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The determinants affecting the intention of urban residents to prevent flooding in China

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Abstract. In the context of global warming and China's disaster response patterns, it is critical to understand how to promote the effectiveness of household flood protection measures among the public. In this study, we developed a comprehensive theoretical framework based on protection motivation theory (PMT) to identify the main determinants that influence urban residents' intention to prepare for flooding. In addition to the fundamental factors in PMT, this framework also considered the influence of individual heterogeneity and social context. We selected urban residents in flood-prone areas of Henan Province as the study population and collected 857 valid questionnaires through an online survey. Firstly, the results showed that both threat perception and coping appraisal of flood risk are effective in increasing residents' intention to prevent. Secondly, negative risk response attitudes reduced people's intention to prepare. If people do not perceive preparedness actions as absolutely necessary, they will postpone or shift to public flood protection measures. In addition, analysis of affective pathways revealed that negative emotions were primarily influenced by perceptions of flood consequences and were not significantly related to perceptions of likelihood. The analysis of trust mechanisms showed that higher levels of trust reduced people's perceptions of flood risk thereby hindering their intention to prepare for floods. Finally, we found that the positive influence of social norms on preparedness intentions makes it appropriate to focus on the power of social mobilization. The findings will provide theoretical references for government departments to design further policy measures to improve integrated flood risk management in China.

1. Introduction

China has a long history of flooding (Jiang et al., 2005). However, in China's long-term fight against floods, the phenomenon of post-disaster emergency relief over pre-disaster emergency preparedness has emerged. For example, in the case of the flooding disaster event1 that occurred in China's Henan Province in July 2021 due to extraordinarily rainstorm, it was found during the rescue process that life jackets, medical first aid kits, and emergency lights were the much-needed supplies for the affected people, which fully exposed the lack of emergency preparedness of the residents. In addition, according to Swiss Re, the current catastrophe insurance coverage in China is only 10%, which results in most of the flood losses being borne by the

[1] In July 2021, the extraordinary rainstorm in Zhengzhou caused 302 fatalities and economic damage of approximately $17.7 billion.

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residents and the government, and the phenomenon of poverty due to disasters has become an urgent problem in China now. But at the same time, it creates an opportunity for China to implement an integrated flood risk management strategy (Holub et al., 2012; Van Herk et al., 2015).

Several studies provide evidence that advance implementation of flood protection measures by individuals or households can be effective in reducing flood losses (Grothmann and Reusswig, 2006; Kreibich and Thieken, 2008; Bubeck et al., 2012; Poussin et al., 2014; Poussin et al., 2015; Botzen et al., 2019). Although studies have shown that implementing flood protection measures is cost effective in many cases (Kreibich et al., 2011), even people living in floodplains are not adequately prepared for potential flood events. For example, a survey conducted by Meyer et al. (2014) of coastal residents in several U.S. states showed that only 25% of residents surveyed had taken protective measures prior to the arrival of Hurricane Sandy. To this end, researchers have conducted numerous behavioral studies in an attempt to understand and influence individual decisions related to flood management (Owusu et al., 2015; Liu et al., 2018). However, to date, there has been little research on the impact of key factors on residents' flood risk decisions in China. Understanding the key factors influencing the residents' motivation for flood protection in China is essential given the increasing risks associated with flooding and the changing policy environment that is devolving more responsibility to communities and the public. Besides, unlike the bottom-up model of risk governance in the West and other Asian countries (Shi et al., 2013), China currently adopts a top-down model of national disaster response (Ge et al., 2021).

Given this context, the question arises what are the determinants that influence the motivated intentions of residents' flood mitigation in China and how does China's flood risk response model affect residents' intentions to prevent floods? To address this question, this study examined the preparedness intentions of residents in flood-prone areas of Henan Province and explored the mechanisms driving residents' preparedness intentions in a structured framework. Understanding these key factors will help governments design further policy measures to improve communication and flood risk management.

The remainder of this article is structured as follows. Section 2 discusses the theoretical background of flood protection actions as well as the integration model and key hypotheses. Section 3 illustrates research methodology, including measured variables, research sample and data collection procedure issues. Section 4 presents the results in terms of descriptive statistics and structural equation model. Section 5 discusses the research results. In the final Section, we conclude this research and introduce the limitations.

2. Theoretical background and conceptual framework

2.1 Theoretical background

In fact, many factors influence the intentions of individual to implement flood protection actions, including perceptions of flood risk, experience, attitudes, and socio-demographics (Weyrich et al., 2020). Therefore, it is difficult to identify the drivers that influence individuals to implement flood protection measures. Even so, models of human behaviour provide a simplified representation of the main driving forces and resulting actions involved in certain contexts. These models have

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shown effectiveness in understanding, predicting, and influencing factors in human behaviour (Martin et al., 2017). To date, researchers have developed several theories to study the factors that influence the public's implementation of flood mitigation measures. However, the use of a single theory is often incomplete, and many of the factors that are excluded may also play a role in behaviour. Therefore, the development of a comprehensive and integrated psychosocial model is particularly important for studying the public's flood mitigation behaviour.

The theoretical basis for explaining flood mitigation intentions in this study is protection motivation theory (PMT). PMT was first introduced by Rogers in 1975 (Rogers, 1975). It was originally used to explain when individuals would take precautions to reduce their health-related risks (Milne et al., 2000). In recent years, PMT has been widely used to explain the risk reduction behaviour of residents or farmers against natural hazards (Poussin et al., 2015; Van Duinen et al., 2015). According to PMT, an individual's decision to take protective action or not is driven by two main cognitive processes, namely, threat appraisal and coping appraisal (Rogers and Prentice-Dunn, 1997). Threat appraisal includes both variables of perceived likelihood and perceived consequence. And some researchers have defined threat assessment as risk perception (Grothmann and Reusswig, 2006; Bubeck et al., 2018). Coping appraisal consists of three variables: perceived response efficacy, perceived self-efficacy, and perceived response cost. Perceived response efficacy is the individual's perceived usefulness of the measure in reducing losses. Perceived self-efficacy refers to an individual's self-assessment of his or her ability to implement protective action measures. The perceived response cost is the individual's expectation of the cost in terms of financial, time, and effort of the protective measures to be implemented (Poussin et al., 2014). In the context of flood risk, the threat appraisal reflects an individual's perception of flood risk, while the coping appraisal reflects the extent to which an individual expects flood protection measures to be effective, easy to implement, and not too costly.

However, most researchers do not consider the heterogeneity of individual risk response behaviour (Von Gaudecker et al., 2011) and the influence of social context when using PMT theory. In order to complete this theoretical model as much as possible, this study added both individual heterogeneity and social context components to the PMT framework. Considering the difficulty of the actual survey, we characterized the individual heterogeneity characteristics as individual risk coping attitude. Meanwhile, the measure of social context was characterized as two variables, social norms and trust in public flood protection. A structured research framework linking the above-mentioned factors was used to identify the factors that trigger an individual's intention to implement protection. Meanwhile, the interactions between the factors were also analysed.

2.2 Integration model

Based on PMT, this study used an integrated approach to examine determinants affecting the intention of residents' flood protection actions in China. The integration model as shown in Fig. 1 is proposed.

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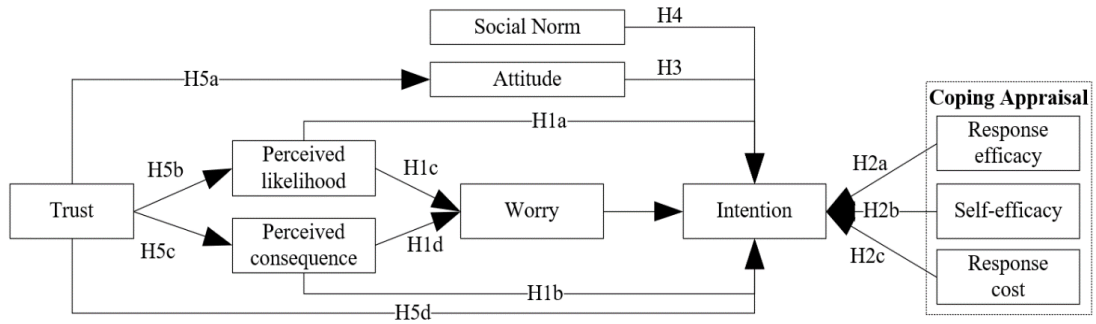

Fig. 1. Framework of the integration model.

In this study, threat appraisal refers to an individual's perceived level of flood risk, including both perceived likelihood and consequence. Studies have shown that individuals with high threat appraisal are more likely to take protective measures (Grothmann and Reusswig, 2006; Poussin et al., 2014; Weyrich et al., 2020). However, some studies have found that people with high levels of risk perception caused by flood experience and trust do not necessarily take flood precautions (Wachinger et al., 2013). There is no direct relationship between risk perceptions and preparedness (Diakakis et al., 2018). In addition, researchers have found that the nature and extent of people's emotional responses during a disaster event can influence their plans and actions for the future (Slovic et al., 2005). In a study of affective and cognitive routes to flood preparedness behaviour, Terpstra (2011) found that affective mechanisms influence citizens' intention to prepare. Ejeta et al. (2018) found that perceived risk of flooding has a direct effect on negative emotions in a study of flood preparedness among residents of Dire Dawa town, Ethiopia. In addition, Papagiannaki et al. (2019) integrated people's worry about the occurrence and consequences of flood into the flood-risk prevention model as a mediator variable, and the results also found that worry had a significant positive effect on the intention to implement flood mitigation behaviours. These results are partially contradictory. This indicates that we should not only pay attention to flood risk perception as the direct driving force of individuals' intention to prepare for disaster, but also understand the influence of other factors that may have an effect on risk perception. Therefore, we propose the following hypotheses:

H1a-H1b: Perceived likelihood and consequence have direct effects on preparedness intention.

H1c-H1d: Worry mediates the effects of perceived likelihood and consequence on preparedness intention.

Once a certain level of threat is reached, people will consider adaptive strategies to deal with the threat. Before this step is taken, people often consider the benefits of possible actions and assess whether they have the capacity to take them. This process is defined in PMT as coping appraisal. Numerous studies have shown that coping appraisal have a more salient impact on people's intentions to implement flood mitigation measures than threat appraisal (Bubeck et al., 2018; Poussin et al., 2015). Meanwhile, perceptions of high response efficacy, high self-efficacy, and low response costs are positively associated with the intention to implement flood mitigation measures (Parker et al., 2009; Kellens et al., 2013). However, focus group interviews conducted by Haney and Mcdonald-Harker (2017) with residents of flood-prone communities in High River, Alberta, found that respondents perceived their coping capacity to be weak and lacked resources, which led to

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inaction in flood risk reduction. Thus, further understanding is needed for the study of individual coping abilities. Based on the above study, hypotheses are proposed:

H2a-H2c: Response efficacy, self-efficacy and response cost have direct effects on preparedness intention.

Attitude is one of the most mentioned factors in the study of human social behaviour and has been shown to be an important factor influencing intention and behaviour (Fishbein and Ajzen, 2011). It can be defined as an individual's positive or negative evaluative response to a person or thing, which is usually rooted in the individual's beliefs and expressed in the individual's feelings or behavioural tendencies (Eagly and Chaiken, 2005). In general, the more positive a person's attitude toward a particular behaviour, the more likely he or she is to engage in that behaviour, and vice versa. Therefore, when faced with flood risk, if people are more positive about implementing flood prevention measures, the more likely they are to do so. positive responses are those that prevent damage, such as purchasing insurance (Shao et al., 2019). Negative responses, on the other hand, include such things as denial of the threat, wishful thinking (Grothmann and Reusswig, 2006; Bubeck et al., 2013), and fatalism (Botzen et al., 2019). Bubeck et al. (2018) argued that negative risk response attitudes (fatalism, postponement and low risk aversion) have a negative impact on the implementation of flood mitigation measures. Similarly, according to expected utility theory, protection against risk (in this case flooding) is less valuable for individuals who are less risk averse (Von Neumann and Morgenstern, 1947). Based on the above studies, this study focuses on the impact of residents' negative risk attitudes. We therefore propose the following hypothesis:

H3: Attitude has direct effects on preparedness intention.

So far, we have discussed the impact of "intra-individual" factors on preparedness, but what about the impact of "inter-individual" factors on residents' intention to prepare for floods? We first considered the power of social influence and characterized it as a social norm. Social norms are the social pressures that people feel to act in a certain way (Abrahamse and Steg, 2013). People who are important to the individual may exert pressure to perform the behaviour explicitly or indirectly (Cialdini et al., 1990). In behaviour theory, a range of norms have been shown to explain behaviour and play a role in behaviour change. Many social psychologists view social norms as potential influences. Studies have shown that individuals are more likely to prepare for disasters if neighbours, friends or family members take mitigation measures (e.g., purchase flood insurance) (Kunreuther et al., 1978; Bubeck et al., 2018). Meanwhile, Botzen et al. (2019) also considered norms as a driving force for people to prepare and adopt flood-risk mitigation measures. We assume that similar relationships exist in our data. And in addition to social relationships, we add the effect of government policy to the observed question items. The hypothesis is:

H4: Social norm has a direct effect on preparedness intention.

Since most flood control efforts in China rely on public flood control measures, it is also important to assess the impact of this factor on individuals' flood control intentions. Although laypeople lack the expertise needed to calculate the actual level of protection provided by flood protection facilities, they can deduce the likelihood of flooding based on the level of trust inspired by their observations. Grothmann and Reusswig (2006) surveyed citizens in the German city of Cologne and found that those citizens who had more confidence in public flood protection showed lower perceptions of flood risk and took less

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precautionary measures. And Terpstra (2011) also found that the perception of flood risk is reduced by a high level of trust in flood protection facilities, which in turn discourages citizens from planning to prepare for potential flood disasters. This conclusion was also supported by subsequent studies (Wachinger et al., 2013; Buchanan et al., 2019). Papagiannaki et al. (2019) used survey data from a representative sample of Greek households to show that trust in government flood control measures had a negative impact on flood fear, leading to lower levels of preparedness. Based on the above study, we assume the same relationship for our data. Also, we focused on the effect of people's trust in public flood protection on their attitude toward flood protection. We propose the following hypotheses:

H5a-H5d: Trust has a direct effect on attitude, perceived likelihood, perceived consequence and preparedness intention.

3. Materials and methods

3.1 Measurements

In order to empirically test the hypotheses, this study used a questionnaire to collect data. To ensure the reliability and validity of the scales in this study, the measurement scales were compiled mainly through research analysis of the existing literature and appropriate revisions in the context of the actual situation in China. Table 1 provides the operational definitions and sources for these constructs. In the survey, respondents were asked to assess their level of agreement with the measured items. All items measured were administered on a five-point Likert scale.

Before the main survey, a pre-test was conducted to ensure the logical consistency and ease of understanding of the designed questionnaire in July 2021. Firstly, some of the questions in the questionnaire were adjusted and amended based on the opinions of relevant experts in this field. Then we selected the subjects through WeChat (a social software like Facebook). Using snowball sampling, these people provided us with further contacts (Weyrich et al., 2020). Finally, we conducted online or telephone semi-structured interviews with 40 contacts who had different education level, age and life backgrounds. A content analysis was implemented based on the responses of the contacts. The analysis included further categorization, merging and deletion of questions. In order to further improve the comprehensibility, the wording was modified according to the way of thinking of the respondents. The modified constructions and its measurement items are shown in Table S1.

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Operational definitions and sources for constructs.

Construct	Operational definition	Source
Intention	The extent to which individuals intend to implement measures in terms of flood prevention.	Papagiannaki et al. (2019); Terpstra (2011).
Perceived likelihood	Perceive the possibility of flood disasters.	Poussin et al. (2014); Bubeck et al. (2013).
Perceived consequence	Perceive the consequences of a flood disaster.	Poussin et al. (2014); Bubeck et al. (2013).
Response efficacy	Perceived effectiveness and usefulness of the measures in reducing losses.	Poussin et al. (2014); Bubeck et al. (2013); Bubeck et al. (2018); Grothmann and Reusswig (2006).
Self-efficacy	Personal perceptions of your ability to implement measures.	Poussin et al. (2014); Bubeck et al. (2013); Bubeck et al. (2018).
Response cost	Individuals expectations of the financial cost of the measures, but also the time and effort required to implement them, etc.	Poussin et al. (2014); Bubeck et al. (2013); Bubeck et al. (2018); Grothmann and Reusswig (2006).
Attitude	Personal views on the implementation of flooding measures.	Botzen et al. (2019); Grothmann and Reusswig (2006); Shao et al. (2019).
Social norm	The social pressure that people feel to act in a certain way.	Bubeck et al. (2013).
Worry	Fear of flooding and its consequences.	Papagiannaki et al. (2019); Ejeta et al. (2018).
Trust	Trust in the governments flood prevention efforts.	Papagiannaki et al. (2019); Lin et al. (2008); Terpstra (2011).

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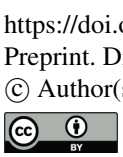

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3.2 Sample

Sample size needs to be calculated before conducting the survey. According to (Chin, 1998), the sample size of the questionnaire is determined by the number of variables studied and the corresponding measurement items, and the sample size should be at least 10 times the total number of measurement items. In this present study, the total number of items measured was 44. Therefore, the sample size should be more than 440. Considering the response rate and invalidation, the sample size for this study was 1000.

Henan Province is a flood-prone area in China. Spanning four major river basins: Huai River, Yangtze River, Yellow River and Hai River, it has a well-developed water system and a dense river network (Liu et al., 2018). In recent decades, flooding has occurred almost every year in the region due to a significant and continuous increase in precipitation and its uneven spatial and temporal distribution. According to incomplete statistics, there were 1152 floods in Henan Province in 1950-2004. The cumulative death toll exceeded 20,000 and the direct economic loss was about US$ 3.5 billion (Liu et al., 2017). Therefore, this paper took Henan Province as the study area and selected residents with stable income for the online survey, which was conducted from mid-August to late September 2021. The distribution of the sample is shown in Fig. 2.

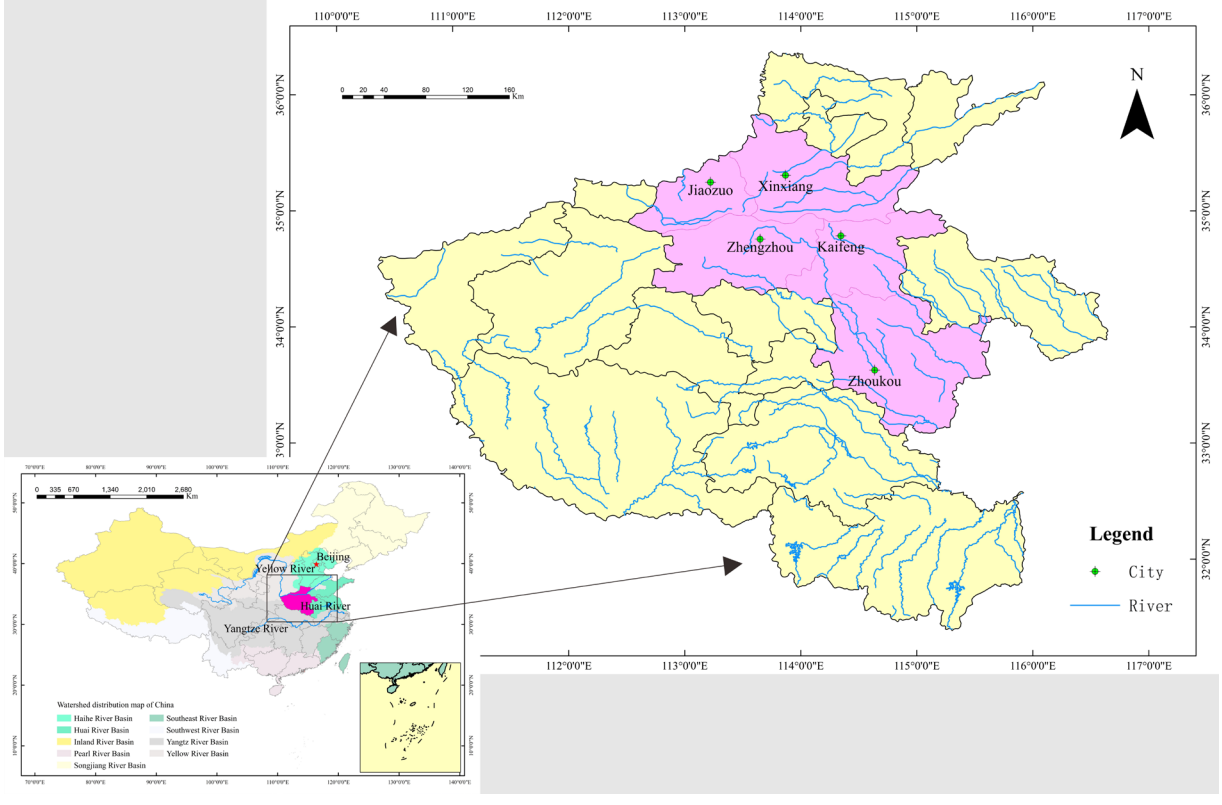

Fig. 2. Location of survey sample.

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3.3 Data collection

The impact of COVID-19 prevention and control policy and frequent rainfall weather made it quite difficult to implement the field research. Therefore, we chose a professional online questionnaire platform called WenJuanXing (http://www.wjx.cn) to conduct online surveys. In addition to overcoming the above two problems, online surveys also have the advantages of saving survey time and costs, reducing data entry errors and reaching a wider group of people (Wang et al., 2019a). In China, researchers commonly use this questionnaire platform to conduct online surveys, which has over 28.7 million registered members (Zhai et al., 2020). Firstly, the designed questionnaire was uploaded to the platform, and then the platform generated an online questionnaire and an URL (Uniform Resource Locator) link of the online questionnaire. Respondents can access the questionnaire through this URL link. With the help of a computer program, this platform randomly selected 1,000 eligible people from its member roster as potential respondents and sent them the URL link to answer the survey.

To better motivate respondents to participate in the survey and increase the response rate of the questionnaire. We assured respondents that their responses were strictly anonymous and confidential, and they would be paid 9.50 RMB as remuneration upon finishing the questionnaire survey. 857 questionnaires were finally obtained after eliminating those with missing main variables and those with response time less than 180 seconds.

3.4 Research method

This study used structural equation modelling (SEM) method to analyse and hypothesis test the survey data. The method is widely used in the social sciences. Researchers used this method to determine the extent to which data on a set of variables are in line with the theory about the interrelationship between variables (Wang et al., 2019b). And it also provides researchers with ample means to evaluate and modify the relationships between constructs and offers great potential for further development of theories to test and modify the relationships between detection structures (Kolar and Zabkar, 2010). SEM is divided into two methods: covariance-based SEM (CB-SEM) and partial least squares SEM (PLS-SEM) (Haenlein and Kaplan, 2004). In this study, PLS-SEM is chosen for analysis because it performs more efficiently and clearly in estimating complex models involving multiple constructs compared to CB-SEM (Hair Jr et al., 2017). In addition, its assumptions on the distribution of variables and error terms are less stringent (Zhang, 2007).

SEM consists of two models: the measurement model and the structural model. The measurement model focuses on the relationship between the measured items and the constructs. The structural model focuses on the relationship between the constructs. In the following data analysis, the reliability and validity of the variables were assessed by measurement models with the help of SmartPLS 3.0 (student version) and SPSS 22 software package, while the hypothesized relationships between the constructs were tested by structural models.

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4. Results

4.1 Descriptive sample information

Table 2 provides the statistics information of 857 respondents. The number of female respondents (53.12%) was slightly higher than the number of male respondents (46.88%). This may be due to the fact that women are more likely to implement disaster mitigation measures (Osberghaus, 2015). And the respondents were concentrated between the ages of 20-40 (87.89%), which can be explained by the fact that children were excluded from the survey. A majority of respondents had a high level of education, with 74.96% holding an associate or bachelor degree, followed by master's or doctoral degree (13.51%). The distribution of respondents' age and education level shows that the respondents are relatively young and their education levels are relatively high. This may be due to the fact that younger and better educated people are more likely to be online (Wang et al., 2019a), more concerned about heavy rainfall issues, and more likely to have a higher intention to answer the questionnaire. About 70.18% of respondents earn a yearly income below RMB 200,000. However, the percentage of income between 200,000-300,000 RMB is still 17.12%, which is related to the level of economic development in the regions studied. More than half of the respondents are homeowners (73.5%), and only 26.5% of the respondents are renters. In addition, the majority of respondents in this survey are from urban areas and live in areas with more than 3 floors, which is related to the level of urbanization in the surveyed cities.

Table 2

Statistics information of respondents (N=857).

Items	Category	Number	Percent
Gender	Male	402	46.88
	Female	455	53.12
Age	<20	1	0.12
	20-30	332	38.79
	31-40	421	49.10
	41-60	95	11.12
	>60	7	0.87
Personal yearly income (ten thousand RMB)	<10	351	40.94
	10-20	251	29.24
	20-30	147	17.12
	30-40	45	5.24
	40-50	37	4.37
	>50	26	3.09
Education level	junior high school or below	29	3.44
	Senior high school	69	8.10
	Associate degree or bachelor degree	642	74.96
	Masters degree or PhD degree	116	13.51

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Housing	Home ownership	630	73.50
	Tenancy	227	26.50
Floor level	First floor or basement	86	10.02
	Second floor	112	13.10
	Third and upper floors	629	73.38
	other	30	3.49

4.2 Common method bias

When all data have the same source, they may have common method bias, which may have an impact on the validity of the study. Since our questionnaires were collected online, the samples were not restricted to a particular group. However, we still used Harman's one-factor test to identify any potential common method bias (Podsakoff and Organ, 1986). The effect of common method bias can be high if a single factor accounts for more than 50% of the variance (Shiau et al., 2020). Principal component factor analysis in SPSS produced 10 principal components, accounting for 61.55% of the total variance, with the first (largest) factor accounting for 15.84% of the variance, not exceeding 50%. Therefore, it can be concluded that there is no serious common method bias in this scale.

Moreover, before the factor analysis, this study first conducted the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of Sphericity on the scale (Table 3). The KMO value was 0.812 (the measurement criterion was >0.5) and the P value of Bartlett's test of Sphericity was 0 (the measurement criterion was P<0.05), which passed the significance test with a significance level of 1%. This shows that this data is suitable for factor analysis.

Table 3

Results of KMO and Bartlett's Test of Sphericity.

Kaiser-Meyer-Olkin test		0.812
Bartletts test of Sphericity	Approximate chi-square	1019.724
	df	210.000
	Sig.	0.000

4.3 Measurement model

The scales used in this study were derived from those used in the relevant literature. These scales were modified according to the needs and usage scenarios of this study. Therefore, the scales used are content-valid.

Measurement model testing entails testing the reliability and validity of the scales. This study assessed the reliability of the measurement model using two indicators, Cronbach's alpha values and composite reliability (CR). The critical value for both indicators is 0.7 (Fornell and Larcker, 1981). For the validity evaluation of the measurement model, the factor loadings of the measurement items and the average variance extracted (AVE) of the latent variables were used to assess the convergent validity, where the critical value of factor loading value is 0.5 and the critical value of AVE is 0.5 (Fornell and Larcker, 1981). The Fornell-Larcker Criterion was used to evaluate the discriminant validity. When the square root of the AVE values

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of the constructs are greater than the correlation coefficient between the construct and any other constructs, the discriminant validity of the construct is acceptable (Fornell and Larcker, 1981). Meanwhile, the Heterotrait-Monotrait (HTMT) ratio of correlation was selected as an auxiliary criterion for the determination of discriminant validity (Henseler et al., 2015). Kline (2016) suggested that the HTMT ratio should be < 0.85. The results of reliability and validity analysis were summarized in Table S2-S4. As can be seen from Table S2, the Cronbach's alpha values and CR of the 10 latent variables were greater than 0.7, indicating good internal consistency reliability. Meanwhile, the loadings of the measured items and the AVE values of the latent variables were greater than 0.5, indicating the convergent validity was supported. As shown in Table S3, the square roots of AVE values were ranged from 0.738 to 1. The square root of AVE value for each latent variable was larger than its correlations with other latent variables, thus proving support for discriminant validity. Besides, as presented in Table S4, HTMT values ranged from 0.026 to 0.679, which indicates that the latent variable has good discriminant validity.

4.4 Structural model

According to the evaluation steps of the structural model, it is necessary to first analyse whether there is a multicollinearity problem between the structural model's constructs. Garson (2016) argued that multicollinearity increases the error and makes the significance test of independent variables unreliable. In PLS-SEM, the variance inflation factor (VIF) was used to evaluate the multicollinearity between latent variables. The results showed that all VIF<1.7 (the critical value is less than 3.3.) (Hair Jr et al., 2021). Therefore, it can be determined that there is no multicollinearity problem between the predictor variables of the structural model.

Structural models are designed to reflect the causal pathway relationships between constructs and are the most important element in multivariate studies. This study used the coefficient of determination (R^2) to characterize the extent to which the independent variables of the current model explain the variation in the dependent variable (Chin, 1998). It is generally considered that an R^2 of 0.67 for constructs is considered to have high explanatory power, reaching 0.33 indicates moderate explanatory power, and reaching 0.19 indicates weak explanatory power. The predictive relevance of the model was assessed using the Stone-Geisser cross-validation method (Geisser, 1974), and was tested by calculating the Q^2 value through the Blindfolding Procedure. $Q^2 > 0$ indicates that the variables in the model have predictive relevance for the constructs, while $Q^2 < 0$ indicates a lack of predictive relevance (Hair Jr et al., 2021). In addition, this study used the GoF (Goodness of fit) index to verify the overall goodness of fit of the model (Tenenhaus and Amato, 2004), which is calculated as $GoF = \sqrt{\overline{communality} * \overline{R^2}}$, where communality represents the commonality of latent variables. The categories of GoF are 0.1,0.25 and 0.36, which indicate that the model has weak, moderate and strong fitness, respectively (Wetzels et al., 2009). Table 4 shows the results of R^2, Q^2 and GoF for PMT and the proposed model. In terms of explained variance, the R^2 was 0.372 for IN (intention) in this study. Thus, it can be seen that IN has good explanatory power in this study. The Q^2 values of all endogenous latent variables in this study were greater than 0, which indicates that the model had good predictive power.

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In addition, the GoF value of the structural model was 0.371, which was greater than 0.36, indicating that the model had a good goodness of fit.

Table 4

Results of GoF, R^2 and Q^2.

Model	GoF	R^2					Q^2				
		IN	W	PC	PL	AT	IN	W	PC	PL	AT
PMT	0.412	0.312					0.175				
Proposed model	0.371	0.372	0.145	0.019	0.018	0.010	0.206	0.096	0.013	0.016	0.009

4.4.1 Direct effect analysis

The path coefficient (β), significance level, and f-square effect size (f^2) were used to determine the hypothesized relationships of the model. Significance tests for structural equation model path relationships were performed using Bias-Corrected and Accelerated (BCa) Bootstrap and two-tailed tests (significance level set at 0.05). The test results of the hypotheses are shown in Fig. 3 and Table S5.

First, the analysis supported the predicted effects of perceived likelihood ($H1a; \beta = 0.072, p < 0.01, f^2 = 0.015$) and perceived consequence ($H1b; \beta = 0.167, p < 0.001, f^2 = 0.132$) on intention. Meanwhile, we also found that perceived consequence was a significant predictor of worry ($\beta = 0.393, p < 0.001, f^2 = 0.193$). However, the analysis rejected the predicted effect of perceived likelihood on worry ($\beta = -0.024$, ns). This suggested that worries only mediated between perceived consequences and preparedness intentions, so H1c ($\beta = -0.003$, ns) was rejected and H1d ($\beta = 0.057, p < 0.001$) was supported. Besides, the results supported the predicted direct positive effect of worry on intention ($\beta = 0.144, p < 0.001, f^2 = 0.154$).

Second, response efficacy ($H2a; \beta = 0.329, p < 0.001, f^2 = 0.175$), self-efficacy ($H2b; \beta = 0.209, p < 0.001, f^2 = 0.163$) and response cost ($H2c; \beta = 0.059, p < 0.01, f^2 = 0.106$) had similarly significant positive effects on intention.

Third, negative attitude ($\beta = -0.091, p < 0.001, f^2 = 0.093$) had a significantly negative effect on intention. Thus, H3 was supported. At the same time, there was a significant positive effect of social norms on intention ($H4; \beta = 0.088, p < 0.001, f^2 = 0.112$).

Finally, the model supported the predict effects of trust on negative attitude ($H6a; \beta = -0.067, p < 0.05, f^2 = 0.081$), perceived likelihood ($H6b; \beta = -0.134, p < 0.001, f^2 = 0.135$) and perceived consequence ($H6c; \beta = -0.139, p < 0.001, f^2 = 0.146$), but rejected the predicted effect of trust on intention ($H6d; \beta = 0.038, ns$). As expected, the effects of trust on negative attitudes, perceived likelihood, and perceived consequences were all negative.

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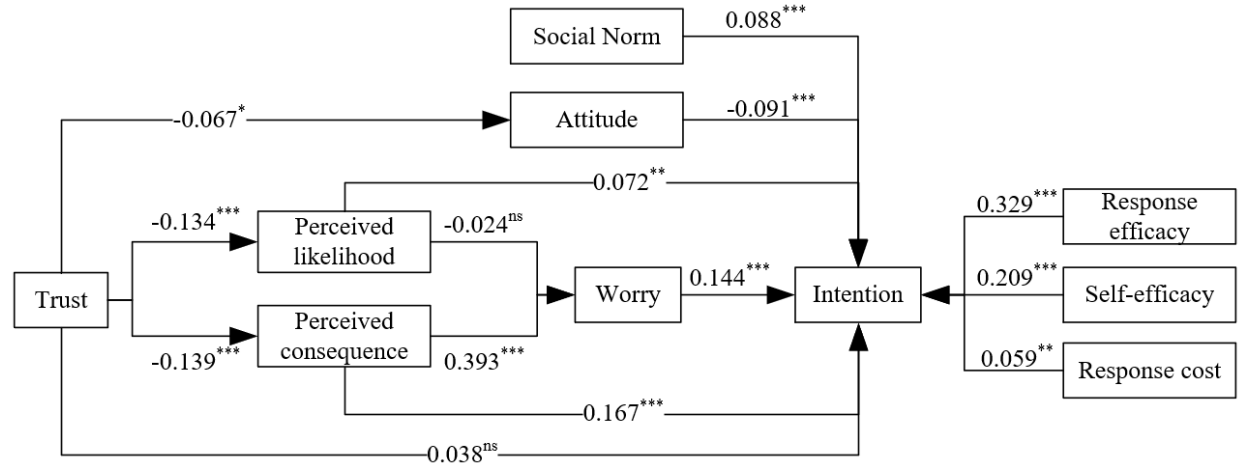

Fig. 3. Significance testing results of the structural model path coefficient. (1) Only the statistically significant direct effects are reported; (2) n=857; (3) Path significance: *** p < 0.001, ** p < 0.01, * p < 0.05, ns p>0.05.

4.4.2 Mediation effects analysis

This study abandoned the traditional Sobel method and instead used the bias-corrected nonparametric percentile Bootstrap method (Wen, 2012) to test for mediating effects. Because studies found that the bias-corrected nonparametric percentile Bootstrap method is more accurate than the Sobel method and has higher test power (Hayes and Scharkow, 2013). According to the mediation test procedure process provided by (Wen and Ye, 2014), Bootstrapping in PLS-SEM was used for the calculation in this study (Table S6).

The results supported the predicted both direct ($\beta = 0.167, p < 0.001$) and indirect effects ($\beta = 0.057, p < 0.001$) of perceived consequence on intention, so that worry mediated between perceived consequence and intention. As expected, indirect effects on preparedness intention due to the mediation of worry were found positive for perceived consequence. In line with the direction of direct effect, worry therefore acts as a complementary mediator. In addition, the PLS-SEM output indicated that the total effect of trust on intention was not significant ($\beta = 0.004, ns$). Meanwhile, there was no support for a direct effect of trust on preparedness intention ($\beta = 0.038, ns$). Rather, the total indirect effect was significant ($\beta = -0.034, p < 0.001$) — that is, the significant effects of negative attitude, perceived likelihood, perceived consequence and worry on intention together with the significant effects of trust on negative attitude, perceived likelihood and perceived consequence fully mediated the effect of trust on preparedness intention. However, the effects of perceived likelihood, perceived consequence, worry, and attitude acted in opposite directions, thus leading to an insignificant total effect of trust on intention.

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5. Discussion

To better understand the motivation of urban residents' intention to prevent flooding, this study developed a comprehensive theoretical framework based on PMT with a sample of urban residents in flood-prone areas of Henan Province, China. These areas experienced severe pluvial flooding events prior to the survey. The results showed that the framework had a stronger explanatory power for residents' flood preparedness intentions, in addition to its stronger overall fitting and predictive power, compared to PMT. Meanwhile, the findings suggested that the framework is useful in assessing residents' perceptions of flood risk and their intention to adopt risk-reducing behaviours.

Firstly, our study confirmed that risk perceptions about flooding can promote residents' preparedness intentions and worry. The former is consistent with the study of Weyrich et al. (2020), which concluded that the higher the public's threat appraisal of flood risk, the higher the intention to implement flood mitigation measures. The latter further supports the study of Ejeta et al. (2018) that perceived risk of flooding has a direct effect on negative emotions. However, we also found that the perceived consequences of flooding alone triggered negative emotions among residents, while the perception of the likelihood did not trigger worrying emotions. From Table S7, urban residents generally had higher perceived consequence to flood hazards but lower perceived likelihood of flood hazards. Besides, the perceived consequences had a greater effect on residents' worry than their intention to prepare for flooding. Also perceived consequence has a greater effect on preparedness intention than perceived likelihood. A review of post-disaster health damage showed that high-impact disasters result in more severe health impairments than moderate or low-impact disasters, and that symptoms of health impairments usually diminished over time (Norris et al., 2002). As we conducted a survey of residents' intentions to prepare immediately after the disaster. People were still impressed by the catastrophic consequences of the flood and had a great deal of negative emotions. These perceived consequences and poor emotional state made people more willing to take disaster preparedness measures.

We also found that individuals' negative emotions can effectively contribute to their flood preparedness intentions, which is consistent with the findings of Siegrist and Gutscher (2008), who suggest that negative emotions explain why flood victims take more measures than non-victims. We try to provide a reasonable explanation for the phenomenon from the perspective of emotional dysregulation (Squires et al., 2021). It is about to be argued that people's negative emotional state in response to a disaster is a dysregulated state, and people will adopt a series of psychological activities or behaviours to release this undesirable state in order to regain the balance. It becomes one of the options for residents to take certain protective measures in order to eliminate their concerns about flood risks.

Secondly, our results confirmed H2. Table S7 showed that urban residents have higher response efficacy and self-efficacy and have lower response costs. This suggests that people are more willing to implement cost-effective measures and feel capable of doing so. This is consistent with Parker et al. (2009) study that high response efficacy, high self-efficacy, and low response costs are positively associated with an individual's intention to take protective action. However, it is important to note that although we categorized the response in our measurements into structural measures (building water retaining walls, etc.), non-structural measures (preparing sandbags, etc.), and purchasing insurance. It is clear that structural measures are

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less attractive to urban residents because in China most urban dwellers live in uniformly constructed buildings. They tend to blame housing developers for the implementation of structural measures. Also, it was found from the survey that most household heads in China are not willing to take measures to move unless they are forced to do so, which is strongly related to the cultural influence.

Besides, H3, stating that negative risk response attitudes had negative effects on residents' flood preparedness intentions, was confirmed. As Ajzen（1991) mentions in the theory of planned behaviour, attitudes toward behaviour can effectively predict behavioural intentions. Negative attitudes towards precautionary measures lead to a reduced willingness to protect against flooding. However, the respondents seemed to have overlooked the important fact that flood risk is still a significant threat even when relatively well-established public flood protection facilities are in place (Bubeck et al., 2013). Unrealistic ideas and attitudes about individual flood safety are a barrier to preparedness intentions.

Finally, in the study of the influence of social context on residents' intention, it was found that social norms play an effective role in promoting residents' intention to prepare. These include the influence of family, neighbours or friends, and government policies. Although the contribution of norms or social networks to residents' intention to prepare has been reported in numerous literatures (Kunreuther et al., 1978; Mileti and Darlington, 1997; Bubeck et al., 2018), no plausible explanation has been given. Deutsch and Gerard (1955) argued that social norms can trigger conformity behaviour in individuals. This stems from the individual's desire to be liked by others, and there is often an emotional cost to people deviating from group norms. This conformity, triggered by social norms, may be one of the reasons why people adopt disaster preparedness measures. The facilitating effect of social norms on preparedness intentions makes it appropriate to focus on the power of social mobilization. Another social context factor to consider is the protection of public flood protection measures. In exploring the effect of trust mechanisms, contrary to our expectation, trust in public flood protection measures had not a direct effect on the preparedness intentions of urban residents. The findings also suggested that attitudes, risk perceptions, and emotions fully mediated the effect of trust on intention. This is in line with the findings of Terpstra (2011). It is that higher trust reduces people's perceived level of risk and ill feelings, thus reducing the intention to prepare. As Poussin et al. (2014) mentioned, trust brings a sense of security and therefore may be an important reason why residents are reluctant to take preventive measures.

In summary, for intra-individual factors, it was found that perceptions and affective-attitudinal paths jointly influence residents' intention, and that affect is largely influenced by perceptions. Research on social context showed that social norms and trust mechanisms were also key factors influencing residents' intention to prepare. Among them, trust plays an important central role. This suggests that effective communication, active social mobilization and sound policies and regulations are effective measures to increase the public's intention to prepare for floods.

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6. Conclusion

Based on PMT, this study comprehensively analyses the factors that influence the willingness of Chinese urban residents to prepare for floods. Firstly, it was found that perceived risk of flooding can effectively promote residents' preparedness intention, and therefore there is a need to raise public awareness of flood protection as well as to establish a proper relationship between citizens and government. Secondly, high response efficacy, high self-efficacy, and low response costs are positively correlated with individuals' intention to take flood protective actions. Therefore, government departments need to clearly tell residents how to do and what scientific and effective disaster prevention and mitigation measures should be taken in case of extreme flood events exceeding standards. Focus publicity on the effectiveness and ease of implementation of the measures. Besides, negative risk response attitudes negatively impacted preparedness intentions. If people do not perceive preparedness actions as absolutely necessary, they will be delayed or shifted to public flood prevention measures. Therefore, government departments should implement relevant policies to stimulate residents' preparedness behaviours, such as subsidies and incentives that can be offered to households that implement measures, which can also further reduce response costs. Finally, we found that the positive effect of social norms on preparedness intentions makes it appropriate to focus on the power of social mobilization. Government departments should actively express that building resilience to flood risk at the community level requires the participation of all people and encourage the participation of the whole community in risk response in order to increase the resilience of society to risk.

However, there are still some limitations that need to be noted. On the one hand, as with all cross-sectional designs, the conclusive causal inferences drawn from this study were limited. That is, if two variables are correlated, does A lead to B or vice versa (Lindell and Hwang, 2008). On the other hand, this study only focused on residents' preparedness intentions, and did not extend to behaviour. As mentioned by (Schifter and Ajzen, 1985), after a person has the intention to act, there may be uncertainty about his or her actual actions. Individuals may indefinitely postpone their behaviours due to non-urgency, so further questions are needed to assess the actual behaviours of respondents.

Data availability

The raw and processed data from the co-authors' research findings cannot be shared at this time, as these data are also part of the ongoing research.

Supplement

The supplement related to this article is available at Supplement.docx.

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Author contributions

TW and TL initiated and led this research. TW conducted online interviews, designed questionnaires, analysed the performance of this model, and wrote the paper. YL dealt with the questionnaires and helped analyse the results. TL defined the framework of the research and revised the manuscript. XY and YiL helped in collecting data.

Competing interests

The contact author has declared that neither they nor their co-authors have any competing interests.

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