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Risk Perception, Risk Communication, and Mitigation Actions of Flash Floods: Results from a Survey in Three Types of Communities

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Abstract: In order to improve the decision-making of risk management and enhance community resilience to flash floods, the perception of risks, communication of warnings, and mitigation actions concerning flash floods were investigated in this study. The survey involves 280 participants from three types of communities in flash flood-prone areas. Results show that: (i) About 55.4% of community participants misperceived or underestimated the risk of flash floods, especially in the suburban communities, and people had misconceptions about the safety of crossing fast-flowing water, even though most of them had experienced flash flood hazards. (ii) In total, 67.9% of participants indicated that they had at some point received a flash flood warning. The perception of accuracy was related to trust in flash flood warnings, but they were different constructs for some individuals. Moreover, residents in the rural community and suburban community reported a closer social communication with neighbors, which would greatly influence inhabitants' attitudes and behaviors towards the flash flood warnings and mitigation actions. (iii) Most of the participants indicated they would take some protective action when they received a warning. Risk perceptions and risk communications influence the mitigation actions in the community. Significant variables in the rural community and non-rural community were explored, and some important suggestions are highlighted. These findings suggest that risk perception and risk communication in neighborhoods help people to decide what action to take in the given scenarios, contribute to enhancing the community resilience, and contribute to coping with future flash floods in a more specific and effective way.

Keywords: flash floods; community resilience; communication; risk perception; urban community; rural community

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1. Introduction

Flash floods are one of the most disastrous forms of natural hazards worldwide due to the devastating impact on lives and infrastructure [1,2]. The rapid and complex evolution of flash floods creates challenges for effective decision-making in risk management [3]. Over the last few decades, massive flood protection efforts have been undertaken, the hydrological model and the improved model were developed [4,5], real-time monitoring and simulation has been conducted [6], and the accuracy of flash flood warnings has improved greatly. According to the Annual Flood and Drought Hazards Report of China [7], direct flood damages for the water year 2016 totaled USD 57 billion in China, and the amount in 2017 decreased to USD 23.1 billion. However, the Ministry of Emergency Management has stated that flood hazards are still the major form of natural disaster in China. Flood hazards affected 55.8 million people during the year of 2018, causing 187 deaths and 32 missing persons. Furthermore, 8.4 million people had to be relocated, and 85,100 houses collapsed.

A community is the smallest scale in hazard risk management, which aims to further strengthen community capacity to resist disasters and help to reduce the degree of community vulnerability to natural hazards, and residents are encouraged to participate in the management of community risk reduction. Community resilience as a concept in hazard risk management has received a sharp increase in attention since the 1970s [8,9]. Community resilience to natural hazards, such as floods, hurricanes, and earthquakes, has been observed to reduce the impacts of disasters on a nation and its communities [10,11]. Community resilience generally refers to the ability that a community maintains or the speed at which it returns to normal operating conditions in the face of a disturbance [8,12]. In literature, the current studies on community resilience mainly refer to: (1) description of community resilience and the multiple dimensions [13,14]; (2) tools for community resilience evaluation [15–17]; and (3) measurements to enhance community resilience [18–20]. A variety of factors assemble and shape community resilience, including the environmental dimension, social relations dimension, economy dimension, institutional dimension, and communications dimension [21,22]. A number of studies have examined the community resilience (e.g., [23–25]), good conditions of infrastructure, transportation, and communication systems, as well as partnerships with the private sector or public organizations, which may play important roles in improving community resilience.

Communication is the core adaptive capacity in the framework of community resilience, which informs people about hazard risks [26,27]. The communication dimension includes communication systems, trust in information sources, and concepts related to interpersonal communication such as social networks [22,28,29]. Communication could enhance community resilience to natural hazards, and the public risk perceptions and mitigation actions are greatly influenced by the communication dimension [30]. The adaptive capacity is required to achieve sustainable resilience in communities; some researchers and practitioners indicate that preparedness is the first level of the hierarchical priorities [31]. Flash floods occur suddenly, and residents' perception and communication significantly impact the disaster response and adoption of mitigation actions [32]. Thus, risk perception can help people to revise their knowledge on community resilience through communication and preparedness and help to improve hazard risk management.

The extent to which a community can demonstrate resilience after a flood largely depends on human perception [33]. Risk perception is a "subjective" cognition used to evaluate the potential impact and consequences of risks and choose appropriate behavioral responses [34–36]. The cognition affects people's early warning risk communication and disaster prevention actions, thus becoming the basis of community flood risk management analysis. It is one of the most significant links to improve the resilience of the community by exploring the relationship between risk perception and behaviors. Studies have been conducted to discuss the relationship between risk perception and risk communication and mitigation actions. Many studies showed that the willingness to take protective measures is positively correlated with the level of risk perception of residents in most cases. Therefore, investigating the risk perception ability of residents in flood-prone areas can help to assess the sensitivity of local residents to disasters and their willingness to resist them and help people understand when, where, and how they are at risk and how to protect themselves if needed [37,38].

In order to address the role of individual flood risk perceptions in enhancing community resilience to flash floods, this study investigated the perception of flash floods and response to flash flood warnings in communities based on the relationship between flash flood risk perception, communication, and mitigation actions. Due to the differences of resources, capacity, and organization in communities, this study utilized the type of community as the parameter of social communication and examined how it affects community resilience to flash floods. The multiple linear regression (MLR) method was applied to quantitatively analyze the correlation between the residents' defense decisions and the social structure, risk perception, and early warning communication. The objectives of this study were as follows: (a) identifying the sensitivity of community residents to disaster

response, so as to assess the risk perception level of residents in the flood-prone area; (b) exploring the relevance of risk perception to risk communication and response, so as to investigate residents' trust in disaster warning and the influence of early warning communication of disaster prevention decision-making; (c) examining the major impact factors of the adoption of flood mitigation actions, so as to provide specific and accurate warnings for different communities, evaluate their risk, and decide how to take effective actions.

2. Methods

2.1. Study Area

The Qingyuan district of Guangdong province in China is prone to flash floods and covers an area of approximately 19,000 km^2. The region has a subtropical monsoon climate and is warm and rainy in summer. The average annual precipitation is 1600 mm. The annual precipitation is uneven, mainly from April to July. The study area is in the north of Qingyuan district, including Lianshan County, Liannan County, Lianzhou County, and Yangshan County (Figure 1), with numerous mountainous areas and rivers. Heavy precipitation accompanied by steep terrain leads to the frequent outbreaks of flash floods. For example, a large-scale flood occurred in Qingyuan on 22 May 2014, which resulted in a reported 712,500 people being affected by the disaster, 1 missing person, and 5 deaths. The direct economic loss of reached USD 363.3 million in this flash flood event, among which the direct economic loss of Lianshan County was USD 18.1 million, and Yangshan County was the most seriously affected, with a direct economic loss of USD 147.1 million. The study area comprises different ethnic minorities, especially in Lianshan County, where ethnic minorities have a population of over 77,728, making up nearly 63.9% of the total population.

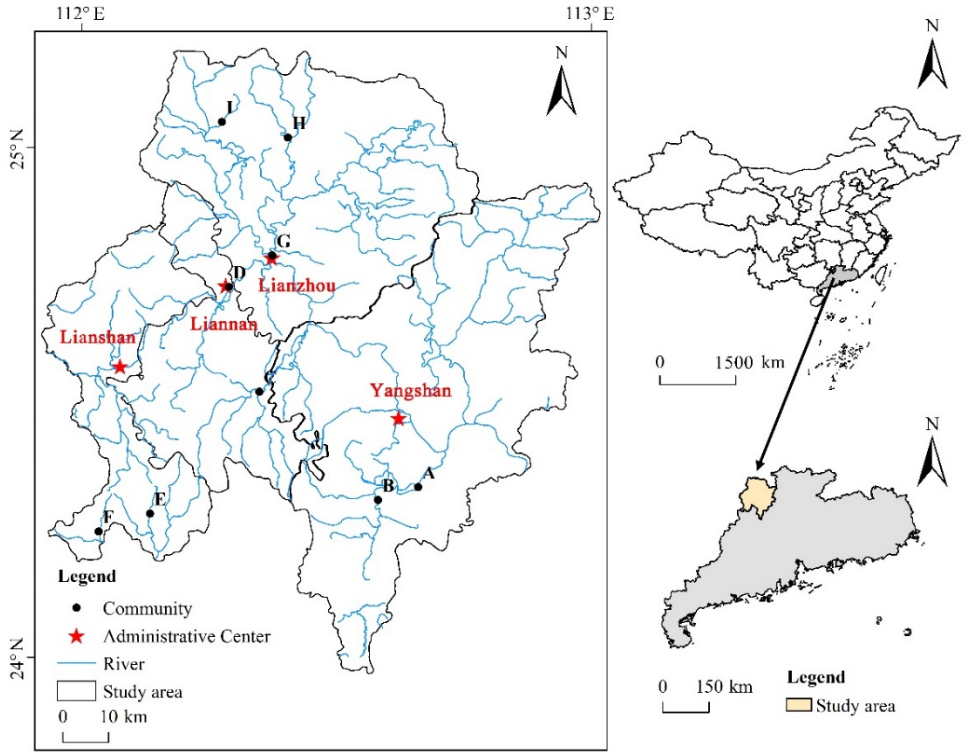


Figure 1. Location map of the investigation regions.

In the administrative divisions of China, the county consists of towns, and the towns are composed of multiple communities with different locations, population compositions, and economic levels. According to urban and rural classification by National Bureau of Statistics of China in 2019, communities in this study were categorized into three different types, including urban, suburban, and rural. Homogenous communities have similar social

characteristics, such as community size, population density, and intensiveness of social interactions among the citizens [39]. The investigations were conducted in 19 communities in this study area distributed into 9 resident locations, in which there are 5 urban communities, 5 suburban communities and 9 rural communities, as shown in Table 1.

Table 1. Types of investigated communities.

County	Code	Town	Community	Type
Yangshan	A	Dubu	Hankeng	rural
	B	Qigong	Furong	rural
			Heping	rural
Liannan	C	Zhaigang	Shikenglang	rural
			Wanjiao	rural
			Jinxing	suburban
			Zhaigang center	urban
	D	Sanjiang	Liulian	suburban
			Donghe	suburban
			Wuxing	urban
			Shunde cultural square	urban
Lianshan	E	Xiaosanjiang	Dengyang	rural
			Luming	rural
	F	Shangshuai	Lianguan	suburban
Lianzhou	G	Lianzhou	Caiyuanba	suburban
			Commercial street	urban
	H	Yao'an	Jiulong	rural
			Luoyang	urban
	I	Fengyang	Kemuwan	rural

2.2. Survey Questionnaire Development

The survey questionnaire used in this study was initially developed based on the literature review [21,22,27,40] and modified by the experts and the government manager in the field of flash flood hazards. The questionnaire was pretested by flash flood professionals and local residents. With the suggestion of experts, some existing questions were modified and some new questions were designed. Based on the preliminary implementation, as well as the ideas of the research team members and cooperative scholars, the revised questionnaire was confirmed in August of 2019.

To determine the sample size of questionnaires, the following formula was used,

$$n = N/(1 + Ne^2) \quad (1)$$

in which n is the population size, N is the corrected sample size, e is the error acceptance, supposing e = 6%. The questionnaires were handed out in the communities of Lianshan County, Liannan County, Lianzhou County, and Yangshan County, where the total permanent resident population was 984,000. By using Equation (1), the formula produces a value of "n = 277.7" with error acceptance value of 6%.

2.3. Data Collection and Analysis

Data collection was based on face-to-face interviews, electronic questionnaires, and door-to-door surveys in this study. The survey data were collected using two sampling strategies: interviewing with community residents and distributing questionnaires to government managers in the community with a simple random sampling method. The questionnaires were distributed in the surveyed communities on site, mainly through

semi-structured interviews. Residents completed paper questionnaires while investigators explained the questionnaire and conducted in-depth communication and inquiries.

Of the returned samples, there were 280 completed surveys and 12 invalid samples, which were abandoned. The reliability and structural validity analyses showed that the Cronbach's alpha was 0.670, the KMO index was 0.673, and Bartlett's test was also acceptable with $p < 0.001$ for the total questionnaire, indicating that the results of this survey were reasonable. Residents living in the rural community of North Qingyuan District are potentially at the highest risk of flash floods, and there is a greater percentage of disabled or elderly people in the rural community. Thus, among valid questionnaires, 146 samples came from the rural community, 77 samples came from the suburban community, and 57 samples came from the urban community, as shown in Figure 2 and Table 2. The total proportion of suburban and rural samples was 48%, which is in line with the urbanization of the city of Qingyuan in 2017 (50.7%). Residents in the rural community were vulnerable groups who might need more help to access transportation or to maintain independence in disease control and prevention actions.

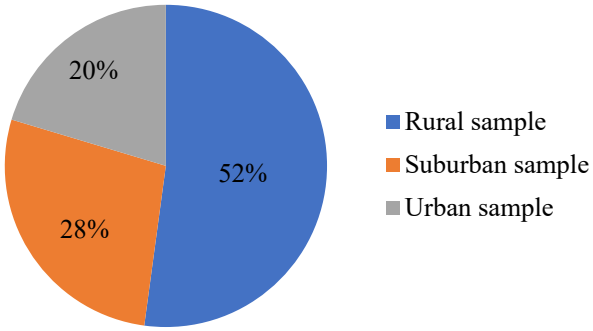


Figure 2. Sample distribution.

Table 2. Sociodemographic characteristics of the rural, suburban, and urban samples.

Sociodemographic Characteristics	Rural (N = 146)	Suburban (N = 77)	Urban (N = 57)
Age (% older than 50)	56.8%	45.5%	29.8%
Gender (% male)	53.4%	42.9%	35.1%
Ethnic (% Han)	77.4%	42.9%	71.6%
Residence ownership [1] (%)	93.8%	91.0%	86.0%
Length of residence in local place (median)	>15 years	>15 years	>15 years
Education [2] (% Bachelor's degree or higher)	8.9%	14.3%	17.5%
Income per month (median)	<500 RMB	500–1000 RMB	1500–2000 RMB
Primary language [3] (% Cantonese)	65.8%	61.0%	68.4%

[1] Percentage of the owner of the house is his/her family. [2] and [3] Percentage of the sample size that contains this option.

Demographic characteristics have a direct impact on community disaster resilience [41]. For example, there are gender differences in disaster response, as women tend to be more risk averse and more likely to respond to warnings, while men are more likely to volunteer to assist with rescue [42]. Communities with higher educational levels, fewer elderly and disabled residents, and more local speaking residents exhibit greater resilience [43]. Culture plays an important role in how people assess risk and make decisions [44]. Sociodemographic characteristics of the community samples are listed in Table 2. Residents aged 50 and above comprised the majority of participants in the rural community and suburban community, accounting for percentages of 56.8% and 45.5%, respectively. The survey sample contained a high percentage of people who were of Han ethnicity, owned their own residence, had lower education, had lower incomes, and spoke Cantonese as a primary language. The survey sample included a variety of ethnic backgrounds, including not only the Han ethnicity but also Yao and Zhuang ethnic minorities. Ethnic minorities have

stronger networks, which can help identify community leaders, spread information, and organize emergency rescue. On the other hand, ethnic minorities usually live in settlements in remote and highly isolated areas, which makes them more vulnerable to disaster.

3. Results and Discussion

3.1. Perceptions of Flash Flood Risks

3.1.1. Experience and Preparation of Flash Flood

Previous studies have found that people with flood experience had more knowledge and better understanding of historical flooding [33,34,45]. Residents' previous experiences of flood events increased their risk perceptions and hazard adjustment. In this survey, most of them mentioned their local experience with a significant flash flood event when it occurred. A total of 80.82% of rural respondents indicated that they had experience with flash flooding, while this percentage was 63.64% for suburban respondents and 71.93% for the urban community, as shown in Figure 3.

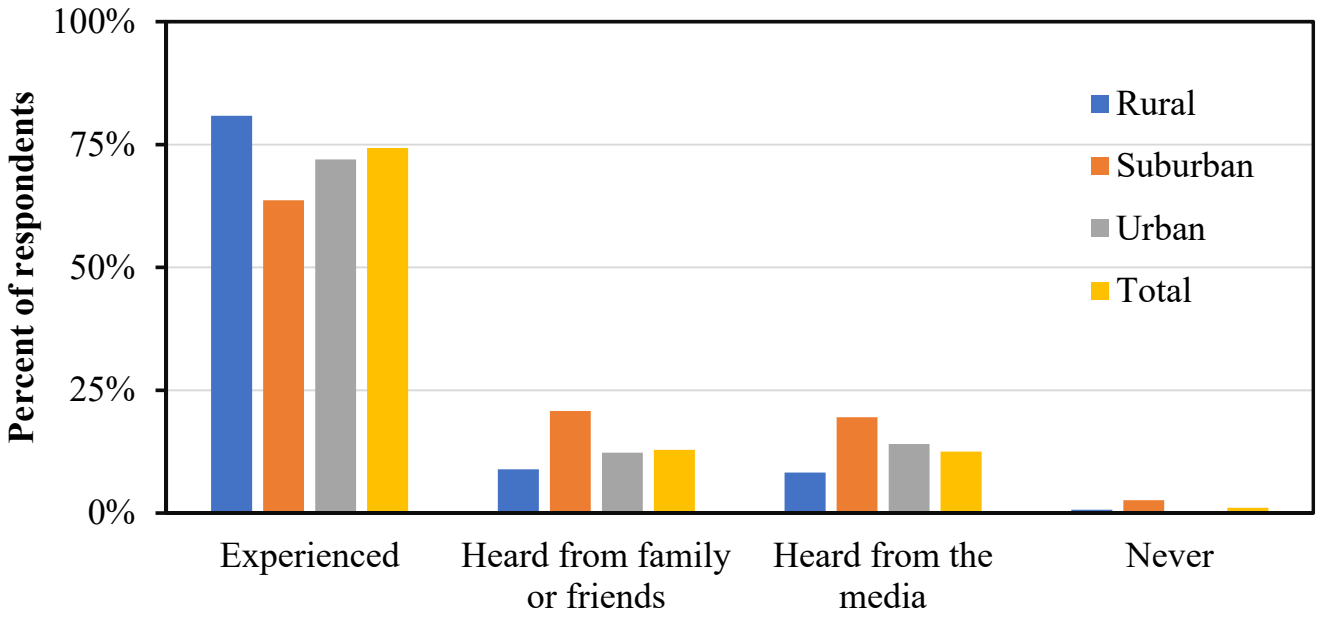


Figure 3. Experience of flash flooding.

Long-term precautionary adaptation by households at risk of flooding can reduce monetary damage by as much as 80% [46]. Moreover, a variety of private mitigation measures have a significant influence on flood damage [47]. Figure 4 displays the preparation for a potential flash flood event in the investigated communities. In the suburban community and urban community, more than half of residents mentioned they had not made any preparations for flood protection. In addition, 63% of village respondents indicated that they had made at least one type of preparation for flash floods. The most common preparation of rural respondents was planning an evacuation route (30.8%), followed by adjusting the structure of a house or household in order to prevent flash flooding (28.8%) and discussing disaster planning with their family (15.8%). With the improvement of levees, dams, and the flood warning and monitoring hardware, residents believe in the protection measures from flood management organizations and tend not to carry out any disaster preparedness by themselves.

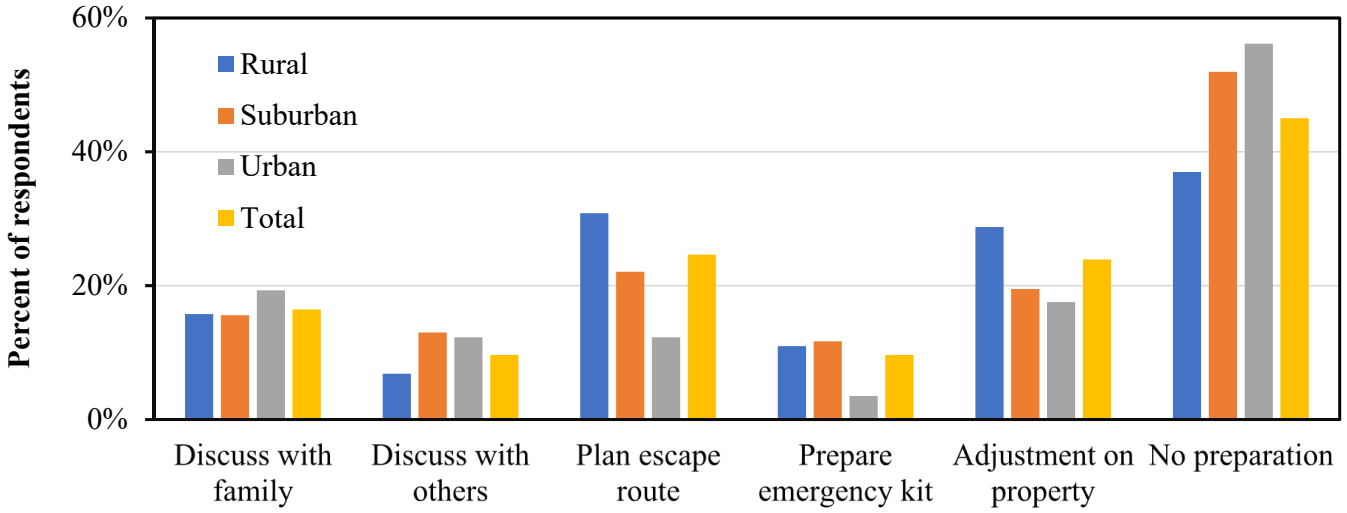


Figure 4. Preparation for flash floods.

Comparing the rural and non-rural subsamples, the assessment of flash flood risk by residents of the rural community is higher than that of the non-rural community. The communities that have previous experiences of flash floods are better prepared; however, household disaster prevention plans should be more widely used.

3.1.2. Understanding of Whether the Community Is Located in the Floodplain

In order to understand the concept of a "floodplain", the question "do you agree on the statement that flash flood risk is only found near creeks?" was asked in the investigation. The results are shown in Figure 5. Only 8.93% of respondents explicitly disagreed, 19.3% of respondents responded with "comparatively agree", and 22.81% of them chose "fully agree".

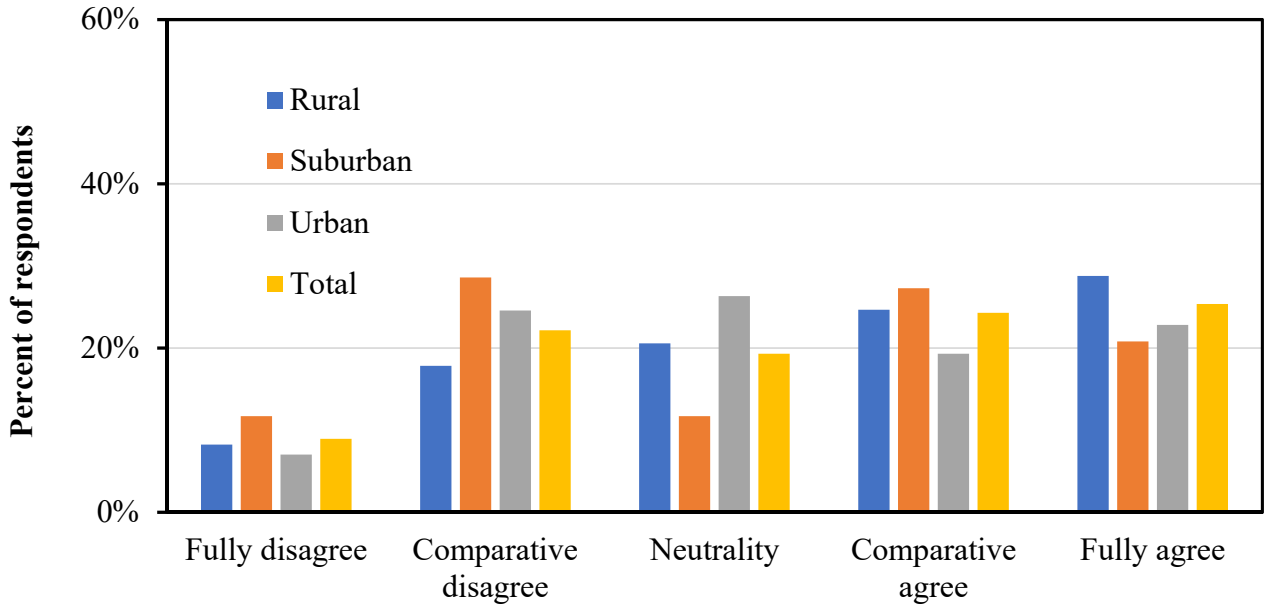


Figure 5. Respondents' perception on the statement "only communities near creeks are at risk".

Table 3 shows results for perceived floodplain locations for the full samples. Approximately 45.5% of respondents in the suburban community believed that they lived in the floodplain, while nearly 48.1% of them indicated that they were not in the floodplain, the greatest proportion in the three community types. In the rural community and urban

community, the percentage of residents who believed they were in a floodplain was nearly twice that of the residents who believed they were not in a floodplain. This suggests that the respondents in the rural community and urban community tend to perceive more flash flood risk, which would influence their response to a flash flood threat. Most areas of the investigated urban community had not experienced major flood events in the recent decades, and so most of the respondents were not clear on the floodplain locations, while 14.0% of respondents said they did not know whether they were located in the floodplain. According to the flood risk zone shown in Table 1, approximately 30.8% of rural respondents and 29.8% of urban respondents had an incorrect perception of the floodplain. The proportion of respondents who misread the floodplain was particularly high in the suburban community, reaching 48.1%; moreover, nearly 6.5% of suburban respondents chose "Don't know". The proportion of rural respondents who correctly perceived the floodplain was the greatest, reaching 60.3%, followed by 56.1% of urban respondents and 45.5% of suburban respondents. In the full samples, 55.4% respondents could correctly perceive whether their community was in a flooded area. If people believed that they were in the flash flood-prone area, they were more likely to take the protective action for flood hazards. Our findings are consistent with those of Ullah et al. [45], which indicated that respondents with flood experience were more likely to perceive high flood risk. Furthermore, our results also suggested that the awareness of flash floods needs to be strengthened, and more information and knowledge should be promoted in flash flood-prone areas, which would greatly help residents to correctly perceive flash flood hazards and possibly respond to flooding risk with stronger measures.

Table 3. Respondents' understanding of whether their community is located in the floodplain.

Community Type	In Floodplain	Not in Floodplain	Don't Know
Rural	88 (60.3%)	45 (30.8%)	13 (8.9%)
Suburban	35 (45.5%)	37 (48.1%)	5 (6.5%)
Urban	32 (56.1%)	17 (29.8%)	8 (14.0%)
Total	155 (55.4%)	99 (35.4%)	26 (9.3%)

3.1.3. Understanding of the Likelihood of Flash Floods

In order to measure the risk perception in the investigated communities, the respondents were asked to estimate the likelihood of flash floods in the next three years. As shown in Figure 6, 3.6% of residents said there would be no flash floods occurring in their community in three years, while 26.8% said that it was "not very likely". When the scale is broken down to three types of communities, the results are consistent with the full samples.

Risk perception directly affects the behavior choices of community members. Previous studies indicate that risk perception can be used either to reduce risk or to change behavior [48]. In terms of the possibility of flash flood outbreak, the perception of residents in the communities tends to be the same. Compared with the risk level of flash floods in northern Qingyuan District, the perceived possibility of residents in the community is less than the actual possibility.

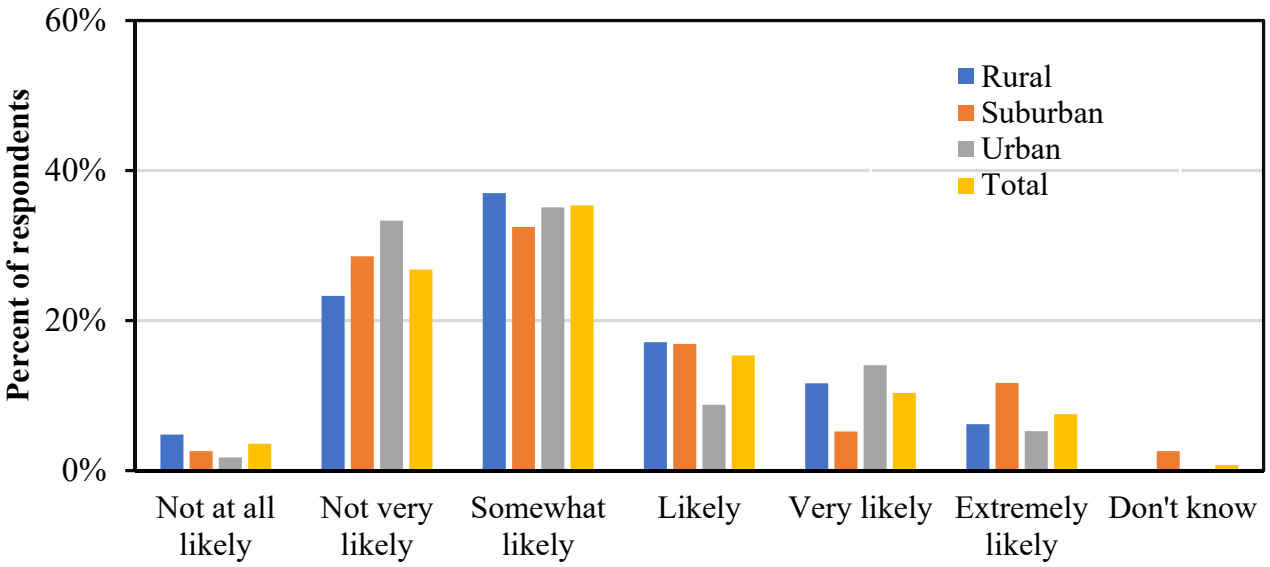


Figure 6. Understanding on the likelihood of flash floods occurring in the next three years.

3.1.4. Perception of the Loss from Flash Floods

Previous studies found that risk characteristics, such as seriousness of consequences, were important attributes for laypeople's judgments of risks [49]. To investigate perceptions of the risks posed by flash flooding in the study area, respondents were asked about the likelihood of the potential loss once flash floods occurred in their communities. The potential loss included the economic loss, road disruption, injury, damage to the ecological environment, interruption of water supply, and interruption of power supply, as shown in Figure 7.

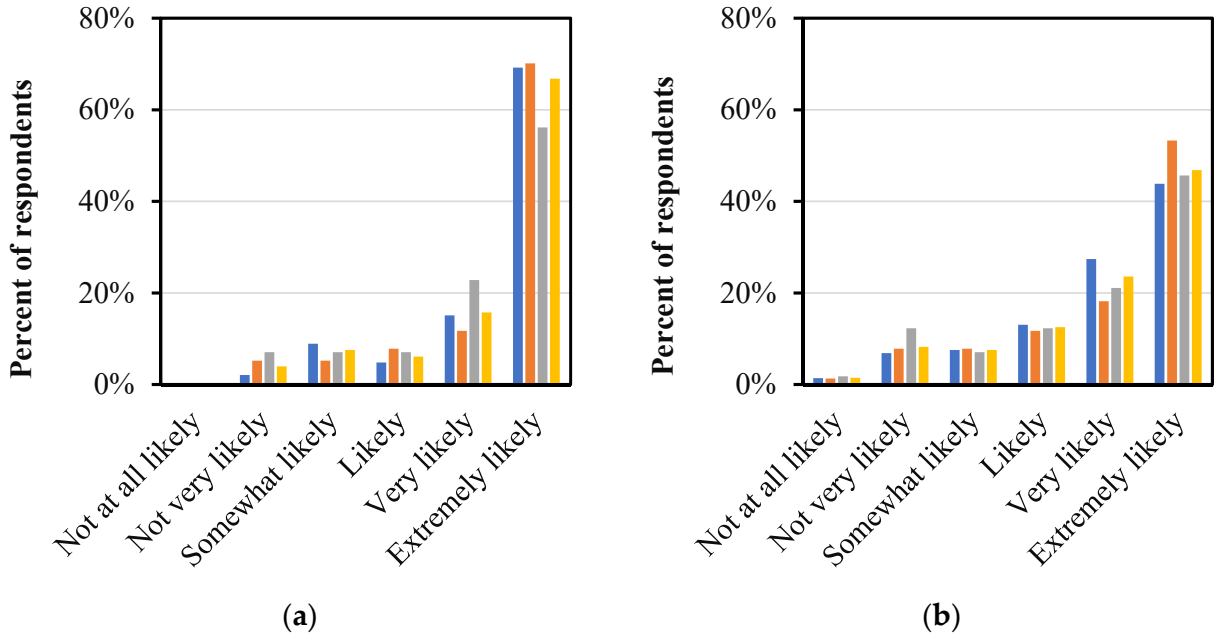


Figure 7. *Cont.*

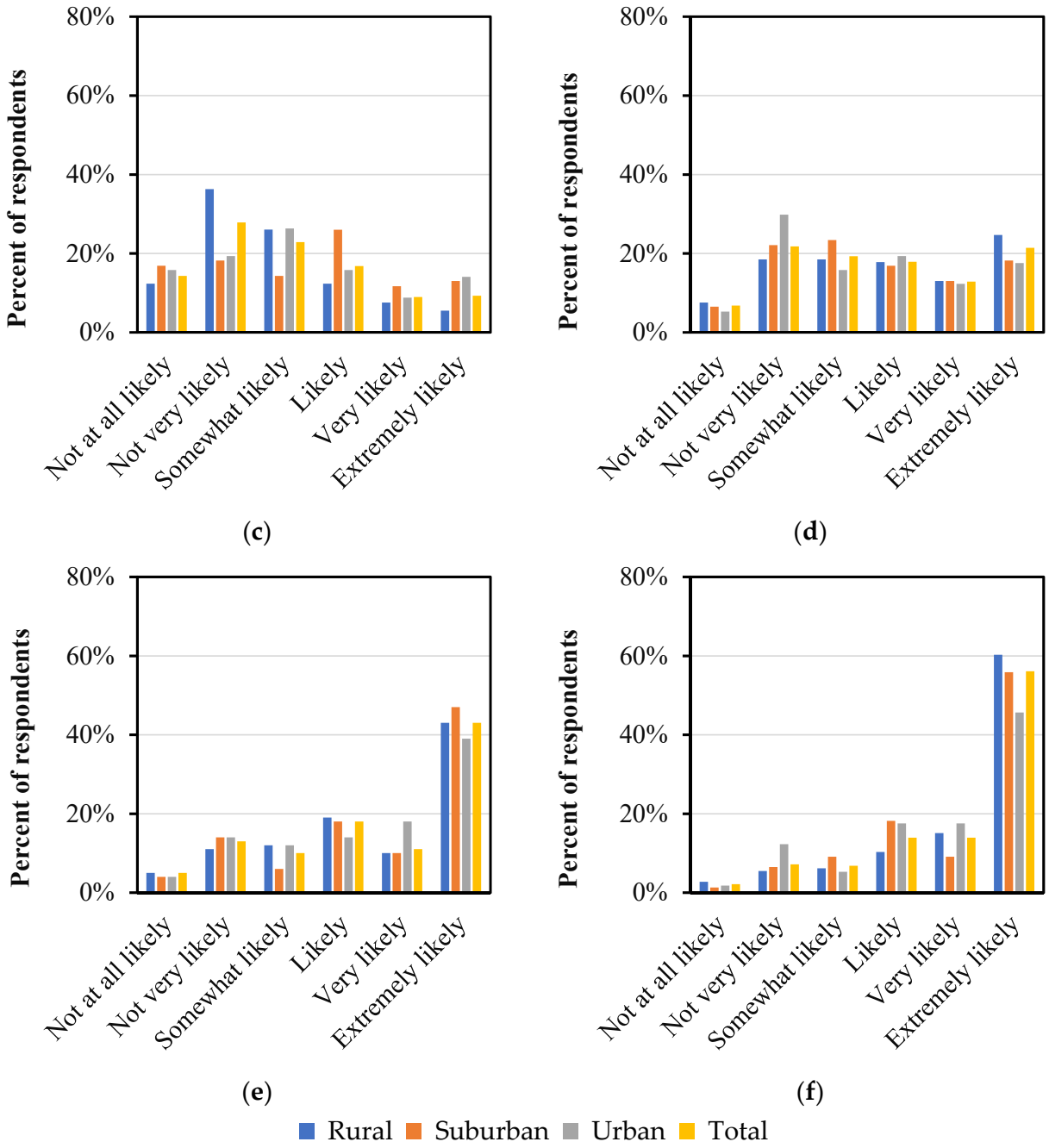


Figure 7. Perception of the loss from flash floods. (**a**) Economic losses; (**b**) road disruption; (**c**) injury; (**d**) irreversible damage to the ecological environment; (**e**) water supply; (**f**) power outages.

Results showed that residents in the three types of communities all agreed that the most likely loss caused from flash floods is power outages (Figure 7f), followed by road disruptions (Figure 7b) and economic losses (Figure 7a). However, when it comes to the likelihood of injury, respondents in the rural community chose "Not very likely" as the most common choice (36.3%) and respondents in the suburban community chose "Likely" as the most common choice (20.0%), while in the urban community, the most common choice was "Very likely" (8.8%). Results indicated that the perception of the loss from flash floods was mostly concentrated in daily necessity in the investigated samples, while the fear of injury in flash floods might be underestimated.

Overall, community residents' perceptions and understandings of flash flood risk were examined in the survey. Four analyses were carried out in the investigation, including the

experience and preparation, understanding of the location of the floodplain, understanding the likelihood of flood risk, and perception of loss. The findings suggest the potentially important aspects of community residents' attitudes towards and beliefs regarding flash flood risks, which interact with interpretations of flash flood warnings and their decisions in flash flood hazards. The media plays an important role in influencing public perception of disasters, and the findings also suggested that the government exploit social media to raise people's awareness of disaster risk reduction strategies. We recommend that communications be strengthened among the community and the concept of flood plain be promoted by multiple media.

3.2. Communication of Flash Flood Warnings

3.2.1. Coverage of Flash Flood Warning in Investigated Communities

The early warning system is an essential factor in reducing the loss from flash floods [50,51]. Flash flood warnings in the community usually include SMS, radio, television, siren, and internet, as well as door-to-door warnings. Choosing an early warning channel is also important [52] because each type of warning differs in the accuracy of the communication and the specificity, and the public are informed of how much time they have through the flash flood warnings.

According to Table 4 and Figure 8, most of the residents perceived that they received flash flood warnings. The percentage was 61.0% in the rural community, 75.3% in the suburban community, and 75.4% in the urban community. However, respondents from different types of communities received significantly different types of flash flood warnings. For example, residents in the rural community received multiple warnings, and this was almost evenly distributed across each type. Residents in the suburban community and urban community received warnings mainly by SMS, radio, and television. Relating to the sociodemographic characteristics shown in Table 2, there were more elderly residents in flood-prone areas who were less likely to receive warnings by mobile phone or internet; this would be one of the reasons for the difference in types of flash flood warnings in different communities. Moreover, frequent occurrence of flash floods in the rural community is also the reason why the respondents from the rural community pay more attention to the flash floods and the multiple types of flash flood warnings received.

3.2.2. Trust in Flash Flood Warning and Awareness of Its Accuracy

Trusting in hazard warnings and the warning sources can be an important component of people's interpretations and use of information about risks. People tend to ignore early warnings if they do not trust in the warning (e.g., [49,52]). In this investigation, residents were asked whether they trust in flash flood warnings, and the results did not show a significant difference in the three types of communities. As shown in Table 5, most respondents indicated a full trust in the flash flood warnings—the percentage was 50.4% in the full sample—followed by the opinion of comparatively trusting in flash flood warnings, with a percentage of 34.6%.

Table 4. Experience of flash flood warnings before flash flood events.

Type	Experience of Flash Flood Warnings		
	Yes	**No**	**Don't Know**
Rural	89 61.0%	35 24.0%	22 15.1%
Suburban	58 75.3%	10 13.0%	9 11.7%
Urban	43 75.4%	8 14.0%	6 10.5%
Total	190 67.9%	53 18.9%	37 13.2%

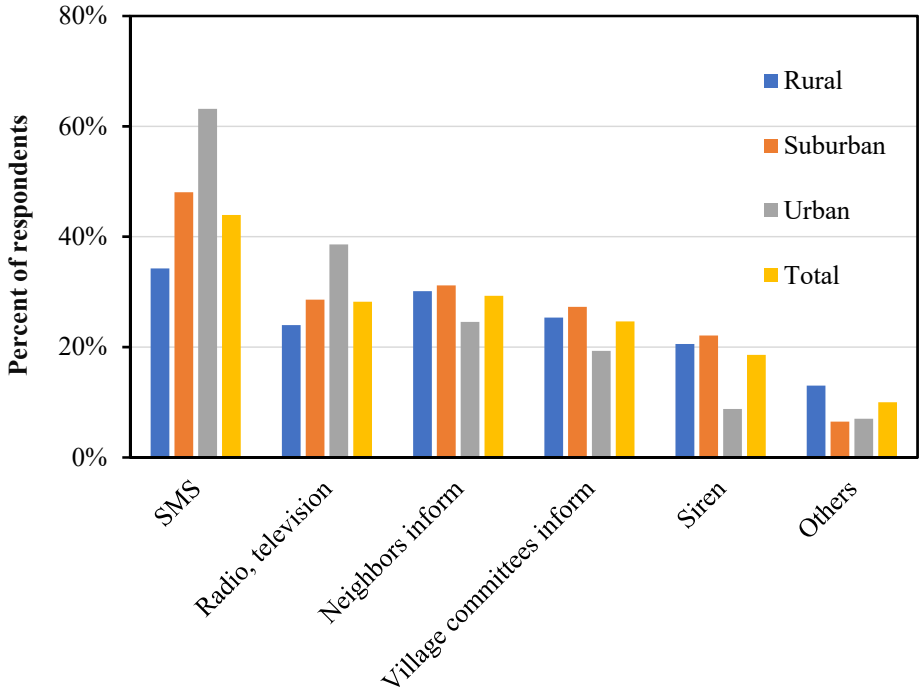


Figure 8. Types of flash flood warnings.

Table 5. Trust in flash flood warnings.

Community Type	Distrust	Mistrust	Comparative Trust	Fully Trust	Don't Know
Rural	1 (0.7%)	12 (8.2%)	44 (30.1%)	77 (52.7%)	12 (8.2%)
Suburban	2 (2.6%)	5 (6.5%)	28 (36.4%)	38 (49.4%)	4 (5.2%)
Urban	1 (1.8%)	2 (3.5%)	25 (43.9%)	26 (45.6%)	3 (5.3%)
Total	4 (1.4%)	19 (6.8%)	97 (34.6%)	141 (50.4%)	19 (6.8%)

Awareness of flash flood warning was related to residents' trust in the information. Higher levels of awareness of inaccuracy corresponded with less trust; moreover, less trust would probably decrease the likelihood of protective action in response to the warning [53].

In this investigation, residents were asked about the accuracy of flash flood warnings, and differences were observed between the trust and the awareness of accuracy. Results are shown in Table 6. In the rural community, 71.2% of respondents acknowledged the accuracy of the warning, while only 56.1% trusted or fully trusted flash flood warnings. Therefore, for residents in the rural community, the accuracy of flash flood warning is higher than that of trust. This indicates that residents in the rural community sometimes do not trust flash flood warnings. The reason might be that various warnings are received in the rural community but residents only trust one kind of warning (such as village committee information); they prefer to trust the accuracy of that warning because they are always alerted to flash flood risks.

Table 6. Awareness of the accuracy of flash flood warning.

Community Type	Inaccurate	Less Accurate	Comparative Accurate	Fully Accurate	Don't Know
Rural	2 (1.4%)	23 (15.8%)	72 (49.3%)	32 (21.9%)	17 (11.6%)
Suburban	2 (2.6%)	15 (19.5%)	30 (39.0%)	26 (33.8%)	4 (5.2%)
Urban	1 (1.8%)	5 (8.8%)	36 (63.2%)	12 (21.1%)	3 (5.3%)
Total	5 (1.8%)	43 (15.4%)	138 (49.3%)	70 (25.0%)	24 (8.6%)

Contrarily, residents in the suburban and urban communities trust the flash flood warning more than its accuracy. In the urban community, 84.3% of respondents acknowledge the accuracy of the warning, while 89.5% trust or fully trust flash flood warnings. The percentages in the suburban community are as follows: 72.8% of respondents acknowledge the accuracy of the warning, and 85.8% trust or fully trust flash flood warnings. This indicates that residents in the rural community prefer to trust flash flood warnings, while residents in the suburban and urban communities tend to notice the accuracy of flash flood warning. The reason might be that residents in the suburban and urban communities believe in the flooding protection design in their area and sometimes ignore the flash flood warnings.

Moreover, Figure 9 relates to the awareness of accuracy of flash flood warning shown in Table 6, which indicates that most respondents trust the accuracy of flash flood warnings and believe that flash floods will occur within 24 h of when the flash flood warning is received.

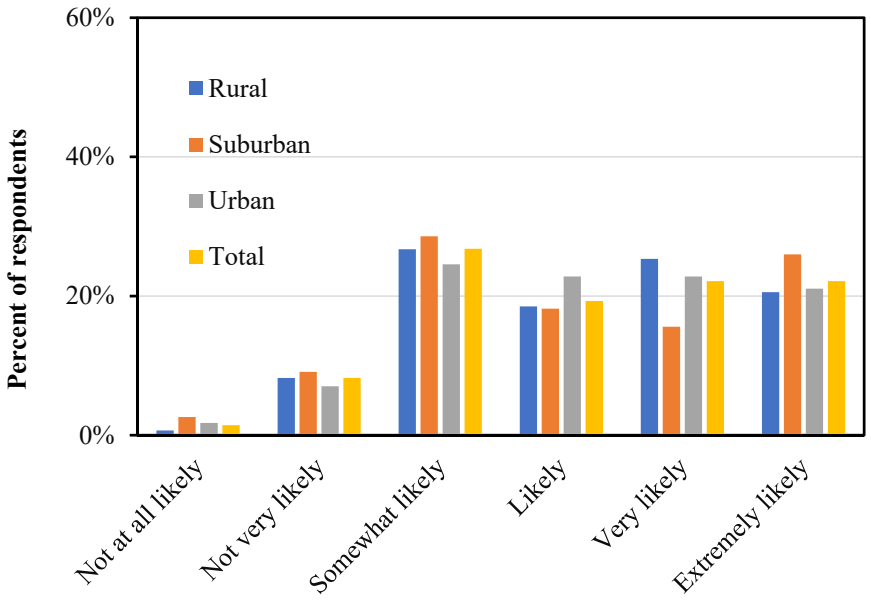
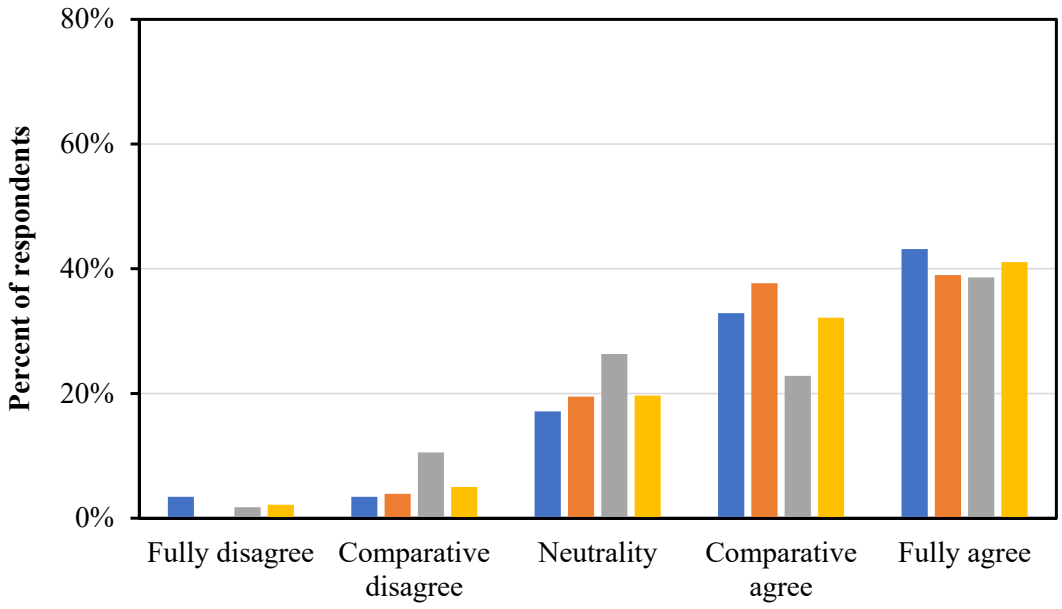


Figure 9. Possibility of flash floods occurring within 24 h after flash flood warning is received.

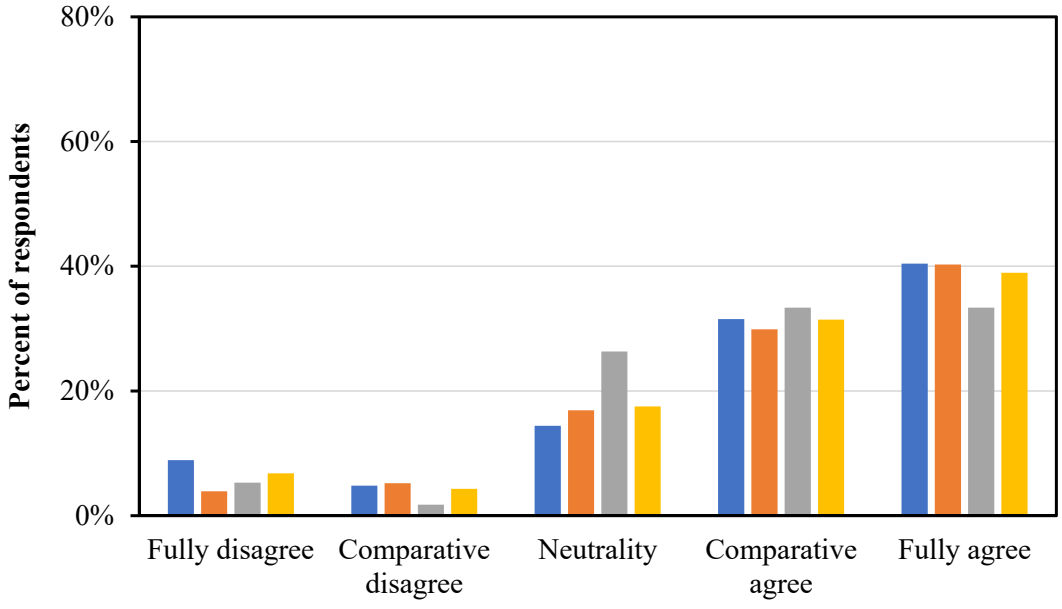
3.2.3. Communications with Neighbors

The communication dimension in risk was defined as the purposeful exchange of information about environmental risk and individual knowledge about hazards within parties, groups, or organizations [34,54]. Effective communication may have a major influence on how well neighbors in a community are prepared for a flash flood event. In this survey, the trust, cooperation, and information sharing among residents were investigated, and results are shown in Figure 10. Most of the respondents fully agree on the

communications within the community, accounting for the highest proportion. As can been seen in Figure 10, the urban community has a lower rate than the rural community and suburban community, which indicates that residents in the rural community and suburban community report closer communication with neighbors. Furthermore, participation in a community association may greatly enhance communications with neighbors. As shown in Table 7, a few residents (15.4%) indicated that they participate in the community associations, and 6.4% of the residents said that they did not know about the community associations. Though they report they keep in close communication with neighbors, the major path to exchanging information was daily communications. No significant difference was found between the three different types of residence.



(**a**)



(**b**)

Figure 10. *Cont.*

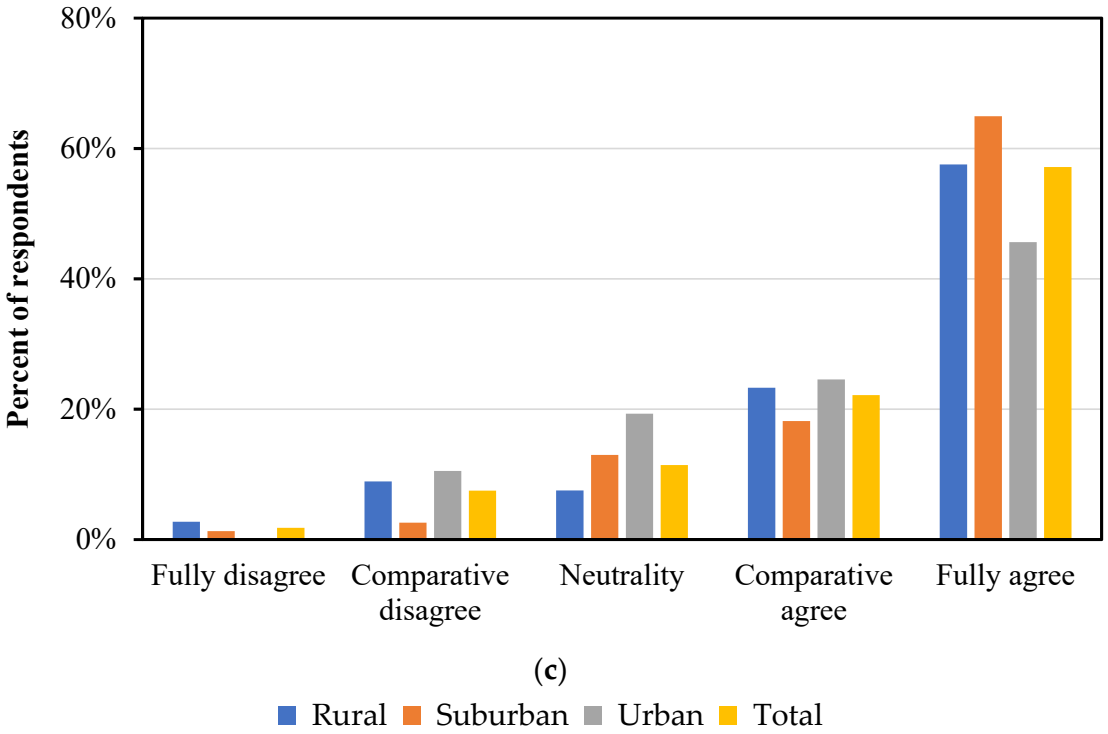


Figure 10. Communication with neighbors. (**a**) Trust in neighbors; (**b**) Cooperation with neighbors; (**c**) Sharing information with neighbors.

Table 7. Participation in community associations.

Community Type	Yes	No	Don't Know
Rural	20 (13.7%)	116 (79.5%)	10 (6.8%)
Suburban	13 (16.9%)	58 (75.3%)	6 (7.8%)
Urban	10 (17.5%)	45 (78.9%)	2 (3.5%)
Total	43 (15.4%)	219 (78.2%)	18 (6.4%)

3.3. Discussion of Mitigation Actions towards Flash Floods

3.3.1. Likelihood of Taking Actions When Given a Flash Flood Warning

Respondents were asked how likely they would be to take protective action if they received a flash flood warning, and the results of this question are shown in Figure 11. Nearly 75.0% of respondents said that they were somewhat likely or extremely likely to take protective action if they received a warning, with the proportion reporting extremely likely being especially high: 68.5% in the rural community, 64.9% in the urban community, and 57.1% in the suburban community, indicating that when people feel they are in danger or insecure they will take protective actions against disaster [30].

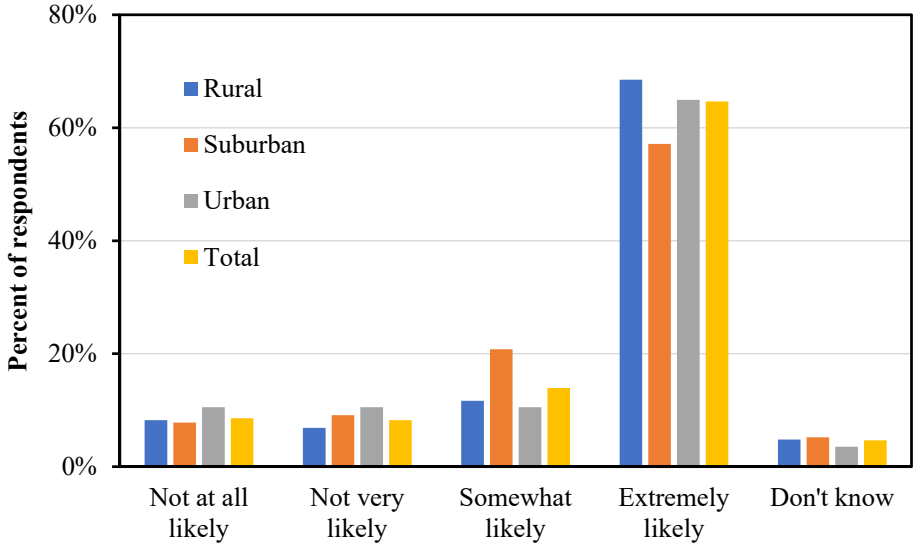


Figure 11. Likelihood of taking actions when given a flash flood warning.

In order to explore how the likelihood of flash flood warning response relates to the respondents' sociodemographic characteristics, receptions of flash flood risks, and communication of flash flood warnings, regression analysis was employed between a subset of the independent variables in this survey. Multiple linear regression (MLR) is a statistical method that models the relationship between two or more interpretive variables (independent variables) and a response variable (related variables) by linear equations. The equation for MLR is:

$$y_i = a_0 + a_1 x_{i,1} + a_2 x_{i,2} + \ldots + a_k x_{i,k} + e_i \quad (2)$$

in which y_i is the dependent variable, a_0 is a constant, $x_{i,k}$ is an independent variable, a_k is the vector of regression coefficients, and e_i is random measured errors. The regression results are shown in Table 8, with the significant variables indicated in bold text.

Table 8. Results of multiple linear regression.

Independent Variables		Rural		Non-Rural	
		Parameter Estimate	**Significance**	**Parameter Estimate**	**Significance**
Sociodemographic characteristics	Age	−0.09	0.27	−0.12	0.13
	Gender	−0.12	0.49	0.20	0.32
	Ethnic	0.04	0.86	**0.53**	**0.01**
	Residence ownership	**−0.85**	**0.03**	**−0.72**	**0.03**
	Length of residence in local place	−0.04	0.72	−0.05	0.58
	Education	**0.17**	**0.09**	−0.01	0.92
	Income per month	0.00	0.98	0.05	0.27
Perceptions of flash flood risks	Experience of flash floods	0.12	0.62	0.19	0.43
	Only communities near creeks at risk	0.08	0.28	0.06	0.44
	Located in the floodplain	0.08	0.57	−0.02	0.92
	Likelihood of flash floods occurring in 3 years	0.06	0.44	0.06	0.42
	Perception of economic loss from flash floods	0.07	0.40	0.12	0.16
	Perception of injury from flash floods	0.10	0.18	0.03	0.61
	Perception of water supply outages in flash floods	−0.04	0.44	0.02	0.82
	Perception of power outages in flash floods	−0.08	0.30	**−0.18**	**0.06**

Table 8. *Cont.*

Independent Variables		Rural		Non-Rural	
		Parameter Estimate	Significance	Parameter Estimate	Significance
Communications on flash flood warnings	Experience of flash flood warnings	0.18	0.16	−0.01	0.95
	Trust in flash flood warnings	**0.24**	**0.07**	**0.45**	**0.00**
	Awareness of the accuracy of flash flood warning	0.07	0.48	−0.13	0.33
	Possibility of flash floods occurring within 24 h	**0.25**	**0.00**	0.09	0.22
	Whether trust in neighbors	−0.08	0.52	−0.11	0.42
	Whether cooperation with neighbors	−0.09	0.35	0.07	0.56
	Whether share information with neighbors	0.06	0.54	0.01	0.95
	Participate in the community association	0.02	0.93	−0.12	0.58

In the rural communities, residence ownership and education are identified as a significant predictor in the sociodemographic characteristics, which indicates that the residence owners and the residents with high education have a significantly higher likelihood to take action for a flash flood warning. Moreover, two variables of communication of flash flood warnings are identified as significant: trust in flash flood warnings and possibility of flash floods occurring within 24 h. Results indicate that people who trust in flash flood warnings are more likely to take actions for flash flood warnings, and protective action intentions were higher for respondents who perceived a high possibility of flash floods occurring within 24 h [49]. Although some respondents in the rural community have an incorrect or incomplete understanding of flash flood risks, there were no significant variables related to the protective action intention.

In the non-rural communities, several variables were identified as significant predictors: ethnic and residence ownership in the sociodemographic characteristics, perception of power outages in flash floods in the perceptions of flash flood risks, and trust in flash flood warnings in the communication of flash flood warnings. The results shed light on the perceptions of flash flood risks, as protective action intentions were higher for residents in the non-rural communities who perceive the possibility of power outages in flash floods.

3.3.2. Protective Actions in Response to the Flash Flood Warning

Respondents were also asked what they would do if a flash flood warning was issued; the results are shown in Table 9. Nearly 80.0% of respondents indicated that they would engage in more than one protective activity, such as placing sandbags outside the door; storing food and supplies; preparing torches, whistles, and colorful flags to signal for help; or planning a safe route with their family. The remaining respondents said they would stay at home and do nothing, usually because they did not believe their home was at risk, or they would try to avoid risky areas on the second floor. The percentages of respondents who indicated that they would do nothing was 22.8% in the urban community, 19.9% in the rural community, and 13.0% in the suburban community. Thus, the protective actions in response to the flash flood warning were mostly influenced by residents' judgments and their house conditions.

3.3.3. Decision-Making When a Flash Flood Threatens

The deaths caused by flash floods usually occur when people became trapped in or enter floodwaters, such as by driving in a vehicle or entering flooded areas on foot. The reason might be a misunderstanding of the flash flood risks. In order to explore whether residents know what actions to take, respondents were asked about the decisions they would made in the flash floods in different scenarios, such as while outdoors, while in a vehicle, while walking, and while driving.

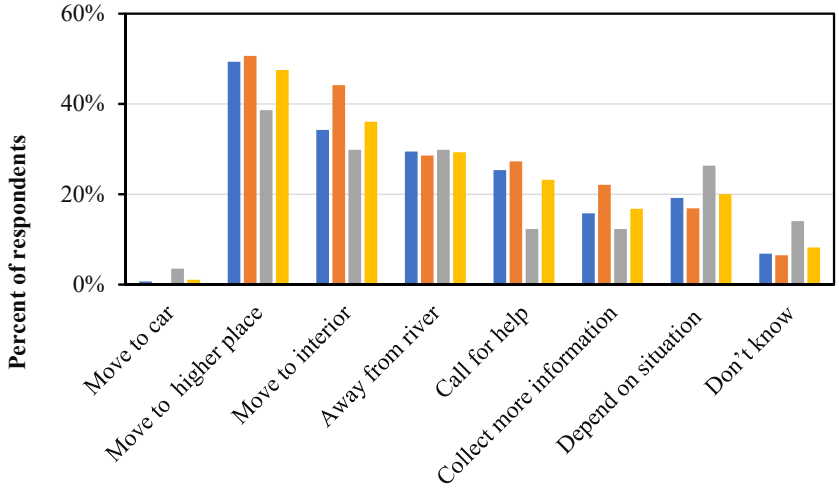
Table 9. Protective actions in response to the flash flood warning.

Community Type	Placing Sandbags Outside the Door	Storing Food and Supplies	Preparing Torches, Whistles, and Colorful Flags to Signal for Help	Planning a Safe Route with Family Members	Transferring of Risk Aversion	Nothing to Do
Rural	17 (11.6%)	55 (37.7%)	52 (35.6%)	26 (17.8%)	69 (47.3%)	29 (19.9%)
Suburban	11 (14.3%)	40 (51.9%)	24 (31.2%)	22 (28.6%)	36 (46.8%)	10 (13.0%)
Urban	8 (14.0%)	24 (42.1%)	13 (22.8%)	11 (19.3%)	29 (50.9%)	13 (22.8%)
Total	36 (12.9%)	119 (42.5%)	89 (31.8%)	59 (21.1%)	134 (47.9%)	52 (18.6%)

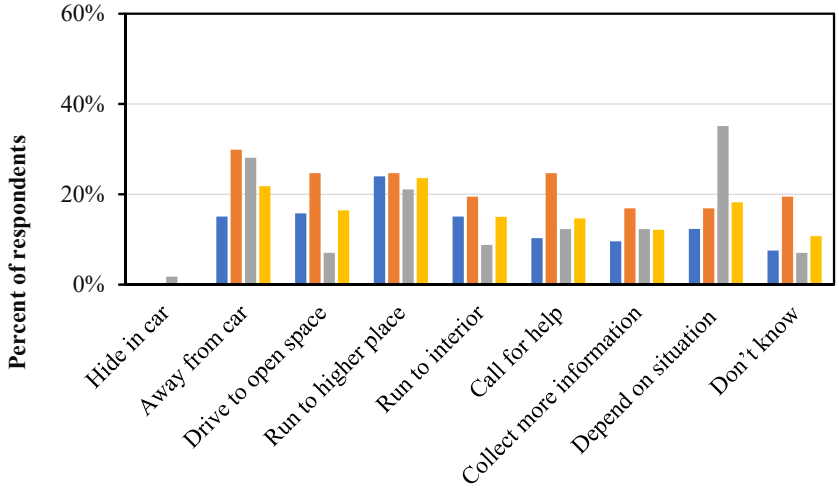
As shown in Figure 12a, respondents suggested several specific actions while outdoors when a flash flood threatens, for example, moving to higher place (shelter), moving to an interior, moving away from the river, calling for help, and collecting more information. Some respondents noted the difficulty in evaluating the flash flood risks, and it may depend on the specific circumstances; thus, these respondents indicated "depends on the situation". The percentages of these respondents were 19.2% in the rural community, 16.9% in the suburban community, and 26.3% in the urban community. Only one responder in the rural community and two respondents in the urban community said they would move their car while outdoors when a flash flood threatened. As shown in Figure 12b, several specific actions while in vehicle when a flash flood threatens were also indicated by respondents, for example, moving away from the car, running to a higher place, running to an interior, calling for help, collecting more information, depends on the situation, and driving to open space. Only one responder said he would hide in the car and wait for rescue. It is important to highlight that "not trying to drive or hide in the car" is the advocated safe rule in flash flood hazards. Results show that most of the respondents would take the correct actions when a flash flood threatens, though some respondents said they would drive to an open space, which might be because they would estimate the risk in advance and make the decision related to their situation.

In the walking scenario, as shown in Figure 12c, most of the respondents would try to go through the flooding area with calves submerged (24.35%), knees submerged (21.4%), and thighs submerged (16.1%); 14 respondents even said they would go through the flooding area with the head submerged (5%). In addition, 5.4% of the respondents showed conservative judgement and stated that it would not be safe no matter how deeply submerged. These percentages were 6.8% in the rural community, 5.2% in the suburban community, and 1.8% in the urban community.

In the driving scenario, as shown in Figure 12d, most of the respondents indicated that it was not safe to drive through the flooding area (20.0%), when with the hub is submerged (15.7%), and when half of the wheel is submerged (27.5%). Moreover, 19.3% of the respondents said it was difficult to make a decision, as they did not own a car or rarely went out by car. The results of decision-making in the driving scenario displayed a similar distribution in the three types of communities.



(**a**)



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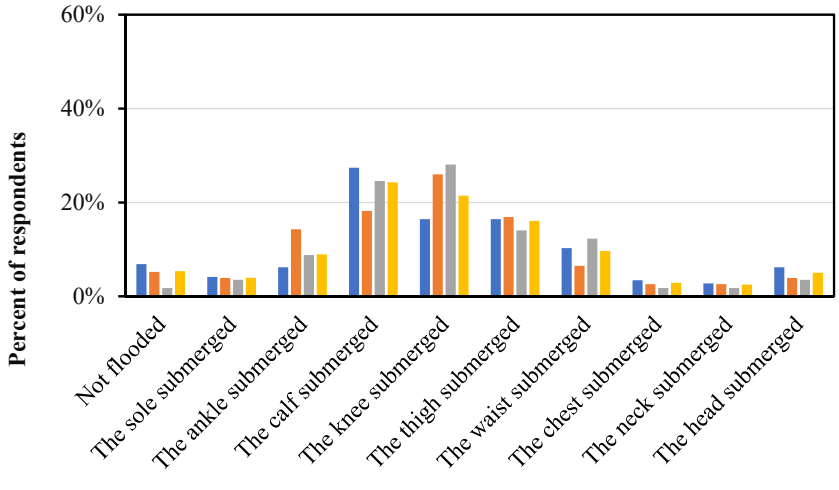

(**c**)

Figure 12. *Cont*.

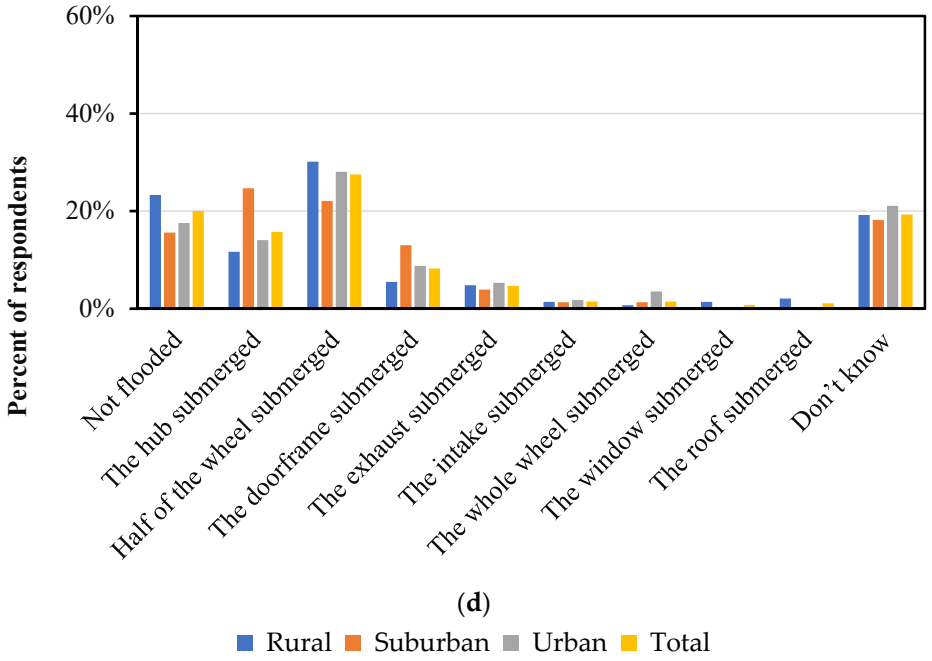

Figure 12. Decision-making when a flash flood threatens. (**a**) Outdoors; (**b**) in car; (**c**) walking safety; (**d**) driving safety.

4. Conclusions

Community resilience plays a major role in risk disaster reduction, as different types of communities might experience different levels of loss in the hazardous event. This research investigated perception of risks, communication of warnings, mitigation actions concerning flash floods, and the differences among different community types. The findings are based on a survey of 280 samples from the residents in the north of Qingyuan district, and the main conclusions of the investigation are as follows:

1. For the exposed and vulnerable communities, the perception of flash flood risk is an essential link in the response of flash flood warnings. The conscious and unconscious attitudes towards the risk from the residents were defined by quantitative and qualitative analysis, which revealed the psychological vulnerability of the inhabitants and could characterize the community resilience to flash flood in the study area. Some residents misperceive or underestimate the risk of flash floods in the survey. The proportion is higher in the suburban community, and at the same time, their general level of anxiety for flash flood loss is significantly smaller than that of the participants from the rural communities and urban communities. These subjective attitudes would greatly influence the response to flash flood warnings and the mitigation actions for flash floods.
2. This research also shed lights on the communications dimension of community resilience. The differences of coverage of flash flood warnings, trust in flash flood warnings, and awareness of their accuracy were investigated in three types of communities. The findings suggest that residents in the rural community usually ignore early warnings because there are more elderly residents in the rural community, and they do not fully trust in the warnings but believe in their own judgement from previous experiences, while residents in the suburban and urban communities trust the flash flood warning more than its accuracy. Thus, multiple types of flash flood warnings are frequently used in the rural community, such as door-to-door informed warnings. Moreover, residents in the rural community and suburban community report a closer social communication with neighbors (e.g., cooperating within neighborhoods, sharing lifestyles), which would greatly influence inhabitants' attitudes and behaviors in flash flood warnings and mitigation actions.

3. This study focused on residents' effective responses to mitigation actions towards flash floods, and some significant variables were explored in the rural communities and non-rural communities. The findings suggest that residence ownership, education, trust in flash flood warnings, and possibility of flash flood warnings within 24 h influence the decisions of inhabitants in the rural community. The results also indicate that in the non-rural (urban and suburban) communities, the significant variables were ethnicity, residence ownership, perception of power outages in flash floods, and trust in flash floods occurring within 24 h. The differences of significant variables in different types of communities can be used to improve the specific and accurate alerts for different communities, which could help people evaluate their risk and decide what to do effectively. Furthermore, some protective actions and specific scenarios have been investigated in this study, and the findings indicate that incorrect decisions were often mentioned by the respondents, and risk communication would help people to assess their situation accurately in the face of hazards. In order to narrow the gaps, this study also suggests that it is critical to release flash flood warnings in specific scenarios to help people take mitigation actions quickly.

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