

1 Unbalanced relationship between flood risk perception and flood
2 preparedness from the perspective of response intention and socio-
3 economic factors: a case study of Nanjing, China

4 Yabo Li ^{a,b}, Peng Wang ^{b,c,*}

5 ^a Polytechnic Institute, Zhejiang University, Hangzhou 310015, China

6 ^b Faculty of Civil Engineering and Mechanics, Jiangsu University, Zhenjiang 212013,
7 China

8 ^c State Key Laboratory of Pollution Control & Resource Reuse, School of the
9 Environment, Nanjing University, Nanjing 210023, China

*Corresponding author.

E-mail address: upeswp@ujs.edu.cn (P. Wang).

Abstract

Although risk perception and flood preparedness are crucial in flood management, perceived flood risk is not always translated into flood preparedness. It is essential to investigate the potential association between risk perception and flood preparedness. This study selects Nanjing as the research region, designs questionnaire survey and explores the influence relationship between risk perception and flood preparedness. Results indicate that participants show a medium perception of food risk and a higher flood preparedness. Higher risk perception is observed in individuals with regular exercising, the elderly, low education level and long living time. Higher flood preparedness is shown in groups of females, the elderly and high education level. Individuals relies more on threat appraisal to perceive risk, and fails to trigger high enough coping appraisal. Inadequate risk perception leads to a strenuous transform into flood preparedness with unbalanced relationship. Groups with distinct socio-economic characteristics show different preferences to achieve risk perception and flood preparedness. Females relies more on flood knowledge to perceive flood risk. Path analysis suggests that threat appraisal could transform into flood preparedness under the effect of response intention and social-economic features. Groups with high education level or bad health are more likely to perceive risk, and engage in preventive behavior. These findings could provide critical insights into intervention strategies for improving public flood preparedness in flood management.

Keywords: Flood risk perception, flood preparedness, response intention, influence path, flood risk mitigation

1. Introduction

Flood disasters have resulted in immense damage and irreversible losses due to global climate change (Guo et al., 2020). Floods remain the most prevalent and severe disaster worldwide (Li et al., 2023) and account for the dominated composition in a total of 432 disaster events in 2021. Rapid urbanization and the concentration of people and assets in urban areas (Deng et al., 2022; Dong et al., 2022) have led to increased susceptibility and vulnerability to flood events (Wang et al., 2021a). It's predicted that climate change and heavy rainfall would become more frequent and intense with high reliability (Rifat and Liu, 2022; Steinhausen et al., 2021), significantly increasing urban flood risk, especially in developing countries (Zhu et al., 2021). Despite the substantial financial investment and mitigation efforts, floods continue to pose a serious threat to human society in the foreseeable future (Thongs, 2019; Zhang et al., 2022). It is essential to implement effective flood management strategies for sustainable development.

In response to flood events, it is unadvisable to completely take traditional structural measures (Rasool et al., 2022), such as dikes and dams. Risk perception emerges as non-structural measures and has been a significant focus of current research (Ahmad and Afzal, 2020). Flood risk perception reflects risk acceptance (Khan et al., 2020; Rana and Routray, 2016) and related feelings, opinions and judgements regarding direct or potential hazards (Rana et al., 2020; Yang, 2019). According to Protection Motivation Theory (PMT), cognitive process determines the self-protective motivation (Khani Jeihooni et al., 2022), while threat appraisal and coping appraisal are the

important components of risk perception (Roder et al., 2019). Limited understanding of flood risk perception leads to failures in flood management practices (Ahmad and Afzal, 2020). Successful flood management highly depends on the implementation of mitigation measures, because people are both flooding victims and implementors of disaster mitigation policies (Wang et al., 2018; Yin et al., 2021). Furthermore, flood preparedness is defined as individual protection action and response behaviors during floods, including preventive and adaptive behavior (Sado-Inamura and Fukushi, 2019). Subjective expected utility theory assumes that people assess likelihood and consequences of alternative choices (Rufat and Botzen, 2022). Individuals would seek or wait for sufficient information to support the action of responding to flooding (Dootson et al., 2022; Rufat and Botzen, 2022). Adequate flood preparedness ensures that people could adjust their behaviors more rationally and effectively, making minor changes to mitigate adverse impacts from floods (Valois et al., 2020).

Flood risk perception is believed to promote flood preparedness (Ali et al., 2022; Shah et al., 2024), but current research has revealed that high perceptions of risk could not always translate to disaster preparedness (Schlef et al., 2018). And there is not direct and simple relationship between risk perception and flood preparedness as expected. Some studies have found the results contradictory to the popular opinion that high perception of flood risk is associated with high flood preparedness (Rasool et al., 2022) and indicate the weak relationship between risk perception and flood preparedness (Valois et al., 2020), even without direct link (Ao et al., 2020; Wachinger et al., 2018). High risk perception even motivates people to avoid or ignore willfully specific actions

under uncertain circumstances (Wachinger et al., 2013). There is no consensus on how risk perception affects and predicts preparedness behavior (Huang and Lubell, 2022; Taylor et al., 2014). Relationship between risk perception and preparedness appears more strenuous in practice (Valois et al., 2020), due to the ignorance of the existence of unknown intermediary (Ao et al., 2020; Yong and Lemyre, 2019). And theory of Planned Behavior anticipates how people behave in specific situation, connects behavior with individual control and considers intention as the predictive factor of behavior (Ghanian et al., 2020; Kurata et al., 2022). For individual cognitive decision-making, intention serves as the intermediate link between perception and behavior (Soetanto et al., 2017), and sufficient social-scientific evidence supports the positive relationship between risk perception and intention to respond, rather than actual behaviors (Harlan et al., 2019; van Valkengoed and Steg, 2019).

Individuals with different backgrounds get involved in flood management, perceive flood risk in various ways (Rasool et al., 2022) and develop personal intention to follow risk response (Kurata et al., 2022). Socio-economic features are the most controversial driving factors of risk perception (Shah et al., 2020) and flood preparedness (Ao et al., 2020), while relevant studies has reported mixed and inconsistent results (Rufat and Botzen, 2022). Socio-economic features determine the social group to which people belong and affect individual perception and action towards hazards (Harlan et al., 2019). However, most studies only estimate simple correlations and incorporate socio-economic factors as control variables in regression analysis (Rufat and Botzen, 2022). Moreover, most studies focus on the influencing factors of

98 risk perception and flood preparedness (Ao et al., 2020; Sun and Sun, 2019; Ullah et
99 al., 2020). Limited studies attach importance to the influence path between flood risk
100 perception and flood preparedness (Wachinger et al., 2018). Existing literatures
101 extensively examine risk perception and flood preparedness in developed nations, but
102 the potential linkage between flood risk perception and disaster preparedness has been
103 relatively under-explored, particularly in developing countries (Scaini et al., 2021;
104 Zhang et al., 2021b). Effective policies for flood management could benefit from a more
105 integrated intervention framework that connects risk perception with flood
106 preparedness.

107 Despite the continuous flood protection efforts, Nanjing has experienced
108 increasingly severe flood damage in recent years. This study examines flood risk
109 perception in Nanjing, and investigates the transformation relationship between risk
110 perception and flood preparedness from the perspective of response intention and socio-
111 economic factors. This study aims to: (1) identify the distribution characteristics of risk
112 perception and flood preparedness; (2) analyze the influence effect of different factors
113 combined with social-economic feature; (3) reveal the influence path between risk
114 perception and flood preparedness. **Fig. 1** illustrates the comprehensive framework of
115 this study.

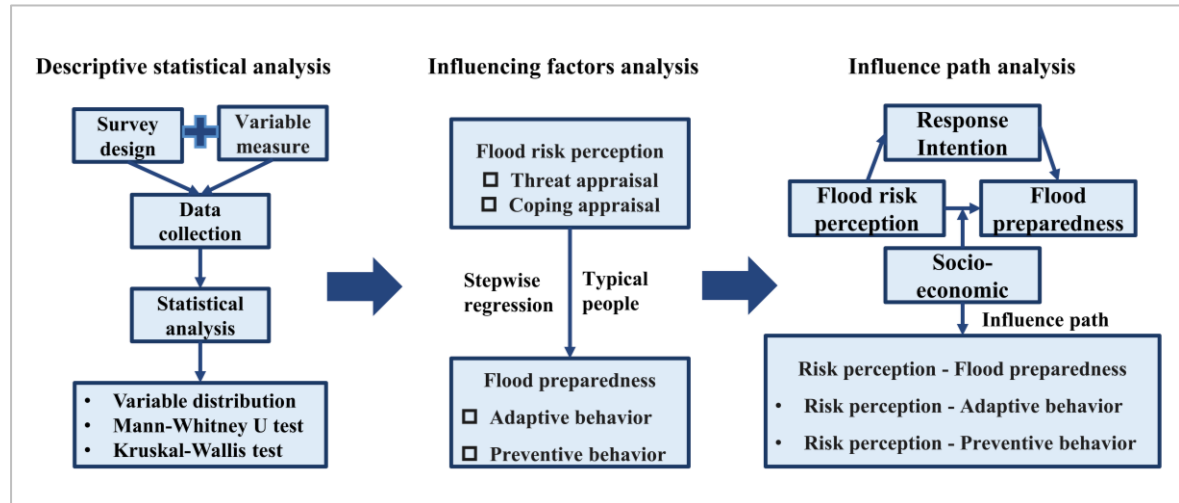


Fig. 1. Overall framework of this study.

2. Material and methods

2.1 Study region

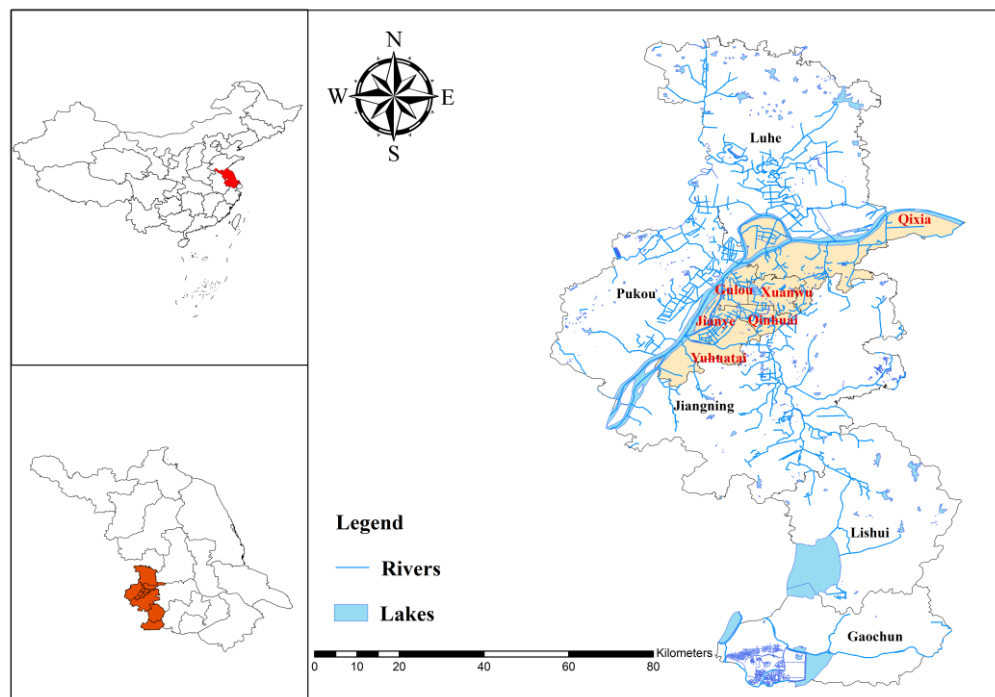


Fig. 2. Study area

Nanjing is situated in the middle and lower reaches of Yangtze River in eastern China, with a municipal area of 6587.02 km². The city belongs to a typical subtropical and monsoon climate region and gets characterized by distinct seasonal changes and

abundant rainfall. Nanjing has 11 urban district, 95 streets and 6 towns by 2021. As one of national key flood control cities, Nanjing is confronted with the conflict of rapid urbanization and increasing floods (Zhang et al., 2021a). Nanjing is estimated to exhibit higher flood risk across various flood return periods (Wang et al., 2021b), especially in the central urban districts surrounding the Yangtze River (Li et al., 2022). Therefore, this study considers six districts (**Fig. 2**) of urban center to explore the relationship between flood risk perception and flood preparedness for flood resilience.

2.2 Survey design and variables measure

This study developed a semi-structured questionnaire through Likert scale to investigate flood risk perception in Nanjing. The survey primarily was comprised of four parts: (1) Socio-economic condition; (2) Flood risk perception; (3) Flood preparedness; (4) Response intention. A comprehensive and detailed description of the questionnaire was provided in **Supplementary material**. The first section collected information about participants' socio-economic circumstances, including gender, age, district, education background, living time, physical condition, exercise situation and life style (particularly bad habits, such as smoking). Based on PMT, the second part measured flood risk perception by evaluating both threat and coping appraisal.

Flood preparedness consisted of both adaptive and preventive behaviors in the third section. Adaptive behavior involved a range of measures designed to mitigate and adapt the impact of floods, while preventive behavior focused on actions taken to prevent and reduce the negative effects during floods. The fourth section included a survey on response intention and examined these factors influencing flood risk

perception and preparedness. Furthermore, flood risk knowledge referred to the level of grasping flood related knowledge among residents, while flood risk worry evaluated individuals' fear and concern about floods. Additionally, flood experience reflected the frequency of exposure to flood disasters. Government trust revealed the degree of confidence in government flood management, while flood disaster education measured the diversity of education resources available for residents regarding floods. **Table 1** presented the collected indicators and variables from the questionnaire survey.

Table 1

Indicator and variable measurement.

Indicator	Variable	Range
Flood risk perception	Threat appraisal	(1,5)
	Coping appraisal	(1,5)
Flood preparedness	Adaptive behavior	(1,5)
	Preventive behavior	(1,5)
	Flood risk knowledge	(1,5)
	Government trust	(1,5)
Response intention	Flood risk worry	(0,1)
	Flood experience	(0,1)
	Flood disaster education	(0,1)
	Gender	(1,2)
Socio-economic factors	Age	(1,7)
	District	(1,6)
	Education level	(1,5)
	Living time	(1,5)
	Health condition	(1,5)
	Life style	(0,1)

2.3 Data collection

To solve the potential problems including unclear and ambiguous questions, preliminary tests of online questionnaire were conducted before officially issued for the survey. We collected and sorted out the survey results of interviewees, and modified the questionnaire reasonably according to the feedback. We deleted and reduced the questionnaire options that may lead to bias and misunderstanding. We then conducted face-to-face questionnaire surveys on densely populated streets in Nanjing from April 24, 2021 to April 30, 2021, including Gulou, Xuanwu, Jianye, Qinhuai, Qixia and Yuhuatai district respectively.

Interviewers received excellent survey skills training before formal interview, and they were organized into six groups with at least two members in each group. A group leader was appointed to distribute and collect questionnaires, supervise and record the entire process, and ensure the rationality and effectiveness of data acquisition. Each interviewer introduced and emphasized the objectives of this questionnaire survey at the beginning. Strictly following the principle of voluntary participation and confidentiality, respondents were afforded enough time to review questionnaire content adequately, and permitted to withdraw from survey at any point. Complete questionnaire comprised 52 questions and required approximately 15–20 minutes for completion. To encourage and appreciate participation, interviewers presented self-made gifts to respondents upon completion.

The sample size of respondents was calculated using Yamane's formula (Rasool et

al., 2022). A sample size of 844 was proposed using the sampling method with 95% confidence level, and random sampling was chosen to conduct the survey. This study mainly excluded the invalid responses following the criteria: (1) Incomplete questionnaire, that is, a considerable part of the questionnaire was not filled in. (2) Respondents did not understand the questionnaire and answered incorrectly or did not answer according to the guidance. (3) Interviewees chose the same answer all through even if the question changed. (4) Some questionnaires were missing pages or could not be identified. (5) Inconsistent or obviously wrong questionnaires. Eventually, this study distributed 844 questionnaires and obtained 737 valid questionnaires after excluding 107 invalid ones with an effective rate of 87.32%.

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

where n is the sample size, N is the resident population, and e is the precision level.

2.4 Statistical analysis

By exporting collected data to SPSS software, this study calculated each indicator by averaging the corresponding variables, and conducted descriptive analysis to reveal the distribution features of different indicators and variables. Mann-Whitney U statistical test is a nonparametric statistical test used to compare the values of a variable between two independent groups (Karim et al., 2022) while Kruskal-Wallis statistical test could compare the values of a variable between several independent groups (Kadkhodaei et al., 2022). Mann-Whitney U test was used for ‘yes or no’ questions, and Kruskal-Wallis test was for questions with three or more answer choices (Kadkhodaei et al., 2022; Karim et al., 2022). These tests were used to compare the

differences of flood risk perception and flood preparedness between two and several independent groups. And correlation analysis was used to examine the influence factors of flood risk perception and flood preparedness.

Stepwise regression is a type of multiple linear regression that identifies the optimal combination of independent variables for predicting the dependent variable (Chen et al., 2013; Wang et al., 2023), including forward-adding and backward-deleting methods. When a new variable is introduced, previous variables in the model may lose predictive ability. Then the backward method is employed to remove the new and insignificant variable. The stepwise procedure is terminated once the optimized model is established. We mainly considered the backward elimination approach in stepwise regression and revealed the impact of different factors on risk perception and flood preparedness. Finally, we performed the moderated mediation model in PROCESS macro program of SPSS (Kamau-Mitchell and Lopes, 2024) to capture the influence path between flood risk perception and flood preparedness. The PROCESS program can effectively test the moderated mediation model (McMains et al., 2024) and help to clarify the mediating and moderating roles of different variables. In this model, risk perception, flood preparedness, response intention and social-economic factors acted as independent, dependent, mediating and moderating variables respectively. All statistical analyses were conducted at a significance level of 0.05.

3. Results

3.1 Descriptive statistical analysis

Cronbach's Alpha coefficient reveals the questionnaire reliability and if it is greater

than 0.8, the data is valuable (Chen et al., 2024). KMO value is very important for questionnaire validity, and if KMO value is greater than 0.7, it means that the questionnaire has good validity and can be used for factor analysis and statistical analysis (Zhang et al., 2023). This study found that Cronbach's Alpha (0.894) and KMO value (0.891) were both exceeded 0.7 and illustrated the high reliability and validity in this questionnaire. **Table 2** presented the descriptive analysis about basic information of participants. 739 respondents were included in this study, with a gender distribution with 43.8% males and 56.2% females. Most people were aged from 18 to 25 years (27.5%), followed by 31-40 years (20.8%), 41-50 years (14.5%), 26-30 years (12.5%), over 60 years (11.9%), 51-60 years (11.4%) and below 18 years (1.4%). Most participants came from Jianye district (26.2%), followed by Qixia (23.2%), Gulou (21.8%), Yuhuatai (11.7%), Xuanwu (10.2%), and Qinhuai District (6.9%).

Education level was mostly undergraduate (45.6%), middle school (16.3%), high school (19.7%), postgraduate and above (11.5%) and elementary school (6.9%). Regarding their residence duration in Nanjing, most participants lived for above 10 years (51.4%), 1-3 years (17.0%), 3-5 years (11.9%), 5-10 years (11.9%), and below 1 years (7.7%). More than half of respondents reported excellent health (49.5%), better (34.7%) and general health (13.6%), while few people indicated very poor (0.4%) and poor (1.8%). The majority didn't smoke (81.1%) and 18.9% had the habit of smoking. Over half often engaged in regular exercising (61.2%) and 38.8% lacked adequate exercise. These socio-economic features in our study were consistent with the flood control knowledge survey issued by Nanjing government, as illustrated in

Supplementary material.

Table 2

Profile of socio-economic feature in respondents.

Characteristic	Description	Frequency	Rate
Gender	Male	323	43.8
	Female	414	56.2
Age	≤18 years	10	1.4
	18-25 years	203	27.5
	26-30 years	92	12.5
	31-40 years	153	20.8
	41-50 years	107	14.5
	51-60 years	84	11.4
	≥60 years	88	11.9
District	Gulou	161	21.8
	Jianye	193	26.2
	Qixia	171	23.2
	Qinhuai	51	6.9
	Xuanwu	75	10.2
	Yuhuatai	86	11.7
Education level	Elementary school	51	6.9
	Middle school	120	16.3
	High school	145	19.7
	Undergraduate	336	45.6
	Postgraduate and above	85	11.5
Living time	Less than 1 years	57	7.7
	1-3 years	125	17.0
	3-5 years	88	11.9
	5-10 years	88	11.9

	More than 10 years	379	51.4
	Very poor	3	0.4
	Poor	13	1.8
Health condition	General	100	13.6
	Better	256	34.7
	Excellent	365	49.5
Life style	Smoking	139	18.9
	Not smoking	598	81.1
Exercise situation	Regularly exercising	451	61.2
	Not exercising	286	38.8

Table 3 showed the score of each variable and indicator. Flood risk perception was found to be at a medium level with an average score of 3.57. Residents demonstrated a high level of threat appraisal and a medium level of coping appraisal. The average level of flood preparedness was relatively high (4.05), and local participants exhibited a high level of adaptive behavior (4.25) and a medium level of preventive behavior (3.85). Furthermore, a medium level of flood risk knowledge and government trust was observed among respondents (2.73 and 2.94). There was also a low level of flood experience and flood disaster education (0.45 and 0.46). Flood risk worry showed a medium level (0.50), while participants had a relatively low level in response intention (2.73).

Table 3

Descriptive statistics of each indicator and variable.

Name	Min	Max	Mean	Standard Deviation
Flood risk perception	1	5	3.57	0.68
• Threat appraisal	1	5	4.10	0.61

• Coping appraisal	1	5	3.03	1.07
Flood preparedness	1	5	4.05	0.76
• Adaptive behavior	1	5	4.25	0.79
• Preventive behavior	1	5	3.85	0.87
Response intention	1	5	2.87	0.79
• Flood risk knowledge	1	5	2.73	1.25
• Government trust	1	5	2.94	0.50
• Flood risk worry	0	1	0.50	1.15
• Flood experience	0	1	0.45	0.25
• Flood disaster education	0	1	0.46	0.50
Gender	1	2	1.56	0.50
Age	1	7	4.01	1.74
District	1	6	2.92	1.63
Education level	1	5	3.39	1.10
Living time	1	5	3.82	1.41
Health condition	1	5	4.31	0.80
Life style	0	1	0.19	0.39
Exercise situation	0	1	0.61	0.49

3.2 Distribution test

Table 4-7 presented the significant results of Mann-Whitney U test. In gender category, there were significant differences in adaptive behavior, preventive behavior, flood preparedness, flood risk worry and government trust. Males' mean rank was 340.71, 336.66, 338.06, 343.22 and 392.47, while females demonstrated the mean rank of 391.07, 394.23, 393.14, 389.11 and 350.69 respectively. Women exhibited a higher level in flood preparedness, adaptative and preventive behavior, and flood risk worry, while men had a higher level of government trust. Regularly exercising people showed a higher level of threat appraisal and flood risk perception, with average ranks of 389.37

and 385.47, compared to those who did not exercise (336.88 and 343.02). Furthermore, individuals with flood risk worry exhibited higher levels of flood risk perception, flood preparedness and response intention, with mean rank of 387.33, 397.41 and 479.18, respectively. Individuals with flood experience showed a higher level of flood risk perception and response intention (416.08 and 507.11).

Table 4

Mann-Whitney U test in gender.

Category	Gender		Z-value	P-value
	Mean rank			
	Male	Female		
Adaptive behavior	340.71	391.07	-3.22	0.00
Preventive behavior	336.66	394.23	-3.65	0.00
Flood preparedness	338.06	393.14	-3.49	0.00
Flood risk worry	343.22	389.11	-3.35	0.00
Government trust	392.47	350.69	-2.65	0.01

Table 5

Mann-Whitney U test in exercise situation.

Category	Exercise situation		Z-value	P-value
	Mean rank			
	Regularly exercising	Not exercising		
Flood risk perception	385.47	343.02	-2.64	0.01
Threat appraisal	389.37	336.88	-3.28	0.00

Table 6

Mann-Whitney U test in exercise situation.

Category	Flood risk worry
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	Mean rank		Z-value	P-value
	Yes	No		
Flood risk perception	387.33	350.42	0.02	0.02
Threat appraisal	398.91	338.68	-3.86	0.00
Flood preparedness	397.41	340.20	0.00	0.00
Adaptive behavior	386.47	351.29	0.02	0.02
Preventive behavior	401.09	336.47	0.00	0.00
Response intention	479.18	257.32	0.00	0.00

Table 7

Mann-Whitney U test in flood experience.

Category	Flood experience			
	Mean rank		Z-value	P-value
	Yes	No		
Flood risk perception	416.08	330.62	0.00	0.00
Coping appraisal	419.43	327.88	0.00	0.00
Response intention	507.11	256.41	0.00	0.00

Table 8-11 displayed the significant results of Kruskal-Wallis statistical test.

Among age groups, individuals aged 31 to 40 showed a higher level in threat appraisal than those aged 18 to 25. The level of coping appraisal was lower in the 18-25 age group compared to those aged 51-60 and above 60 years. Preventive behavior was lower among people aged 51-60 than those aged 18-25 and 31-40, respectively. People aged 51-60 demonstrated more flood risk knowledge than those aged 18-25. Government trust was higher among individuals aged under 18 and 41 to 50 than aged 51 to 60. The level of flood disaster education was higher in the 41-50 age group than the 18-25 age group. Flood risk perception was higher among individuals aged 51-60

289 and over 60 years than those aged 18-25. Flood preparedness was higher among
 290 individuals aged 31 to 40 than those aged 51 to 60 years, while response intention was
 291 higher within people aged 51-60 years than those aged 18-25.

292 **Table 8**

293 Kruskal-Wallis test in age.

Category	Age							Sig.(p)
	Mean rank							
	≤18	18-25	26-30	31-40	41-50	51-60	≥60	
Threat appraisal	—	325.28	—	389.43	—	—	—	0.000
Coping appraisal	—	324.17	—	—	—	447.88	410.81	0.000
Preventive behavior	373.19	388.55	—	402.44	—	298.23	—	0.000
Flood risk knowledge	—	328.55	—	—	—	442.48	—	0.001
Government trust	543.8	—	—	—	414.45	312.82	—	0.005
Flood disaster education	—	397.46	—	—	305.3	—	—	0.004
Flood risk perception	—	321.87	—	—	—	418.44	405.55	0.000
Flood preparedness	—	—	—	414.17	—	315.46	—	0.009
Response intention	—	333.9	—	—	—	425.55	—	0.021

294 In terms of education level (**Table 9**), the mean rank of threat appraisal for
 295 postgraduate and above was lower than that of high school and undergraduate. Coping
 296 appraisal for postgraduate was lower than that of middle school, high school and
 297 undergraduate. People with an undergraduate education exhibited a higher mean rank
 298 of preventive behavior than those in middle school. People with middle school and high
 299 school education demonstrated a higher level of flood risk knowledge than that of
 300 postgraduates and above. There was a higher level of flood disaster education at the

undergraduate level than that of middle and high school. Individuals with postgraduate and higher levels of education showed a lower level of flood risk perception than those in middle school. Additionally, individuals with the undergraduate degree demonstrated a higher level of flood preparedness than those in middle school.

Table 9

Kruskal-Wallis test in education level.

Category	Education level					Sig.(p)
	Mean rank					
	Elementary school	Middle school	High school	Under -graduate	Postgraduate and above	
Threat appraisal	–	–	383.63	382.05	296.02	0.000
Coping appraisal	–	399.48	399.89	366.10	291.75	0.001
Preventive behavior	–	330.55	–	403.93	–	0.001
Flood risk knowledge	–	393.72	398.97	–	300.49	0.009
Flood disaster education	–	325.10	335.67	395.81	–	0.003
Flood risk perception	–	382.68	406.71	–	298.69	0.000
Flood preparedness	–	330.47	–	400.63	–	0.004

Moreover, people with more than 10 years of residence had a higher mean rank of coping appraisal than those living for less than 1 year, 1-3 years and 5-10 years in **Table 10**. Living for less than 1 year showed a low level in coping appraisal than residing for 3-5 years. Individuals with residence duration of over 10 years grasped more flood risk knowledge than living time of less than 1 year, 1-3 years and 5-10 years. Mean rank of flood experience was higher for individuals residing for over 10 years than those living for less than 1 year, 1-3 years, and 3-5 years. People with over 10 years living time had

314 a higher level of flood risk perception and response intention than those residing for
315 less than 1 year and 1-3 years. In **Table 11**, as physical health improved from better to
316 excellent, there was an increasing trend in the mean rank of threat appraisal and flood
317 risk perception. People with excellent health exhibited a higher level in preventive
318 behavior than those with general health. And general and better health conditions had a
319 lower mean rank of government trust than those with excellent health.

320 **Table 10**

321 Kruskal-Wallis test in living time.

Category	Living time					Sig.(p)
	Mean rank					
	< 1 years	1-3 years	3-5 years	5-10 years	>10 years	
Coping appraisal	246.36	317.28	354.16	337.88	415.18	0.000
Flood risk knowledge	259.13	311.44	—	33.33	414.90	0.000
Flood experience	326.33	330.26	329.12	—	402.82	0.000
Flood risk perception	275.73	318.74	—	—	409.12	0.000
Response intention	—	319.23	—	322.77	406.30	0.000

322 **Table 11**

323 Kruskal-Wallis test in health condition.

Category	Health condition					Sig.(p)
	Mean rank					
	Very poor	Poor	General	Better	Excellent	
Coping appraisal	—	—	—	329.43	400.45	0.000
Preventive behavior	—	—	326.03	—	399.35	0.001
Government trust	—	200.35	308.91	—	392.22	0.000
Flood risk perception	—	—	—	342.38	390.58	0.009

3.3 Correlation analysis

In **Fig. 3**, flood risk knowledge demonstrated a significant and positive relationship with coping appraisal and flood risk perception. There was a moderately positive and significant correlation between government trust and flood risk perception. Flood risk worry, flood disaster education and flood experience showed a significantly and weakly positive relationship with risk perception. Among socio-economic factors, gender had no significant correlation with flood risk perception, and other variables were weakly related to flood risk perception. Government trust was significant and moderately positive correlated with flood preparedness, while flood risk knowledge, flood risk worry, flood disaster education and flood experience showed weakly related to flood preparedness. Only living time, district, education level, life style and exercise situation were unrelated to flood preparedness. Gender, age and health condition were weakly correlated with flood preparedness. Flood risk perception was significantly and positively related to response intention, but flood preparedness showed a lower correlation with flood risk perception and intention response.

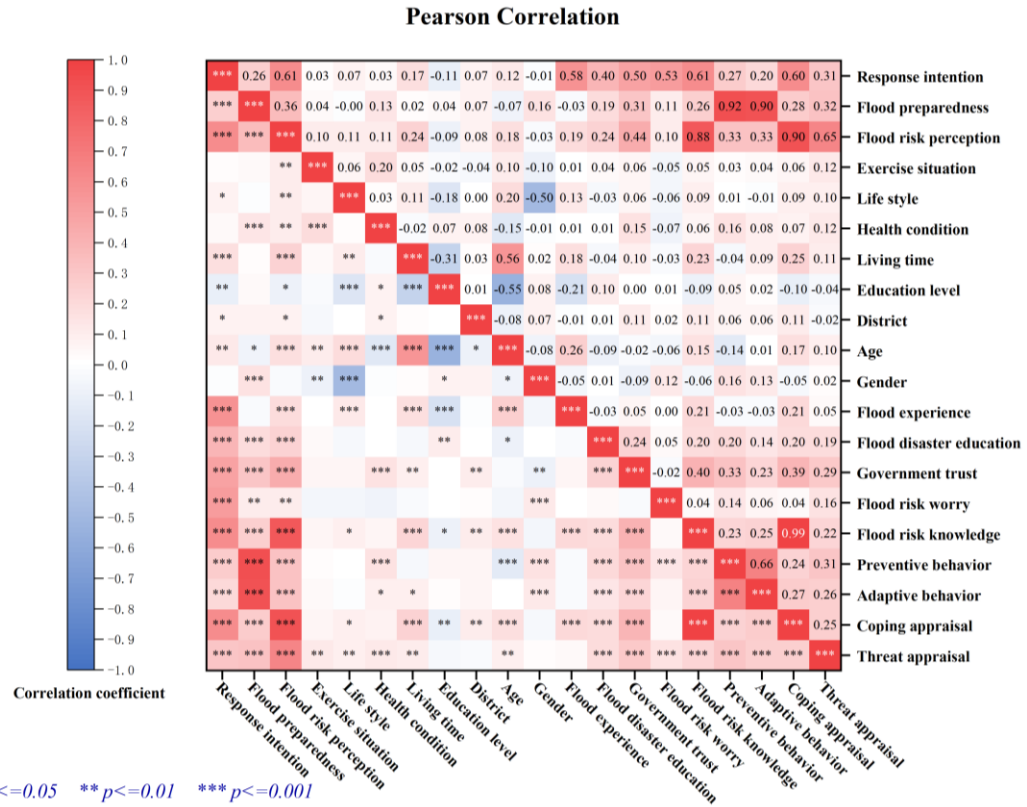


Fig. 3. Pearson correlation analysis (The top diagonal is regression coefficients, and the bottom diagonal is the significance).

3.4. Influencing factors of risk perception

Table 12 presented the results of stepwise regression analysis. The initial step involved the selection of all variables for regression analysis in Model 1. This process revealed that flood risk knowledge demonstrated a significant and positive effect, while the other variables exhibited relatively lower effects. Then after removing socio-economic variables, this study established model 2 with a high goodness of fit (adjusted $R^2=0.788$). Flood risk knowledge also maintained a higher influence (0.827) on flood risk perception. Furthermore, we excluded the variable of flood risk knowledge in model 3, with a low goodness of fit (adjusted $R^2=0.246$). But government trust, flood experience, flood disaster education and flood risk worry significantly and positively

influenced risk perception, indicated by increased regression coefficients, and the effect of flood experience shifted from insignificant to significant. We found that while flood risk knowledge has the potential to significantly improve risk perception, it can also inhibit and diminish the positive impact of other contributing factors. Due to insufficient flood risk knowledge, maintaining trust in government and recalling past flooding experience were crucial for enhancing flood risk perception.

Table 12

Stepwise regression analysis results of flood risk perception.

Variable	Model 1		Model 2		Model 3	
	Standardized coefficient	95% CI	Standardized coefficient	95% CI	Standardized coefficient	95% CI
Flood risk knowledge	0.814***	[0.420, 0.461]	0.827***	[0.427, 0.468]	-	
Flood risk worry	0.074***	[0.055, 0.144]	0.067***	[0.046, 0.136]	0.100**	[0.051,0.221]
Government trust	0.093***	[0.033, 0.077]	0.094***	[0.196,0.273]	0.396***	[0.196,0.273]
Flood disaster education	0.060***	[0.07, 0.254]	0.053***	[0.218,0.568]	0.146***	[0.218,0.568]
Flood experience	-0.010***	[-0.06, 0.033]	0.01	[0.143,0.315]	0.168***	[0.143,0.315]
Gender	0.057**	[0.026, 0.13]	-	-	-	-
Age	0.067**	[0.008, 0.044]	-	-	-	-
District	-0.027	[-0.025, 0.003]	-	-	-	-
Education level	0.01	[-0.018, 0.03]	-	-	-	-
Living time	0.01	[-0.015, 0.024]	-	-	-	-
Health condition	0.056**	[0.019, 0.077]	-	-	-	-
Life style	0.057**	[0.033, 0.165]	-	-	-	-
Exercise situation	0.038*	[0.006, 0.099]	-	-	-	-
R ²	0.803		0.790		0.250	
Adjusted R ²	0.800		0.788		0.246	

RMSE	0.303	0.312	0.589
F	227.27***	549.53***	61.083***

*** P < 0.001, ** P < 0.01, * P < 0.05

360 This study explored the impact of different factors on flood risk perception by
361 different groups of participants based on socio-economic features. **Fig. 4** listed the
362 significant results of regression analysis and more detailed information was provided
363 in **Supplementary materials**. Among males, flood risk knowledge, flood risk worry,
364 government trust and flood disaster education positively affected flood risk perception,
365 with standardized coefficients of 0.815, 0.087, 0.105 and 0.062, respectively. In females,
366 flood risk knowledge, flood risk worry and government trust exhibited a significant
367 effect on risk perception (0.841, 0.043 and 0.090). Flood risk knowledge demonstrated
368 a higher impact among females, while flood risk worry and government trust had a
369 greater influence in males. Among the elderly, flood risk knowledge and worry
370 significantly affected flood risk perception (0.828 and 0.128). Flood risk knowledge,
371 flood risk worry, government trust and flood disaster education showed a significant
372 effect (0.823, 0.059, 0.101 and 0.056) among young and middle-aged individuals.
373 Compared with the non-elderly, the elderly exhibited a higher influence of flood risk
374 knowledge and worry on risk perception.

375 In people with high education level, flood risk knowledge and government trust
376 significantly and positively affected flood risk perception (0.817 and 0.124). However,
377 for individuals with low education level, flood risk knowledge showed a great impact
378 (0.831), and flood risk worry and flood disaster education significantly influenced risk
379 perception (0.109 and 0.093). For individuals with a short living time, only flood risk

knowledge and government trust showed a significant positive effect (0.734 and 0.187). But for people with long living time, flood risk knowledge demonstrated a greater impact on risk perception (0.829), while government trust exhibited a lower effect (0.064). Furthermore, flood risk worry and disaster education showed a significant effect (0.051 and 0.083).

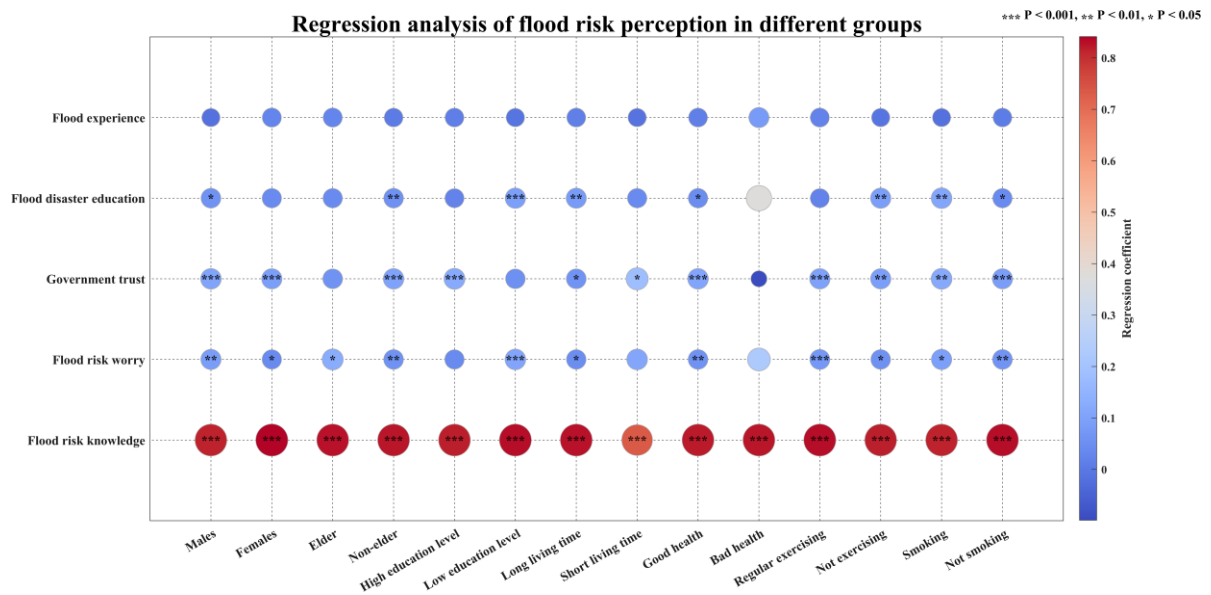


Fig. 4. Regression analysis of flood risk perception.

For individuals in good health, only flood risk knowledge significantly affected risk perception (0.821). Among people in bad health, flood risk knowledge showed a greater effect (0.824), while flood risk worry, government trust and flood disaster education also influenced risk perception (0.059, 0.107 and 0.046). For individuals who regularly exercised, flood risk knowledge, flood risk worry, government trust and flood disaster education demonstrated a significant positive effect (0.817, 0.056, 0.091 and 0.090). However, flood risk knowledge, flood risk worry and government trust showed a lower impact (0.833, 0.076 and 0.097) among groups without exercising. For people with bad habit, flood risk knowledge, flood risk worry, government trust and flood

disaster education had a significant effect (0.815, 0.093, 0.118 and 0.111). The effect of flood risk knowledge was lower (0.831) among groups without bad habit, while flood risk worry, government trust and flood disaster showed a greater impact on risk perception (0.063, 0.086 and 0.041).

3.5. Influencing factors of flood preparedness

Table 13 presented the stepwise regression results of flood preparedness. Threat appraisal had a significant and positive influence (0.213), followed by government trust (0.178), flood risk knowledge (0.140), flood disaster education (0.08) and flood risk worry (0.07), while only flood experience exhibited a negative effect (-0.09). Lower influence of threat appraisal on flood preparedness suggested that high risk perception was associated with insufficient flood preparedness behavior. This study also considered socio-economic features as group categories, and explored the effects of different factors on flood preparedness (**Fig. 5**). **Supplementary materials** provided more detailed information about regression results.

In the high risk-perception groups, threat appraisal significantly and positively affected flood preparedness (0.171), followed by flood disaster education (0.079), flood risk worry (0.118), government trust (0.198), flood risk knowledge (0.169). Only flood experience had a negative effect (-0.125). For the low risk-perception groups, threat appraisal showed a higher influence (0.309), but other factors were not significant. Among individuals with low response intention, only threat appraisal and government trust demonstrated a significant positive effect on flood preparedness (0.211 and 0.172). For people with high response intention, the effect of threat appraisal and government

trust increased and reached 0.216 and 0.193 respectively, while flood risk knowledge, flood disaster education and flood experience also exhibited a significant influence (0.217, 0.106 and -0.112). High response intention improved the influence effect of threat appraisal and government trust, and led to significant effects of other different factors.

Table 13

Stepwise regression analysis results of flood preparedness.

Variable	Standardized coefficients	95% CI
Threat appraisal	0.213***	[0.177,0.352]
Flood risk knowledge	0.140***	[0.040,0.129]
Flood risk worry	0.072*	[0.008,0.210]
Government trust	0.178***	[0.068,0.167]
Flood disaster education	0.075***	[0.020,0.433]
Flood experience	-0.078	[-0.220, -0.016]
R ²	0.184	
Adjusted R ²	0.177	
RMSE	0.68512	
F	27.439**	

*** P < 0.001, ** P < 0.01, * P < 0.05

Among males, threat appraisal, flood risk knowledge and government trust had a significant effect on flood preparedness (0.263, 0.192 and 0.240). In females, threat appraisal, government trust, and flood disaster education significantly affected flood preparedness (0.154, 0.141, and 0.123). The effect of threat appraisal was crucial in males compared to females. Among the elderly, only threat appraisal and government trust demonstrated a significant and positive effect (0.237 and 0.319). But for non-

elderly individuals, the influence of threat appraisal and government trust was lower (0.217 and 0.155), while flood risk knowledge, flood risk worry, flood disaster education and flood experience significantly affected flood preparedness (0.136, 0.028, 0.096 and -0.086).

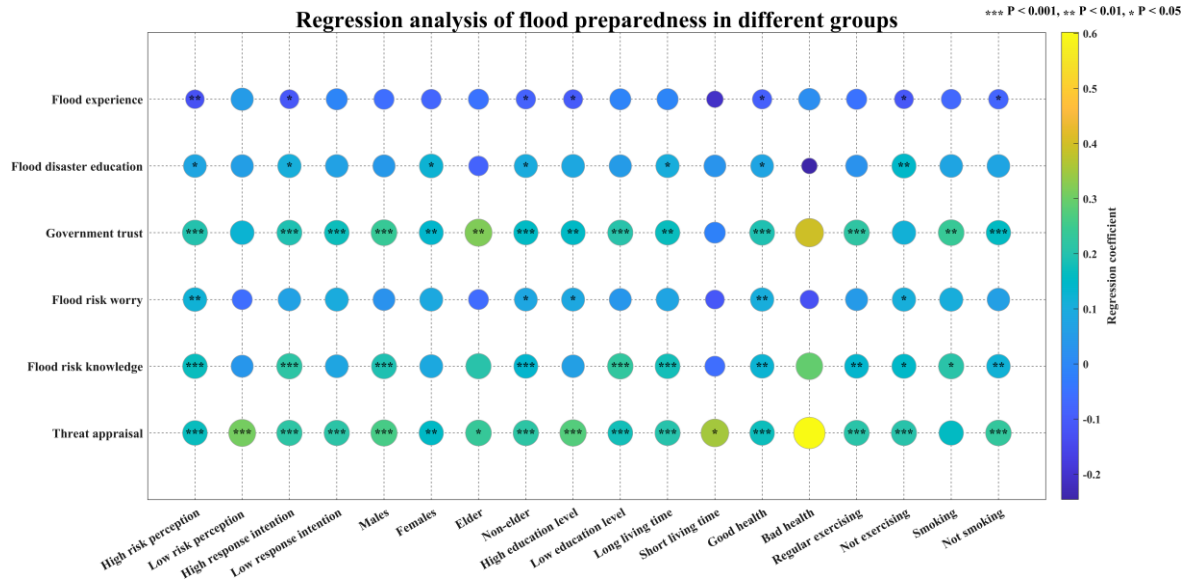


Fig. 5. Regression analysis of flood preparedness.

In people with a high level of education, threat appraisal, flood risk worry, government trust and flood experience significantly affected flood preparedness (0.276, 0.088, 0.152 and -0.102). But among individuals with low education, the effect of threat appraisal and government trust declined and reached 0.180 and 0.205, respectively, and flood risk knowledge also had a positive influence (0.226). Among individuals with long living time, threat appraisal, flood risk knowledge, government trust and flood disaster education showed a significant and positive effect (0.204, 0.180, 0.169 and 0.102). But for those with short residence duration, only threat appraisal exhibited a significant effect on flood preparedness (0.352).

For people in bad health, threat appraisal and flood risk knowledge demonstrated

a higher effect (0.602 and 0.292), but none of the variables were statistically significant. Among groups in good health, although only flood experience had a negative effect (-0.091), all variables affected flood preparedness significantly and positively. In people without exercising, threat appraisal, flood risk knowledge and government trust showed a significant and positive effect on flood preparedness (0.207, 0.147 and 0.116). But among groups with regular exercising, the effect of threat appraisal and government trust improved and achieved 0.208 and 0.218, respectively, while the influence of flood risk knowledge decreased (0.137). For individuals without bad habit, threat appraisal, flood risk knowledge and government trust demonstrated a significant effect (0.229, 0.119 and 0.161), while only flood experience exhibited a negative influence (-0.078). However, among people with bad habit, the effect of flood risk knowledge and government trust improved, and both significantly and positively affected flood preparedness (0.210 and 0.238)

3.6 Influence path of flood preparedness

This study examined the moderating and mediating effects and explored the influence path between flood risk perception and flood preparedness. **Supplementary materials** presented more detailed information. Risk perception, flood preparedness, response intention and social-economic factors acted as independent, dependent, mediating and moderating variables, respectively. We aimed to explore the moderating effect among independent, dependent, moderating variables by increasing and decreasing the level of moderating variable. This study could reveal whether the independent variable has a significant positive predictive effect on the dependent

variable, with moderating variable being one standard deviation below (M-1SD) or above (M+1SD) its mean value.

In **Fig. 6(a)**, health condition played a negative moderating role between threat appraisal and flood preparedness. Threat appraisal had a significant and positive effect on response intention (0.397) and flood preparedness (0.313), while response intention also positively affected flood preparedness (0.174). Under the influence of health condition and response intention, the direct effect of threat appraisal on flood preparedness was greater than indirect effect. The slope of low, medium and high moderation changed obviously and tended to be gentle in **Fig. 7(a)**. With the increasing moderation effect, health condition interfered with the influence of threat appraisal on flood preparedness. In **Fig. 7(b)**, as health condition worsened (M-1SD), threat appraisal exhibited a significant and positive prediction effect on flood preparedness (Slope =0.400). The prediction effect of threat appraisal gradually weakened with the improved health condition. Threat appraisal showed a positive prediction effect (Slope =0.238), as health condition became good (M+1SD). Improvement in health condition reduced the positive effect of threat appraisal on flood preparedness.

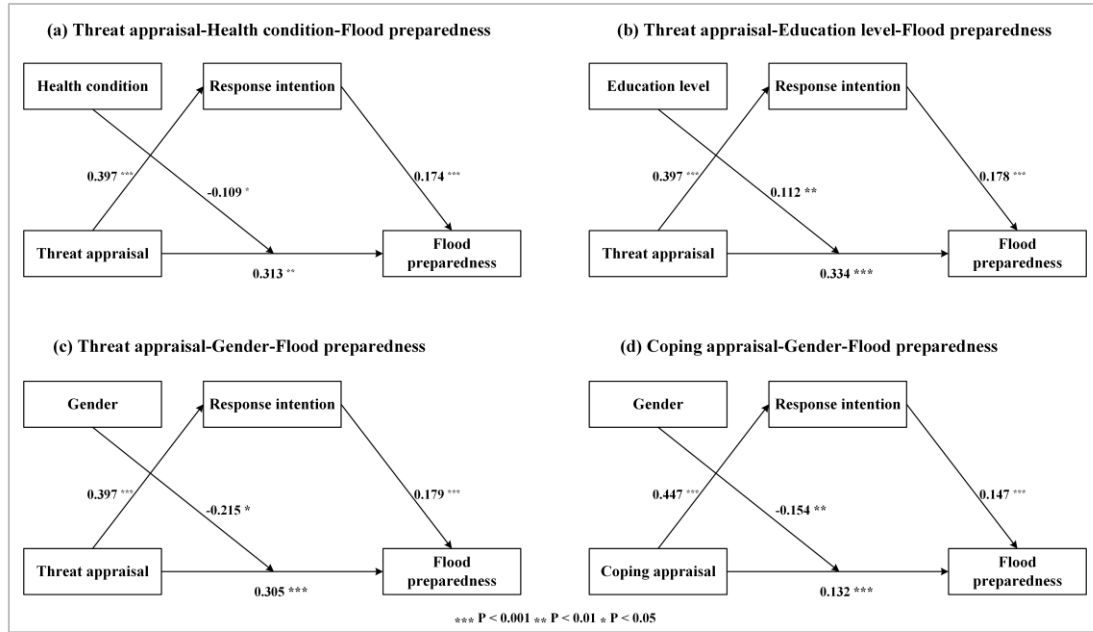


Fig. 6. Influence path of flood preparedness.

Relationship between threat appraisal and flood preparedness was positively moderated by education level. Threat appraisal showed a significant and positive effect on response intention and flood preparedness (0.334) in **Fig. 6(b)**. Response intention also demonstrated a positive effect on flood preparedness (0.178). Direct effect of threat appraisal on flood preparedness was greater than indirect effect under the impact of education level and response intention. Slope test revealed that, in **Fig. 7(b)**, when education level was low (M-1SD), threat appraisal had a positive prediction effect on flood preparedness (0.211). When education level was high (M+1SD), threat appraisal also significantly and positively predicted flood preparedness with greater prediction effect (0.457). As education level improved, there was a decreasing trend in the predictive effect of threat appraisal.

Gender also played a negative moderating effect between threat appraisal and flood preparedness in **Fig. 6(c)**. Threat appraisal exhibited a positive effect on response

intention and flood preparedness (0.305), and response intention also had a positive effect (0.179). With the influence of gender and response intention, direct effect of threat appraisal on flood preparedness was more substantial than indirect effect. In Fig. 7(c), for individuals with male gender (M-1SD), threat appraisal positively predicted flood preparedness (0.426). For individuals with female gender (M+1SD), threat appraisal positively still showed a significant and positive prediction effect (0.211). Predictive effect of threat appraisal on flood preparedness was essential in the male group than females.

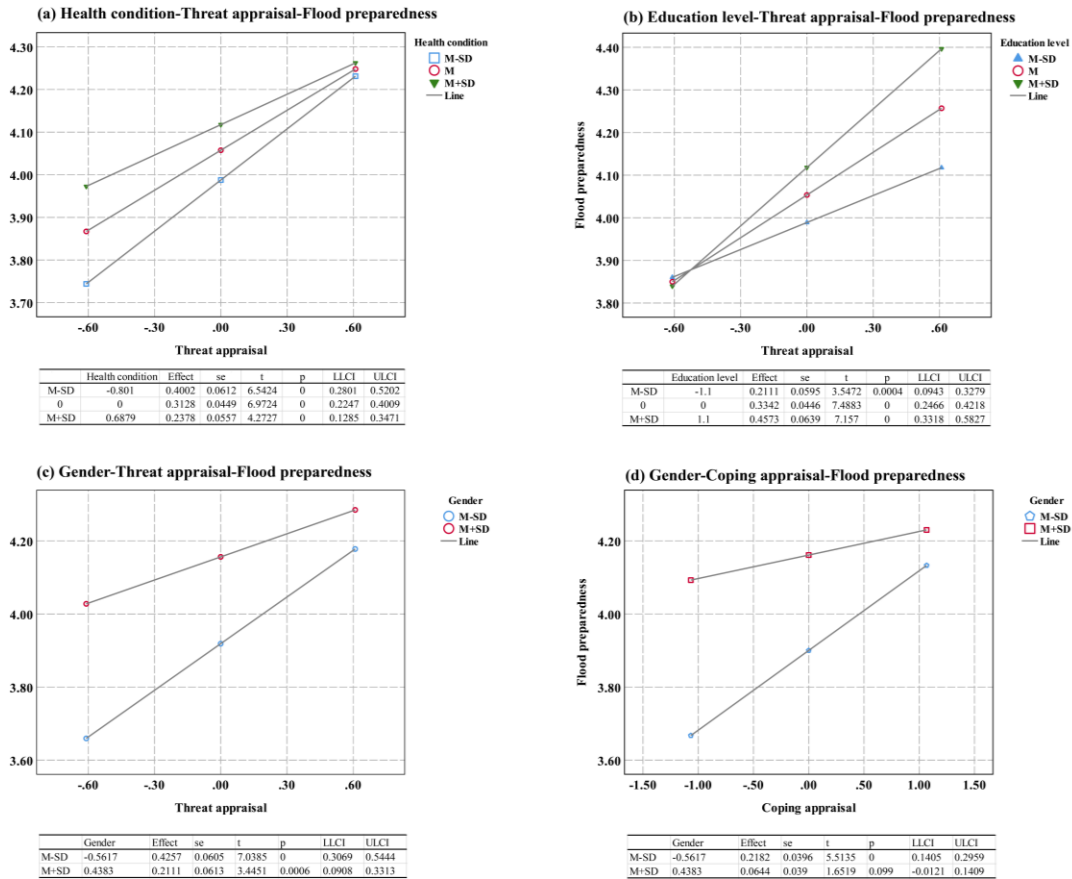


Fig. 7. Moderating effect on flood preparedness.

Gender negatively moderated the relationship between coping appraisal and flood preparedness. In Fig. 6(d), coping appraisal positively influenced response intention (0.447) and flood preparedness (0.132), and response intention showed a positive effect

on flood preparedness (0147). Under the influence of gender and response intention, coping appraisal exhibited a greater direct effect on flood preparedness than indirect effect. In **Fig. 7(d)**, when gender was male (M-1SD), coping appraisal positively predicted flood preparedness (0.218). When gender was female (M+1SD), coping appraisal represented a positive but insignificant prediction effect (0.064). The predictive effect of coping appraisal on flood preparedness was observed to be lower among females.

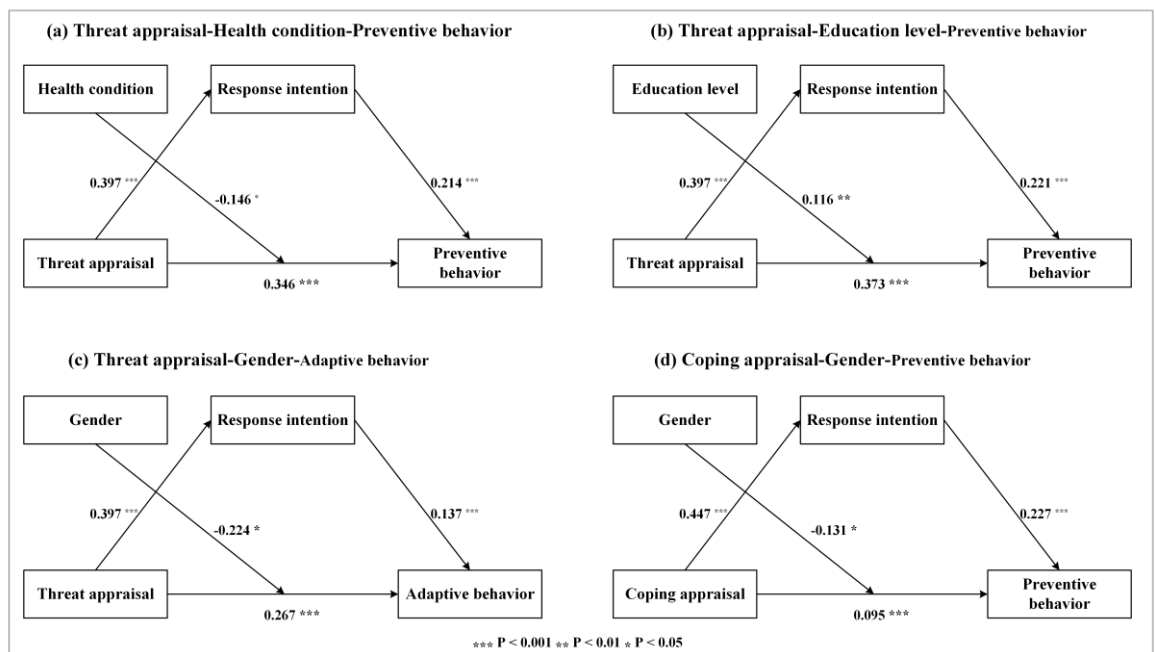


Fig. 8. Influence differences on adaptive and preventive behavior.

This study examined the behavior differences of flood preparedness influenced by flood risk perception, response intention and social-economic factors. Health condition played a negative mediating effect between threat appraisal and preventive behavior, and response intention showed a moderation effect (**Fig. 8(a)**). Threat appraisal could transform into preventive behavior under the influence of response intention and health condition. Slope test (**Fig. 9(a)**) revealed that prediction effect between threat appraisal

and preventive behavior diminished with an improvement in health condition. Furthermore, education level displayed a moderating effect between threat appraisal and preventive behavior (**Fig. 8(b)**). Threat appraisal could transform into preventive behavior under the fluence of education level and response intention. But prediction effect diminished, as education level increased, based on slope test (**Fig. 9(b)**).

Gender played a moderation effect between threat appraisal and adaptive behavior. Threat appraisal could transform into adaptive behavior with the effect of response and gender (**Fig. 8(c)**). When gender was male (M-1SD), threat appraisal demonstrated a stronger positive prediction effect on adaptive behavior (0.458) in **Fig. 9(c)**. Furthermore, coping appraisal could transform into preventive behavior under the mediating effect of response intention and the moderation effect of gender (**Fig. 8(d)**). When gender was male (M-1SD), coping appraisal positively predicted preventive behavior (0.168) in **Fig. 9(d)**. When gender was female (M+1SD), coping appraisal had a weak and insignificant prediction effect on preventive behavior (0.0378). Risk perception was more likely to be translated into preventive behavior among males.

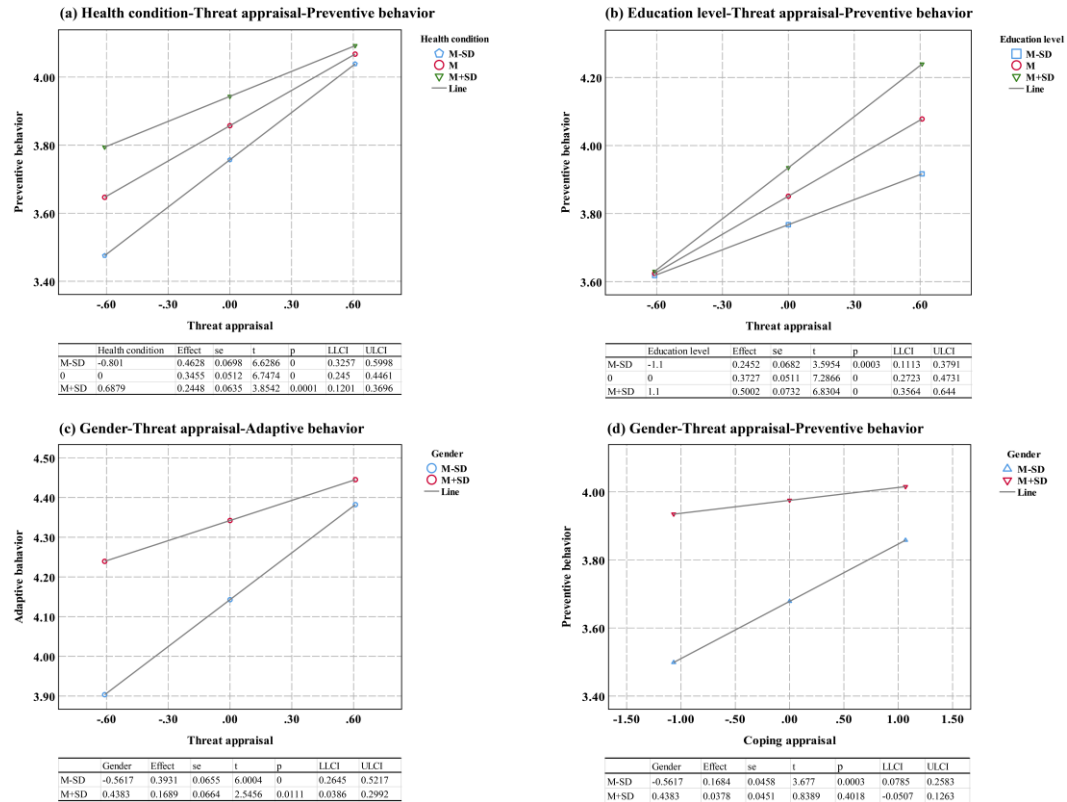


Fig. 9. Moderating effect on adaptive and preventive behavior.

4. Discussion

This study revealed that there was no significant difference of risk perception in genders, but females demonstrated a higher level of flood preparedness, consistent with previous research (Rana et al., 2020; Rasool et al., 2022). Individuals who regularly exercised exhibited a higher level of risk perception, because adequate physical activity enhanced their response and judgment capabilities, and made cognitive activities more active. The elderly, particularly those aged 51-60 and above 60, showed a higher level of risk perception but the lower flood preparedness. Regarded as socially vulnerable groups, the elderly more probably perceived flood risk (Harlan et al., 2019), and due to insufficient fitness and reaction, they struggled to undertake practical behaviors in response to hazards. Higher risk perception was observed on groups with low education

level, while those with high education level showed a higher level of flood preparedness. People with lower educational degree were typically associated with lower social status, and more inclined to engage in occupations that are dangerous or risky (Bollettino et al., 2020; Kiani et al., 2022), which incentivized them to proactively perceive flood risks. But highly educated people could seek out diverse information about disasters and prepared adequately for floods (Rana et al., 2020). Long living time made people become acquainted with local conditions, leading to a positive perception of flood risk. People who experienced and worried about flood tended to perceive a higher risk, and made adequate preparation for floods. Past flood experiences were found to trigger risk perception and a greater intention to take adjustment action (Ao et al., 2020). Individuals were more likely to report higher risk perception and preparedness, when floods were associated with negative emotions or memories (Rufat and Botzen, 2022).

Enough high threat appraisal could trigger coping appraisal (Schlef et al., 2018), which both caused the higher protection motivation and promoted the mitigation measures (Kurata et al., 2022). Despite finding the high threat appraisal and medium coping appraisal, threat appraisal might not reach the necessary threshold that effectively triggered coping appraisal, and coping appraisal showed no effect on flood preparedness in our results. Individuals tended to rely on threat appraisal to perceive risk and failed to generate an adequate coping appraisal, leading to insufficient risk perception. Therefore, risk perception struggled in translating into flood preparedness, with unbalanced relationship. The influence of threat appraisal on flood preparedness was greater in groups with low risk perception than those with high risk perception. The

transformation of low risk perception into flood preparedness could be attributed to the relatively stronger effect of threat appraisal on flood preparedness. The association between high risk perception and low flood preparedness could arise from the weak effect of threat appraisal on flood preparedness. However, due to the significant influence of other factors, such as government trust, individuals were more likely to demonstrate greater preparedness for floods among groups with a high level of risk perception.

Various social-economic characteristics influenced individual preferences for different ways to achieve risk perception and flood preparedness. Females had higher flood worry and depended more on flood knowledge to perceive risk than males, possibly because of the general cognition that women were more vulnerable and sensitive (Eryılmaz Türkkan and Hırca, 2021). It was suggested that females should keep calm, and improve risk perception through flood knowledge. The elderly relied on both flood knowledge and worry for risk perception. Although they demonstrated a greater influence of government trust on flood preparedness, lower level of government trust could potentially hinder their flood preparedness efforts. People with low education level preferred flood knowledge for risk perception, and were advised to boost their trust in government to improve flood preparedness. Individuals with longer residence durations relied more on flood knowledge for risk perception, while those with short living time, unfamiliar with local floods, depended more on government trust for risk perception and favored threat appraisal to achieve flood preparedness. Groups with poor health relied more on flood knowledge for flood preparedness, as adequate

600 risk knowledge could compensate for physical functional limitations. Individuals with
601 regular exercising group showed a preference for threat appraisal in preparation for
602 floods. Moreover, individuals with bad habits, considered psychologically fragile and
603 sensitive, preferred flood risk worry and knowledge, and government trust for risk
604 perception.

605 In our study, risk perception, including both threat and coping appraisal,
606 demonstrated a direct influence on flood preparedness, and response intention exhibited
607 a mediating effect. Socio-economic factors, especially education level and health
608 condition, played a moderating effect between risk perception and flood preparedness.
609 People with high education level were better equipped to process complicated
610 information, and act promptly during the time lag between action and outcome
611 (Dootson et al., 2022). As health condition improved, there was a negative predictive
612 effect of threat appraisal on flood preparedness. Though people reporting good health
613 displayed confidence with physical function, overconfidence could impede the
614 translation of risk perception into preparedness (Bollettino et al., 2020). These groups
615 should attach importance to timely feedback in response to floods. Among males,
616 despite the low level of flood preparedness, threat and coping appraisal were stronger
617 predictors of flood preparedness. With the effect of response intention and socio-
618 economic factors, risk perception could transform into flood preparedness, and caused
619 the differences of preventive and adaptive behaviors. People with high education level
620 would more probably perceive risk, and engage in preventive behavior against flooding.
621 Groups with bad health were more likely to perceive flood risk and adopt preventive

measures.

This study revealed the influence of socio-economic factors on risk perception and flood preparedness. But we only found the influence path from a part of factors, and results may not be generalized to all socio-economic characteristics. Rationality and reliability of influence path require further empirical validation in future studies. Because of climate change, the adoption of different behaviors was significantly influenced by how individuals perceived and evaluated risk (Bodoque et al., 2019). When risk events were associated with adequate benefits, individuals tended to show a preference for adaptive behaviors (Zhang et al., 2021b). Consequently, comprehensive analysis of benefits and costs was crucial for understanding risk perception and preparedness.

5. Conclusion

A questionnaire survey was designed and conducted to explore the influence relationship between risk perception and flood preparedness. Participants exhibited a medium level of risk perception and demonstrated a high level of flood preparedness. High levels of risk perception were observed on groups of regular exercising, the elderly, flood experience, low education level, long living time and flood worry. Higher floods preparedness was more prevalent among groups of females, the elderly and high education level. Individuals tended to rely primarily on threat appraisal to perceive flood risk, and failed to trigger the adequate coping appraisal. This process resulted in a challenging translation of risk perception into flood preparedness, accompanied by unbalanced relationship. Groups with distinct social-economic features showed

different preferences to realize risk perception and flood preparedness. Females were more inclined to perceive risk through flood knowledge to, and were suggested to keep calm and enhance risk perception by flood knowledge. Elderly individuals and people with low education level also depended on flood knowledge for risk perception, while lower government trust possibly hindered taking flood preparedness. Path analysis indicated that threat appraisal could transform into flood preparedness, influenced by response intention, education level, or health status condition. Groups with high education level or bad health would more probably perceive risk and engage in preventive behavior. This study provided essential insights for promoting flood preparedness in response to floods. Future research should consider the benefits and costs associated with flood risk to reveal the heterogeneity of preparedness behaviors.

Author contribution

Yabo Li: Methodology, Investigation, Writing - Original Draft. **Peng Wang:** Conceptualization, Writing - Review & Editing, Supervision.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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874