology, immersive virtual reality (IVR) and serious games (SGs) have become earthquake emergency training tools used to enhance players' behavioral response and evacuation preparedness [79,80]. However, due to policy differences and economic constraints, the disaster prevention and mitigation training programs carried out in various regions show different characteristics. Therefore, this study defines the focus variable as whether the farmer's family has participated in an earthquake disaster prevention and mitigation training program.

### 2.3.3. Control Variables

Referring to the studies conducted by Fernandez et al. [21], Heller et al. [81], Russell et al. [82], Edwards [83], and Miceli et al. [84], who aim to improve the estimation ability of the model, this study added as control variables some factors considered to influence residents' disaster-preparedness behaviors. These control variables include the characteristics of the farmer household head (such as the age, education level and disaster experience of the head of household), the social and economic characteristics of the family (such as the structure of the family's education level, the family's economic income, the distance from residence to hidden danger points, the distance from residence to commercial center, whether there are family members serving as village leaders, whether the family is located in hilly or mountainous terrain), and the characteristics of the village.

Table 1 presents the variable definitions and descriptive statistical results of this study. The focus variable used in the study is a binary discrete variable. Farmers that had participated in disaster prevention and mitigation training took the value of one, and the value of those that had not participated in training were assigned zero. The dependent variables used in this study include whether farmers adopt disaster-preparedness behaviors and their degree of preparedness. It can be seen from Table 1 that about 46% of the rural households in the sample participated in disaster prevention and reduction training, and the average age of the household head was about 54 years old. Only 10% of the household heads held at least a high school diploma. The overall proportion of family members with at least a high school diploma was about 16%. The average distance from the sampled farmers' households to disaster risk points is only 1.56 km, and nearly 90% of the farmers' households are located on mountainous terrain.

**Table 1.** The definition and data description of the variables in the model.

Variable	Description	Mean	S.D.
disaster-preparedness behavior	1 = if the farmers prepare at least one of the above 9 types of materials to deal with the earthquake disasters; 0 = others	0.31	0.46
degree of disaster preparedness	the number of types of materials prepared by farmers for earthquake disasters (num)	1.09	1.94
training	1 = if the farmers have participated in the earthquake disaster prevention and mitigation training program; 0 = others	0.46	0.50
age	age of household head (year)	53.37	13.4
education	1 = if the household head has a senior high school diploma or above; 0 = others	0.10	0.30
disaster experience	number of earthquake disasters experienced by the household head (num)	8.82	12.07
family education	proportion of family members with senior high school and above (%)	16.14	21.23
family income	family's total income in 2018 (ten thousand yuan)	6.63	7.25
distance 1	distance from the family to a hidden danger point of the disaster (km)	1.56	4.91
distance 2	distance from family to commercial center (km)	5.21	8.03
village cadre	1 = if there are family members belonging to village cadres; 0 = others	0.43	0.5
hill	1 = if the family is located in hilly terrain; 0 = others	0.11	0.32
mountain	1 = if the family is located in mountainous terrain; 0 = others	0.89	0.32

#### 2.4. Method

This study aims to explore the quantitative impact of training on the earthquake disaster-preparedness behaviors of rural households. Meanwhile, in this study, the dependent variables are disaster-preparedness behavior (i.e., it is a binary variable) and degree of disaster preparedness (i.e., it is a discrete and limited variable) respectively. Thus, this study employs the Probit model and the Poisson model to analyze the quantitative relationship between training and earthquake disaster-preparedness behaviors. The estimation formula is as follows Equation (1):

$$Y_i = \beta_0 + \beta_{1i} * ET_i + \beta_{2i} * Control_i + \delta_v + \varepsilon_i \quad (1)$$

where the subscripts  $i$  and  $v$  represent farmer household  $i$  and sample village  $v$ , respectively;  $Y_i$  is the dependent variable, which represents the earthquake disaster-preparedness behaviors of farmers;  $ET_i$  is the focus variable, which indicates whether the farmer participates in the earthquake disaster prevention and mitigation training program;  $Control_i$  represents the control variables (e.g., household head characteristics, family characteristics, and village characteristics);  $\beta_0$  represents a constant term;  $\beta_{1i}$  represents the estimated coefficient of earthquake disaster prevention and mitigation training;  $\beta_{2i}$  indicates the



estimated coefficient of the control variable;  $\delta$  represents a dummy variable, which is the fixed effect of each village; and  $\varepsilon_i$  is the random disturbance term.

### 3. Results

#### 3.1. Estimation of the Impact of Training on the Likelihood of Farmers' Earthquake Preparedness

Table 2 shows the estimated results of training that affects farmers' earthquake-preparedness behaviors. Since farmer households' disaster-preparedness behavior is a binary discrete variable, models (1)–(4) in Table 2 are estimated using the probit model. Moreover, considering that the probit model is a nonlinear model, to facilitate the interpretation of the estimation results, model (5) is set to estimate the marginal effect based on model (4). To support the accuracy of the estimation results as much as possible, this study adopts the strategy of gradually adding variables. In other words, on the basis of model (1), models (2)–(4) gradually control the characteristics of the village, the household head, and the family.

**Table 2.** The impact of training on the possibility of farmers' earthquake preparedness.

	Model 1	Model 2	Model 3	Model 4	Marginal Effect
training	0.6765 *** (0.1491)	0.7519 *** (0.1663)	0.7033 *** (0.1689)	0.6968 *** (0.1695)	0.2139 *** (0.0482)
age			0.0001 (0.0307)	0.0039 (0.0316)	0.0012 (0.0097)
age squared			−0.0000 (0.0003)	−0.0001 (0.0003)	−0.0000 (0.0001)
education			0.6568 ** (0.2783)	0.6578 ** (0.2970)	0.2020 ** (0.0898)
disaster experience			−0.0005 (0.0064)	−0.0017 (0.0069)	−0.0005 (0.0021)
family education				−0.0006 (0.0041)	−0.0002 (0.0012)
family income				0.0048 (0.0120)	0.0015 (0.0037)
distance to hidden danger point				0.0148 (0.0155)	0.0045 (0.0048)
distance to market town				0.0019 (0.0109)	0.0006 (0.0033)
village cadre				0.1451 (0.1596)	0.0446 (0.0488)
hill				−0.2620 (0.3975)	−0.0805 (0.1218)
constant	−0.8296 *** (0.1072)	−1.0986 *** (0.1998)	−1.0922 (0.8039)	−1.1272 (0.8081)	
village effect	no	yes	yes	yes	yes
Wald $\chi^2$	20.6005 ***	37.6137 ***	48.1382 ***	49.6165 ***	49.6165 ***
Pseudo R <sup>2</sup>	0.0522	0.0996	0.1175	0.1232	0.1232
observations	325	325	325	325	325

Note: Robust standard errors are in parentheses; \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ ; “yes” means that the variables are added in model, the same below; village effect is the dummy variable of each village, and the estimation result is omitted, the same below.

According to the estimated results in Table 2, the variables of disaster prevention and mitigation training in models (1)–(4) are all significant at the 1% level, which indicates that training can indeed improve the likelihood that farmers adopt earthquake disaster-preparedness behaviors. According to the estimated results of model (5), compared with the farmers who did not participate in the training, the farmers who participated in training had a 21.39% higher probability of adopting earthquake disaster-preparedness behaviors. Therefore, H1 is supported by our results. In addition, the estimated results in Table 2 show that the variable of household head education is significant at the 5% level, indicating that

increasing the education level of the household head can also improve the earthquake-preparedness behaviors of rural households.

### 3.2. Estimation of the Impact of Training on the Extent of Farmers' Earthquake Preparedness

Table 3 shows the estimated results of the impact of training on the extent of farmers' earthquake preparedness. Since the extent of earthquake-preparedness behaviors (i.e., the number of items farmers prepare for earthquake disasters) is a multivariate discrete variable, the Poisson model is used to estimate models (1)–(4) in Table 2. Moreover, considering that the Poisson model is a nonlinear model, to facilitate the interpretation of the estimation results, model (5) is set to estimate the marginal effect based on model (4). In addition, to improve the accuracy of the estimation results as much as possible, this study adopts the strategy of gradually adding variables. In other words, on the basis of model (1), models (2)–(4) gradually control the characteristics of the village, the household head, and the family.

**Table 3.** The impact of training on the extent of farmers' earthquake preparedness.

	Model 1	Model 2	Model 3	Model 4	Marginal Effect
training	0.8763 *** (0.2047)	0.8868 *** (0.2119)	0.8107 *** (0.2185)	0.8032 *** (0.2188)	0.7542 *** (0.2182)
household head variable	no	no	yes	yes	yes
family variable	no	no	no	yes	yes
village effect	no	yes	yes	yes	yes
Wald $\chi^2$	18.3281 ***	41.5280 ***	58.9548 ***	68.6737 ***	-
Pseudo R <sup>2</sup>	0.0525	0.0933	0.1035	0.1132	-
observations	325	325	325	325	325

Note: This table is the result of Poisson regression, and the dependent variable is the number of types of materials that farmers prepare for earthquake disasters; \*\*\*  $p < 0.01$ .

According to the estimated results in Table 3, the variables of disaster prevention and mitigation training in models (1)–(4) are all significant at the 1% level, indicating that training can indeed increase the level of farmers' adoption of earthquake-preparedness behaviors; that is, it can increase the number of items that farmers prepare for earthquake disasters. According to the estimation results of model (5), compared with the farmers who did not participate in the training, the farmers who participated in the training adopted earthquake disaster-preparedness behaviors to a greater extent, presenting an increase of 0.75 items. As a result, H2 is supported by the empirical results.

### 3.3. Robustness Test

Omitted variables may affect the estimation results [85]. To avoid the impact of omitted variables on the estimation results as much as possible, this study uses the IV-probit model to test the estimation results of the impact of training on farmers' earthquake-preparedness behaviors. The estimated results are reported in Table 4. The results of model (4) and the marginal effect estimation results presented in Table 4 are similar to the results of model (4) and the marginal effect estimation results in Table 2, which indicates that the estimated results regarding the effect of training on farmers' earthquake-preparedness behaviors are robust.

Selection bias may also affect the estimation results [40,86–88]. To avoid the influence of selection bias on the estimation results as much as possible, this study adopts the endogenous conversion probit model to test the estimation results of the impact of training on farmers' earthquake-preparedness behaviors. Table 5 reports the processing effect results based on the endogenous conversion probit model. The results of the treatment effects in Table 5 indicate that after considering the selection bias caused by unobserved and observed factors, training can still improve the possibility that farmers adopt earthquake disaster-preparedness behaviors. This further shows that the estimated results of the effect of training on farming households' earthquake-preparedness behaviors are robust.

**Table 4.** Results of robustness test.

Variable	Model 1	Model 2	Model 3	Model 4	Marginal Effect
training	0.4405 (0.5721)	0.7215 *** (0.1728)	0.6830 *** (0.1766)	0.6714 *** (0.1767)	0.2067 *** (0.0509)
household head variable	no	no	yes	yes	yes
family variable	no	no	no	yes	yes
village effect	no	yes	yes	yes	yes
Wald $\chi^2$	0.5928	35.2993 ***	46.5931 ***	48.9705 ***	48.9705 ***
observations	325	325	325	325	325

Note: This table is the result of IV-Probit estimation, and the purpose is to use the instrumental variable method to solve the endogenous problem caused by the omitted variables and other reasons; \*\*\*  $p < 0.01$ .

**Table 5.** Impacts of training on disaster-preparedness behaviors.

	Trained	Untrained	ATT	t-Value	Change (%)
disaster preparedness behavior	0.1992 (0.2547)	0.1113 (0.1411)	0.0879 (0.3596)	4.4071 ***	44.13%

Note: Standard errors in parentheses; The estimation results of the endogenous conversion Probit regression model are omitted, and interested readers can send an email to the author; \*\*\*  $p < 0.01$ .

#### 4. Discussion

Based on survey data of 325 farmers in rural settlements with a high incidence of earthquakes in Sichuan Province, China, this study uses the probit model and Poisson model to conduct regression analysis to assess the quantitative impact of training on farmers' earthquake-preparedness behaviors.

This study finds that training can significantly improve the preparedness behavior of rural residents to reduce the harmful effects of disasters. Specifically, compared with farmers who have not participated in training, farmers having participated in training present a 21.39% higher probability of undertaking earthquake disaster preparedness measures and a higher extent of adopting earthquake disaster preparedness measures, amounting to 0.75 items. The findings of this study are consistent with those of Sakurai et al. [89], Muttarak and Pothisiri [43], Panic et al. [46], Musacchio et al. [90] and Muttarak and Lutz [60], who also believe that training can improve residents' disaster-preparedness behaviors.

However, the findings of this study differ in some ways from those of existing studies. For example, our findings indicate that disaster experience does not significantly affect the earthquake-preparedness behavior of rural residents. This is different from the research conclusions of Xu et al. [38], Xu et al. [39], Becker et al. [53], Sun and Xue [54], Onuma et al. [28], Russell et al. [82], and Joffe et al. [44]. There may be three reasons for this difference. First, this result may have regional applicability. It may apply only to rural areas, as information is less widely available in rural areas than in cities [36,57], so rural residents do not know how to deal with disasters even if they have experienced them. Second, this result may be related to risk controllability. Controllability refers to "the degree to which an individual can protect himself, his family, and assets from the damage caused by danger" [91]. People with earthquake disaster experience may think that it is difficult to effectively prevent life or economic losses through existing disaster mitigation actions. This sense of powerlessness and low controllability of danger may hinder them from taking actions to prepare for disasters. In addition, the impact of disaster experience on people at different stages of life is different [86,92–95]. In particular, the experience of the early years seems to have a greater impact on personal behavior than the experience of adulthood. For example, [86] argued that groups who experienced early famine showed more enthusiasm for farming. However, the head of the household in the disaster experience variable in this study is an adult with an average age of about 54 years, and it is possible that disaster experience cannot enhance their risk awareness. At the same time, in China, the head of the household is the decision-maker of a family. Therefore, if the disaster experience cannot

enhance the decision-makers' use of disaster response behaviors, then we should consider strengthening the training of decision-makers to increase their awareness of earthquake disaster risks and encourage them to adopt more earthquake disaster avoidance measures.

With the increase of experience in responding to natural disasters, China has continuously reformed its disaster management policies, and its disaster response capabilities and investment levels have also been greatly improved. In the context of the disaster, people have relatively high trust in the Chinese government. However, overconfidence in the government's disaster management capabilities may weaken individuals' protection actions. People from areas with greater danger threats are less willing to accept disaster insurance because they tend to expect the government to make up for their losses. Therefore, people with high trust in the government have less perception of the potential earthquakes, and correspondingly fewer disaster avoidance preparations [8,55,56,96]. However, trust in the basic disaster avoidance facilities and disaster management capabilities of the government cannot be translated into the actual disaster response capabilities of individual farmers. Through training, farmers can have a deeper understanding of how to deal with disasters (i.e., improve disaster avoidance preparedness behaviors).

This study has some limitations that can be further resolved in future studies. Specifically, this study mainly discusses the impact of training on earthquake-preparedness behaviors, and future studies can evaluate the impact of training on other geological disaster-preparedness behaviors. This study focuses on the quantitative impact of training on the earthquake-preparedness behavior of rural residents. Future studies can quantitatively test the mechanism of how training affects rural residents' adoption of earthquake disaster-preparedness behavior. This study takes China's earthquake-prone rural settlements as the research area. Whether the research conclusions are applicable to earthquake-prone rural settlements in other countries remains to be further tested.

## 5. Conclusions and Implications

### 5.1. Conclusions

Compared with existing studies, the marginal contributions of this study are as follows: (1) The existing studies mostly focus on the disaster-preparedness behavior of urban residents, while this study mainly focuses on the disaster-preparedness behavior of rural households with high earthquake incidence. (2) The existing studies mostly focus on the impact of risk perception, disaster experience and other factors on disaster-preparedness behaviors, while this study mainly evaluates the impact of training on residents' disaster-preparedness behaviors. In addition, developing countries are more negatively affected by geological disasters than developed countries are. This study takes China, the largest developing country in the world, as a case study area. The results of the study will help promote the construction of the global resilient disaster prevention and reduction system. The conclusions of this study are as follows:

- (1) Disaster prevention and mitigation training can encourage farmers to adopt earthquake disaster-preparedness behaviors; that is, compared with farmers who have not participated in the training, farmers who have participated in training have a 21.39% higher probability of undertaking earthquake preparedness measures;
- (2) Disaster prevention and mitigation training can increase the extent of farmers' adoption of earthquake-preparedness behaviors; that is, compared with farmers who have not participated in the training, farmers who have participated in training engage in earthquake-preparedness behaviors to a greater extent, with an increase of 0.75 items.

### 5.2. Implications

Reducing the negative impacts of earthquakes, which include substantial losses of life and property to society and bring poverty risks to poor mountainous areas, is an important challenge for the world. Earthquake disaster-preparedness behaviors provide an effective way to address this problem. The results of this study show that training on disaster prevention and mitigation helps encourage farmers to start preparing for

earthquake disasters and can greatly increase the extent of farmers' adoption of earthquake-preparedness behaviors, which helps reduce their earthquake vulnerability and minimize earthquake damage. Based on the above findings, this study proposes the following policy recommendations.

#### 5.2.1. Carry Out Disaster Prevention and Mitigation Training Projects

##### (1) Formulate and improve policies and systems

Formulate and improve laws and policies for disaster prevention and reduction training, especially for local governments in high-risk earthquake areas. It is necessary to clarify who the parties responsible for the implementation of the policies and supervision and management are. Regions should also incorporate the effectiveness of disaster prevention and reduction training projects into their political performance evaluation index system.

##### (2) Strengthen skills support for disaster prevention and mitigation

We recommend that disaster regions hire foreign professionals, or improve the disaster knowledge level of the village's grassroots managers, discover volunteer teams, establish and improve the local disaster prevention and reduction science popularization team, creative team and communication team, to provide guarantees of skillsets and intellectual support for work popularizing disaster prevention and mitigation science. It is advised to hold earthquake disaster knowledge training meetings frequently, organize residents to carry out earthquake escape drills actively, check the sturdiness of farmers' houses regularly, and give full play to their professional knowledge and leadership roles.

##### (3) Increase funding support for disaster prevention and mitigation projects

We advise disaster-prone regions to increase investment in the construction of disaster prevention and mitigation infrastructure in rural areas, especially the construction of internet communication technology; establish a complete platform that can stably disseminate disaster information in the three stages of pre-disaster, during disaster, and post-disaster; realize information sharing, to improve the capabilities of rural residents to obtain information; and speed up the process of information networking construction for disaster prevention and mitigation. We further advise building disaster prevention and mitigation village education and training venues so that rural residents can learn from information and increase their enthusiasm for dealing with geological disasters. Meanwhile, we advise regional governments to increase capital investment to promote the rapid transformation and popularization of scientific research results, improve the technical level of disaster prevention and mitigation, thus making active disaster prevention, scientific disaster avoidance, adequate disaster preparedness, and effective disaster reduction part of farmers' conscious actions.

##### (4) Optimize the allocation of disaster education resources

During the research process, it was also found that improving the education level of household heads can also improve farmers' earthquake disaster preparedness. Therefore, the government can appropriately increase education resources to remote and impoverished mountainous areas, and grassroots management organizations can provide special disaster prevention preparation guidance to household heads. In addition, with the advent of the age of 5G communication, it is necessary to vigorously build an online earthquake science teaching platform to further enhance public disaster knowledge-popularization service capabilities.

#### 5.2.2. Give Primary Focuses to the Role of Training in Building Disaster Prevention and Mitigation Systems

- (1) A rural disaster prevention and mitigation community should be built through training. The government is the main body responsible for disaster prevention and mitigation training, society is a solid force in carrying out disaster prevention training, and farmers are the most extensive subjects participating in disaster prevention and



mitigation in rural areas. Only by mobilizing the enthusiasm of multiple subjects can disaster prevention and mitigation capabilities be improved overall for individuals and society.

- (2) Training lays the foundation for the construction of rural security resilience systems. Earthquake prevention and mitigation work includes three systems: earthquake monitoring and prediction systems, earthquake disaster prevention systems and earthquake emergency rescue systems. On the one hand, training enhances the professionalism and effectiveness of earthquake disaster preparedness, improves farmers' disaster prevention literacy, and strengthens the construction of earthquake disaster prevention systems. On the other hand, with the improvement in disaster prevention literacy, it becomes easier for farmers to understand, support, and cooperate with other earthquake prevention and mitigation systems of the government and society. This can help build resilient villages with respect to disaster prevention and mitigation.

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