https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

Natural Hazards and Earth System Sciences
Discussions
Open Access
EGU

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

Yabo Li [a,b], *Peng Wang* [b,c,*]

[a] *Polytechnic Institute, Zhejiang University, Hangzhou 310015, China*

[b] *Faculty of Civil Engineering and Mechanics, Jiangsu University, Zhenjiang 212013, China*

[c] *State Key Laboratory of Pollution Control & Resource Reuse, School of the Environment, Nanjing University, Nanjing 210023, China*

*Corresponding author.

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

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

Natural Hazards and Earth System Sciences
Discussions

Abstract

Although risk perception and flood preparedness were crucial in flood management, perceived flood risk was not always translated into flood preparedness. It was essential to investigate the potential association between risk perception and flood preparedness. This study focused on Nanjing as the research region, designed questionnaire survey and explored the influence relationship between risk perception and flood preparedness. Participants showed the medium perception of food risk and higher flood preparedness. Higher risk perception was observed in individuals with regular exercising, the elderly, low education level and long living time. Higher flood preparedness occurred among groups of females, the elderly and high education level. Individuals relied more on threat appraisal to perceive risk, which failed to trigger high enough coping appraisal. Inadequate risk perception led to a strenuous transform into flood preparedness with unbalanced relationship. Groups with distinct socio-economic characteristics exhibited varying preferences to achieve risk perception and flood preparedness. Females relied more on flood knowledge to perceive flood risk. Path analysis suggested that threat appraisal transformed into flood preparedness under the effect of response intention and social-economic features. Groups with high education level or bad health were more likely to perceive risk and engage in preventive behavior. These findings could provide critical insights into intervention strategies for enhancing public flood preparedness in flood management.

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

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024


Natural Hazards and Earth System Sciences
Discussions

1. Introduction

Natural disasters caused immense damage and irreversible losses with global climate change (Guo, Wu, & Wei, 2020). Floods still remained the most prevalent and severe disaster worldwide and occupied the dominated composition in a total of 432 disaster events in 2021. Due to rapid urbanization and concentrated population and assets (Deng, Wang, Wu, & Lai, 2022; Dong et al., 2022), urban areas became more susceptive and vulnerable to flood events (P. Wang, Li, & Zhang, 2021). It was predicted that climate change and heavy rainfall were more frequent and intense with high reliability (Rifat & Liu, 2022; Steinhausen et al., 2021), and significantly increased urban flood risk, especially in developing countries (Zhu et al., 2021). Despite the substantial financial investment and mitigation efforts, floods continued to pose a serious threat to human society in the foreseeable future (Thongs, 2019; Ke Zhang et al., 2022). It was imperative to adopt effective flood management for sustainable development.

In response to flood events, it was unadvisable to completely take traditional structural measures (Rasool, Rana, & Ahmad, 2022), such as dikes and dams. Risk perception acted as non-structural measures and received considerable attention in current research (Ahmad & Afzal, 2020). Flood risk perception reflected risk acceptance and revealed feelings, opinions and judgements regarding direct or potential hazards (Rana, Jamshed, Younas, & Bhatti, 2020; Yang, 2019). According to Protection Motivation Theory (PMT), cognitive process determined self-protective motivation (Khani Jeihooni, Bashti, Erfanian, Ostovarfar, & Afzali Hasirini, 2022), and threat

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

appraisal and coping appraisal were the important components of risk perception (Roder, Hudson, & Tarolli, 2019). Limited understanding of flood risk perception led to failures in flood management practices (Ahmad & Afzal, 2020). Successful flood management highly depended on the implementation of mitigation measures, because people were both flooding victims and implementors of disaster mitigation policies (Z. Wang, Wang, Huang, Kang, & Han, 2018; Yin et al., 2021). Flood preparedness acted as individual protection action and reflected response behaviors during floods, including preventive and adaptive behavior (Sado-Inamura & Fukushi, 2019). Subjective expected utility theory assumed that people assessed likelihood and consequences of alternative choices (Rufat & Botzen, 2022). Individuals would seek or wait for sufficient information to support the action of responding to flooding (Dootson, Kuligowski, Greer, Miller, & Tippett, 2022; Rufat & Botzen, 2022). Adequate flood preparedness ensured 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 was believed to promote flood preparedness, but high perceptions of risk could not always translate to disaster preparedness (Schlef, Kaboré, Karambiri, Yang, & Brown, 2018). There was not direct and simple relationship between risk perception and flood preparedness as expected. Some studies found the results contradictory to the popular opinion that high perception of flood risk caused high flood preparedness (Rasool et al., 2022) and suggested the weak relationship between risk perception and flood preparedness (Valois et al., 2020), even without

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024


Natural Hazards and Earth System Sciences
Discussions

direct link (Ao et al., 2020; Wachinger, Keilholz, & O'Brian, 2018). High risk perception even motivated people to avoid or ignore willfully specific actions under uncertain circumstances (Wachinger, Renn, Begg, & Kuhlicke, 2013). There was no consensus on how risk perception affected and predicted preparedness behavior (Huang & Lubell, 2022; Taylor, Dessai, & Bruine de Bruin, 2014). Connection between risk perception and preparedness appeared more strenuous in practice (Valois et al., 2020), due to the ignorance of the existence of unknown intermediary (Ao et al., 2020; Yong & Lemyre, 2019). Theory of Planned Behavior anticipated how people behaved in specific situation and connected behavior with individual control, with intention being the predictor of behavior (Ghanian et al., 2020; Kurata, Prasetyo, Ong, Nadlifatin, & Chuenyindee, 2022). For individual cognitive decision-making, intention served as the intermediate link between perception and behavior (Soetanto, Mullins, & Achour, 2017), and ample social-scientific evidence supported the positive relationship between risk perception and intention to respond, not actual behaviors (Harlan, Sarango, Mack, & Stephens, 2019; van Valkengoed & Steg, 2019).

Individuals with different backgrounds got involved in flood management, perceived flood risk in various ways (Rasool et al., 2022) and developed personal intention to follow risk response (Kurata et al., 2022). Socio-economic features were the most controversial driving factors of risk perception (Shah et al., 2020) and flood preparedness (Ao et al., 2020), with relevant studies reporting mixed and inconsistent results (Rufat & Botzen, 2022). Socio-economic features determined the social group to which people belonged and affected individual perception and action towards

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024


Natural Hazards and Earth System Sciences
Discussions

hazards (Harlan et al., 2019). But most studies only estimated simple correlations and included socio-economic factors as control variables in regression analysis (Rufat & Botzen, 2022). Moreover, most research mainly focused on influencing factors of risk perception and flood preparedness (Ao et al., 2020; Sun & Sun, 2019; Ullah, Saqib, Ahmad, & Fadlallah, 2020). The few attached importance to influence path between flood risk perception and flood preparedness (Wachinger et al., 2018). Existing research has extensively examined risk perception and flood preparedness in developed nations, but the potential linkages between flood risk perception and disaster preparedness was under-explored, particularly in developing countries (Scaini, Stritih, Brouillet, & Scaini, 2021; Keshun Zhang, Parks-Stamm, Ji, & Wang, 2021). Effective policies for flood management could benefit from a more integrated intervention framework that connected risk perception with flood preparedness.

Despite the continuous flood protection efforts, Nanjing has experienced increasingly severe flood damage in recent years. This study examined flood risk perception in Nanjing, and investigated transformation relationship between risk perception and flood preparedness from the perspective of response intention and socio-economic factors. This study aimed to: (1) identify the distribution characteristics of risk perception and flood preparedness; (2) analyze the influence effect of different factors combined with social-economic feature; (3) reveal the influence path between risk perception and flood preparedness. **Fig. 1** illustrated the comprehensive framework of the study.

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

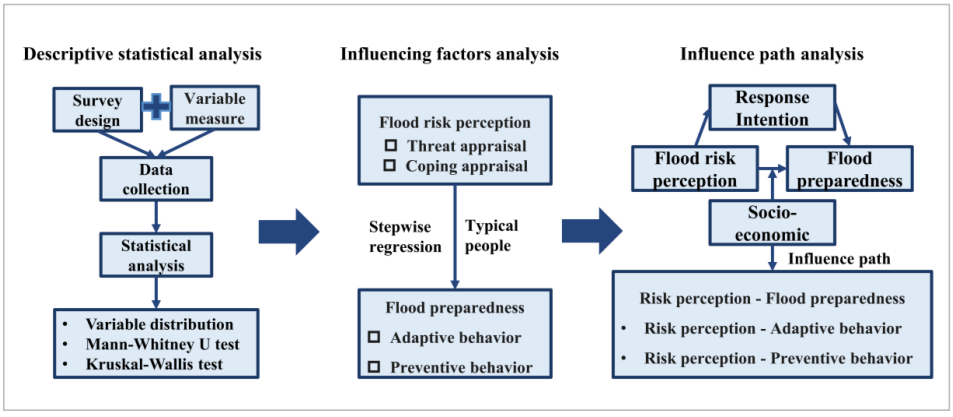


Fig. 1. Overall framework of this study.

2. Material and methods

2.1 Study region

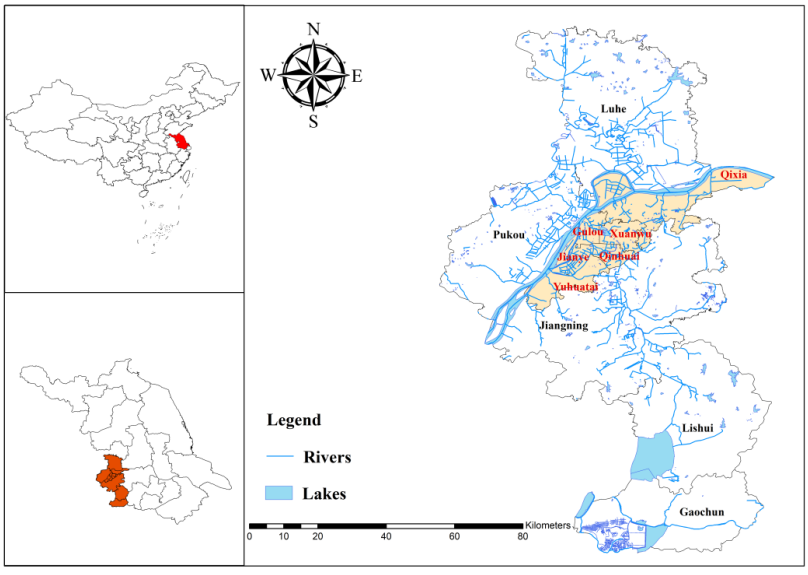


Fig. 2. Study area

Nanjing was located in the middle and lower reaches of Yangtze River in eastern China, with a municipal area of 6587.02 km^2. The city belonged to a typical subtropical and monsoon climate region, characterized by distinct seasonal changes and abundant

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

rainfall. Nanjing had jurisdiction over 11 urban district, 95 streets and 6 towns by 2021. As one of national key flood control cities, Nanjing confronted with the conflict of rapid urbanization and increasing floods (H. Zhang et al., 2021). Nanjing was estimated to exhibit higher flood risk across various flood return periods (P. Wang, Li, Yu, & Zhang, 2021), especially in the central urban districts surrounding the Yangtze River (Li et al., 2022). Consequently, this study focused on six districts (**Fig. 2**) of urban center to explore the relationship between flood risk perception and flood preparedness for fostering flood resilient cities.

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 consisted of four parts: (1) Socio-economic condition; (2) Flood risk perception; (3) Flood preparedness; (4) Response intention. Comprehensive and detailed description of the questionnaire was provided in **Supplementary material**. The first section collected information about participants' socio-economic condition, 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 examining both threat appraisal and coping appraisal.

Flood preparedness encompassed both adaptive and preventive behaviors in the third section. Adaptive behavior involved a series of measures aimed at mitigating and adapting to floods, while preventive behavior focused on actions taken to prevent and reduce negative effects during flood events. The fourth section included a survey on

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024


Natural Hazards and Earth System Sciences
Discussions

response intention and consisted of factors influencing flood risk perception and preparedness. Additionally, flood risk knowledge referred to the level of grasping flood related knowledge among local residents, while flood risk worry evaluated individuals' fear and concern about floods. Furthermore, 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)
Response intention	Flood risk knowledge	(1,5)
	Government trust	(1,5)
	Flood risk worry	(0,1)
	Flood experience	(0,1)
	Flood disaster education	(0,1)
Socio-economic factors	Gender	(1,2)
	Age	(1,7)
	District	(1,6)
	Education level	(1,5)
	Living time	(1,5)
	Health condition	(1,5)

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

	Life style	(0,1)
	Exercise situation	(0,1)

2.3 Data collection

This study conducted a survey in six districts of Nanjing: Gulou, Xuanwu, Jianye, Qinhuai, Qixia and Yuhuatai district respectively. We implemented the preliminary test of online questionnaire before officially issue to minimize the participants' misunderstanding and confusion. Survey results were collected from interviewees and the questionnaire was adjusted based on online feedback to reduce bias. We then performed face-to-face questionnaire surveys in densely populated streets of Nanjing from April 24, 2021 to April 30, 2021.

Interviewers received excellent survey skills training before formal interview, and 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 given enough time to review questionnaire content adequately, and had the option to withdraw from survey at any time. Complete questionnaire comprised 52 questions and required 15–20 minutes for completion approximately. To encourage and appreciate for participation, interviewers presented self-made gifts to respondents after finish. Eventually, this study distributed 844 questionnaires and obtained 737 valid questionnaires after excluding 107 invalid ones with an effective rate of 87.32%.

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

2.4 Statistical analysis

By exporting the 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 and Kruskal-Wallis statistical tests were nonparametric statistical test used to compare the value of variables between two and several independent groups respectively. We employed these tests to compare the average score of indicators and variables and explore whether there were the statistically significant differences in distribution. Correlation analysis were used to examine the influence factors of flood risk perception and flood preparedness. Furthermore, this study implemented the stepwise regression approach to reveal the impact of different factors on risk perception and flood preparedness. Finally, we performed Model 5 in PROCESS macro program of SPSS to capture the influence path between flood risk perception and flood preparedness. All statistical analyses were conducted at a significance level of 0.05.

3. Results

3.1 Descriptive statistical analysis

Cronbach's α (0894) and KMO value (0.891) both exceeded 0.7 in this questionnaire and illustrated the high reliability and validity. **Table 2** presented the descriptive analysis about basic information of participants. Among 739 respondents, there was 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

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024


Natural Hazards and Earth System Sciences
Discussions

(14.5%), 26-30 years (12.5%), over 60years (11.9%), 51-60 years (11.4%) and below 18 years (1.4%). The majority of 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, most participants lived in Nanjing 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 stayed in excellent health (49.5%), better (34.7%) and general health (13.6%), while few people reported very poor (0.4%) and poor (1.8%) health. The majority didn't smoke (81.1%) and 18.9% showed the habit of smoking. Over half often engaged in regular exercising (61.2%) and 38.8% lacked adequate exercise.

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

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

Natural Hazards and Earth System Sciences
Discussions

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
Health condition	Very poor	3	0.4
	Poor	13	1.8
	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 kept at a medium level with the average score of 3.57. Residents exhibited a high level of threat appraisal and a medium level of coping appraisal. The average level of flood

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

preparedness was relatively high (4.05), and local participants demonstrated the high level of adaptive behavior (4.25) and 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

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024


Natural Hazards and Earth System Sciences
Discussions

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 significant results from 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 had higher levels 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. Groups with flood experience showed higher levels of flood risk perception and response intention (416.08 and 507.11).

Table 4

Mann-Whitney U test in gender.

Category	Gender			
	Mean rank		Z-value	P-value
	Male	Female		
Adaptive behavior	340.71	391.07	-3.22	0.00

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

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			
	Mean rank		Z-value	P-value
	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			
	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		

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024


Natural Hazards and Earth System Sciences
Discussions

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 significant results from 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. Coping appraisal levels were lower in the 18-25 age group compared to those aged 51-60 and ≥60 years. Preventive behavior was lower among people aged 51-60 than those aged 18-25 and 31-40, respectively. People aged 51-60 possessed 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. Flood disaster education level was higher in the 41-50 age group than in18-25 age group. Flood risk perception was higher among individuals aged 51-60 and over 60 years than those aged 18-25. Flood preparedness was higher among individuals aged 31 to 40 than those aged 51 to 60 years, while response intention was higher within people aged 51-60 years than those aged 18-25.

Table 8

Kruskal-Wallis test in age.

Category	Age							
	Mean rank							Sig.(p)
	≤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

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

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

In terms of education level (**Table 9**), the average rank of threat appraisal for postgraduate and above was lower than that of high school and undergraduate. Coping appraisal for postgraduate was lower than that of middle school, high school and undergraduate. People with an undergraduate education exhibited a higher mean rank of preventive behavior than those in middle school. People with middle school and high school education possessed a higher level of flood risk knowledge than that of 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 compared to those in middle school.

Table 9

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024


Natural Hazards and Earth System Sciences
Discussions

277 Kruskal-Wallis test in education level.

Category	Education level					
	Mean rank					Sig.(p)
	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

278 Moreover, people residing for over 10 years had the higher mean rank of coping
279 appraisal than those living for less than 1 year, 1-3 years and 5-10 years. Living for less
280 than 1 year brought a low level in coping appraisal than residing for 3-5 years.
281 Individuals with residence duration of over 10 years grasped more flood risk knowledge
282 than living time of less than 1 year, 1-3 years and 5-10 years. Mean rank of flood
283 experience was higher for individuals residing for over 10 years than those living for
284 less than 1 year, 1-3 years, and 3-5 years. People with over 10 years living time had a

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024


Natural Hazards and Earth System Sciences
Discussions

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

Table 10

Kruskal-Wallis test in living time.

Category	Living time					
	Mean rank					Sig.(p)
	< 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

Table 11

Kruskal-Wallis test in health condition.

Category	Health condition	
	Mean rank	Sig.(p)

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

	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 was significantly and positively related to coping appraisal and flood risk perception. There was the moderately positive and significant correlation between government trust and flood risk perception. Flood risk worry, flood disaster education and flood experience showed significant and weakly positive relationship with risk perception. Among socio-economic factors, gender exhibited 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 district, education level, living time, life style and exercise situation were unrelated to flood preparedness. Gender, age and health condition were weakly correlated to flood preparedness. Flood risk perception was significantly and positively related to response intention, but flood preparedness showed lower correlation with flood risk perception and intention response.

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

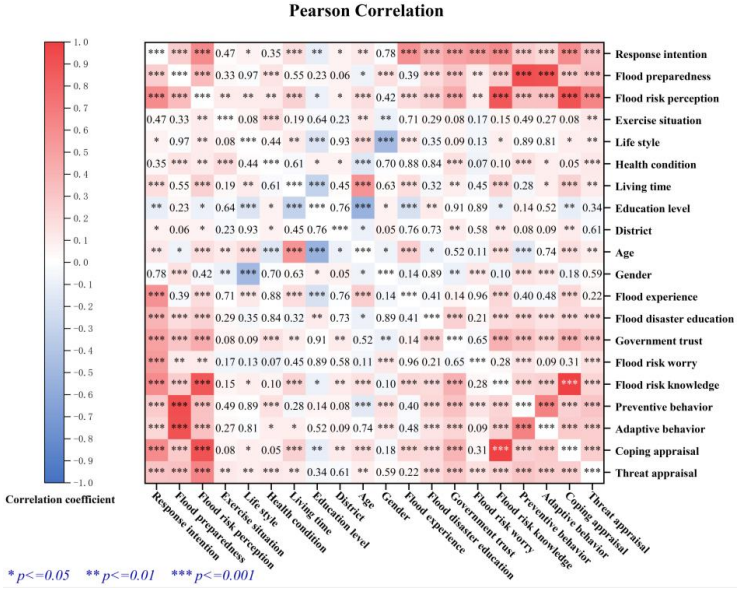


Fig. 3. Pearson correlation analysis.

3.4. Influencing factors of risk perception

Table 12 presented the results of stepwise regression analysis. We selected all variables for regression analysis in model 1, and found that flood risk knowledge showed significant and positive effect while other variables exhibited relatively lower effects. Model 2 demonstrated a high goodness of fit (adjusted R^2=0.788) after removing socio-economic variables, and flood risk knowledge also maintained a higher influence (0.827) on flood risk perception. In model 3, the exclusion of flood risk knowledge resulted in 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. The effect of flood experience on risk perception shifted from insignificant to significant. Although flood risk knowledge significantly promoted risk perception, it

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

also inhibited and decreased the positive effects of other factors. Faced with 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	Standardized coefficient		
	Model 1	Model 2	Model 3
Flood risk knowledge	0.814***	0.827***	-
Flood risk worry	0.074***	0.067***	0.100**
Government trust	0.093***	0.094***	0.396***
Flood disaster education	0.060***	0.053***	0.146***
Flood experience	-0.010***	0.010	0.168***
Gender	0.057**	-	-
Age	0.067**	-	-
District	-0.027	-	-
Education level	0.010	-	-
Living time	0.010	-	-
Health condition	0.056**	-	-
Life style	0.057**	-	-
Exercise situation	0.038*	-	-
R^2	0.803	0.790	0.250
Adjusted R^2	0.800	0.788	0.246
F	227.270	549.538	61.083

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

This study categorized participants based on socio-economic feature to explore the impact of different factors. **Fig. 4** only listed the significant results of regression analysis and more detailed information was provided in **Supplementary materials**.

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024


Natural Hazards and Earth System Sciences
Discussions

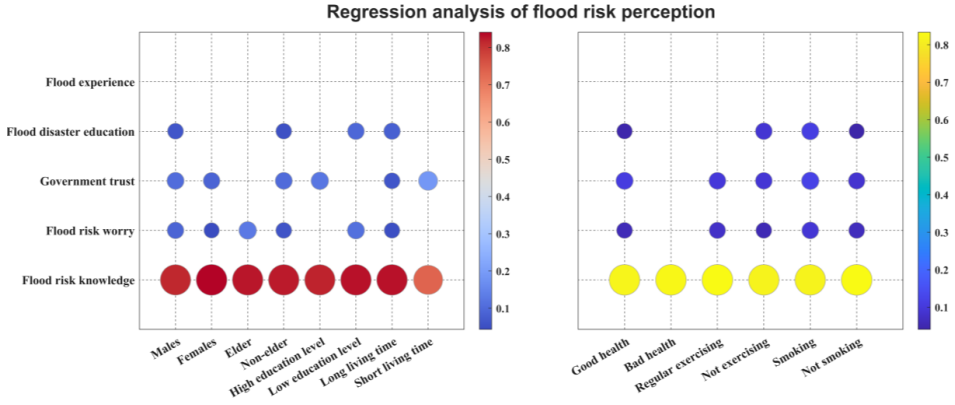
Among males, flood risk knowledge, flood risk worry, government trust and flood disaster education positively affected flood risk perception, with standardized coefficients of 0.815, 0.087, 0.105 and 0.062 respectively. In females, flood risk knowledge, flood risk worry and government trust exhibited significant effects on risk perception, with standardized coefficients of 0.841, 0.043 and 0.090 respectively. Flood risk knowledge showed a greater impact among females, while flood risk worry and government trust had a higher influence in males. Among the elderly, flood risk knowledge and worry significantly affected flood risk perception with influence coefficients of 0.828 and 0.128 respectively. Flood risk knowledge, flood risk worry, government trust and flood disaster education showed significant effects (0.823, 0.059, 0.101 and 0.056) among young and middle-aged individuals. Compared with the non-elderly, the elderly exhibited a higher influence of flood risk knowledge and worry on risk perception.

In people with high education level, flood risk knowledge and government trust significantly and positively affected flood risk perception (0.817 and 0.124). However, for individuals with low education level, flood risk knowledge showed a higher impact (0.831), and flood risk worry and flood disaster education significantly influenced risk perception, with standardized coefficients of 0.109 and 0.093 respectively. For individuals with a short living time, only flood risk knowledge and government trust showed significant positive effects (0.734 and 0.187) to flood risk perception. But among people with long living time, flood risk knowledge had a greater impact on risk perception (0.829), while government trust exhibited a lower effect (0.064).

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

Natural Hazards and Earth System Sciences
Discussions

354 Additionally, flood risk worry and disaster education also showed significant effects
355 (0.051 and 0.083).



356

357 **Fig. 4. Regression analysis of flood risk perception.**

358 For individuals in good health, only flood risk knowledge significantly affected
359 risk perception (0.821). Among people in bad health, flood risk knowledge showed a
360 greater effect (0.824), and flood risk worry, government trust and flood disaster
361 education also affected risk perception with standardized coefficients of 0.059, 0.107
362 and 0.046. For individuals who regularly exercised, flood risk knowledge, flood risk
363 worry, government trust and flood disaster education showed significant positive effects
364 (0.817, 0.056, 0.091 and 0.090) on risk perception. However, among groups without
365 exercising, flood risk knowledge, flood risk worry and government trust showed a
366 lower impact, with standardized coefficients of 0.833, 0.076 and 0.097. For people with
367 bad habit, flood risk knowledge, flood risk worry, government trust and flood disaster
368 education showed significant effects (0.815, 0.093, 0.118 and 0.111) on risk perception.
369 But among groups without bad habit, the effect of flood risk knowledge was lower
370 (0.831), while flood risk worry, government trust and flood disaster showed a greater

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

371 impact on risk perception with standardized coefficients of 0.063, 0.086 and 0.041.

372 **3.5. Influencing factors of flood preparedness**

373 **Table 13** listed the stepwise regression results of flood preparedness. Threat
374 appraisal had a significant and positive influence (0.213), followed by government trust
375 (0.178), flood risk knowledge (0.140), flood disaster education (0.08) and flood risk
376 worry (0.07), while only flood experience exhibited a negative effect (-0.09). Lower
377 influence of threat appraisal on flood preparedness suggested that high risk perception
378 may be associated with insufficient flood preparedness behavior. This study also
379 considered socio-economic features as group categories, and explored the influence
380 effects of different factors (**Fig. 5**). **Supplementary materials** provided more detailed
381 information about stepwise regression.

382 In the high risk-perception groups, threat appraisal significantly and positively
383 affected flood preparedness (0.226), followed by flood disaster education (0.213), flood
384 risk worry (0.162), government trust (0.123), flood risk knowledge (0.103). Only flood
385 experience had the negative effect (-0.171). For the low risk-perception groups, threat
386 appraisal had a higher influence (0.309) on flood preparedness, but other factors were
387 not significant. Among individuals with low response intention, only threat appraisal
388 and government trust had significant positive effects on flood preparedness (0.211 and
389 0.172). For people with high response intention, the effect of threat appraisal and
390 government trust increased and reached 0.216 and 0.193 respectively, while flood risk
391 knowledge, flood disaster education and flood experience also exhibited significant
392 influences (0.217, 0.106 and -0.112). High response intention improved the influence

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024


Natural Hazards and Earth System Sciences
Discussions

393 effect of threat appraisal and government trust and led to significant effects of other
394 different factors.

395 **Table 13**

396 Stepwise regression analysis results of flood preparedness.

Variable	Standardized coefficients	p-value
Threat appraisal	0.213	0.000
Flood risk knowledge	0.140	0.000
Flood risk worry	0.072	0.034
Government trust	0.178	0.000
Flood disaster education	0.075	0.032
Flood experience	-0.078	0.024
R^2	0.184	
Adjusted R^2	0.177	
F	27.439	

397 Among males, threat appraisal, flood risk knowledge and government trust had
398 significant effects on flood preparedness (0.263, 0.192 and 0.240). In females, threat
399 appraisal, government trust, and flood disaster education significantly affected flood
400 preparedness (0.154, 0.141, and 0.123). The effect of threat appraisal was crucial in
401 males compared to females. Among the elderly, only threat appraisal and government
402 trust had significant and positive effects on flood preparedness (0.237 and 0.319). But
403 in non-elderly individuals, the influence of threat appraisal and government trust was
404 lower (0.217 and 0.155). Furthermore, flood risk knowledge, flood risk worry, flood
405 disaster education and flood experience significantly affected flood preparedness, with
406 standardized coefficient of 0.136, 0.028, 0.096 and -0.086 respectively.

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

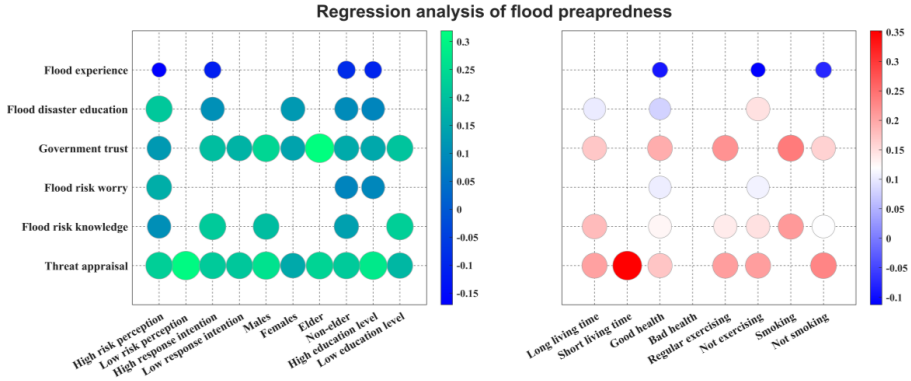


Fig. 5. Regression analysis of flood preparedness.

In people with high education background, 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. Flood risk knowledge also had a positive influence on flood preparedness (0.226). Among individuals with long living time, threat appraisal, flood risk knowledge, government trust and flood disaster education showed significant and positive effects on flood preparedness (0.204, 0.180, 0.169 and 0.102). But for those with short residence duration, only threat appraisal exerted a significant effect (0.352).

For people in bad health, threat appraisal and flood risk knowledge exhibited relatively higher effects (0.602 and 0.292), but none of the variables were statistically significant. Among groups in good health, although only flood experience had the 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 significant and positive effects on risk perception (0.207,

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

424 0.147 and 0.116). But among groups with regular exercising, the effect of threat
425 appraisal and government trust improved and achieved 0.208 and 0.218 respectively,
426 while the influence of flood risk knowledge decreased with standardized coefficients
427 of 0.137. For individuals without bad habit, threat appraisal, flood risk knowledge and
428 government trust had significant effects on flood preparedness (0.229, 0.119 and 0.161),
429 while only flood experience exhibited a negative influence (-0.078). However, among
430 people with bad habit, the effect of flood risk knowledge and government trust
431 improved, and both significantly and positively affected flood preparedness (0.210 and
432 0.238)

433 **3.6 Influence path of flood preparedness**

434 This study examined the moderating and mediating effect and explored the
435 influence path between flood risk perception and flood preparedness. **Supplementary**
436 **materials** presented more detailed illustration. Risk perception, flood preparedness,
437 response intention and social-economic factors acted as independent, dependent,
438 mediating and moderating variables respectively. In **Fig. 6(a)**, health condition played
439 the negative moderating role between threat appraisal and flood preparedness. Threat
440 appraisal had significant and positive effects on response intention (0.397) and flood
441 preparedness (0.313), while response intention also positively influenced flood
442 preparedness (0.174). Under the influence of health condition and response intention,
443 the direct effect of threat appraisal on flood preparedness was greater than indirect effect.
444 The slope of low, medium and high moderation changed obviously and tended to be
445 gentle in **Fig. 7(a)**. With the increasing moderation effect, health condition interfered

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

Natural Hazards and Earth System Sciences
Discussions

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 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.

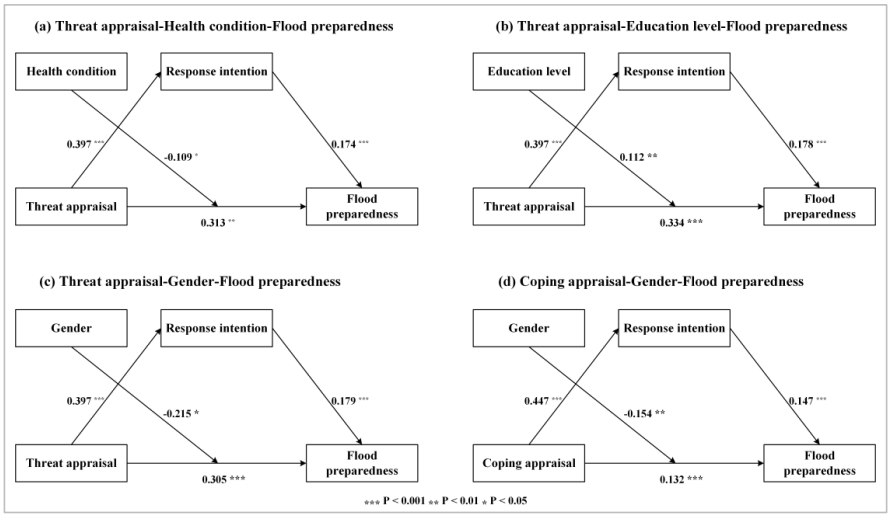


Fig. 6. Influence path of flood preparedness.

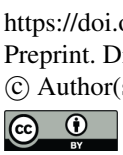
Relationship between threat appraisal and flood preparedness was positively moderated by education level. Threat appraisal showed significant and positive effects on response intention and flood preparedness (0.334) in **Fig. 6(b)**. Response intention also demonstrated a positive effect on flood preparedness (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

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

education level was low (M-1SD), threat appraisal showed 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 an ascending trend in the predictive effect of threat appraisal.

Gender also played the negative moderating effect between threat appraisal and flood preparedness **in Fig. 6(c)**. Threat appraisal exhibited positive effects 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 compared to females.

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024



Natural Hazards and Earth System Sciences
Discussions

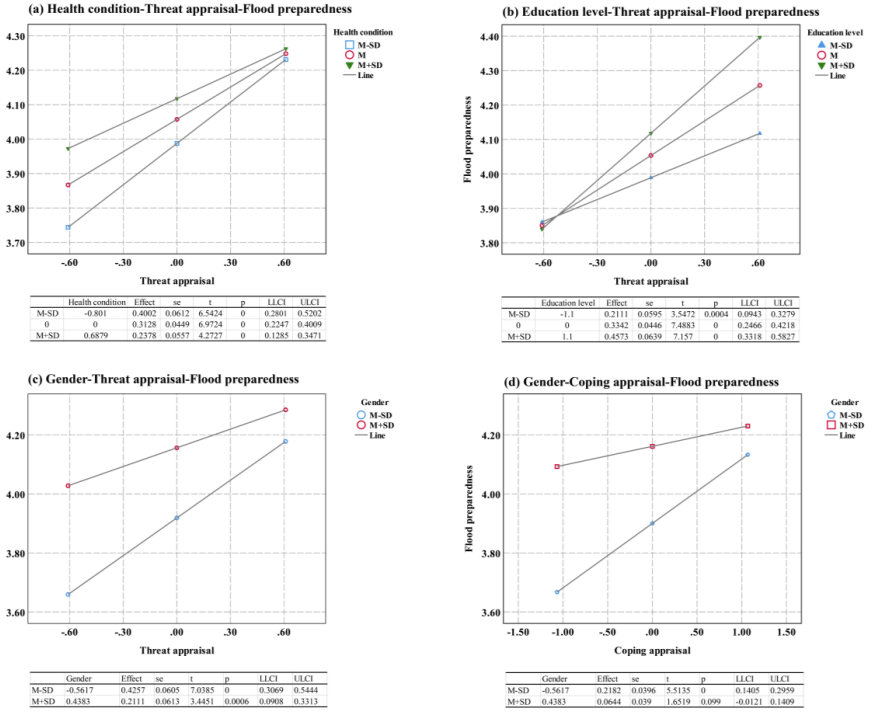


Fig. 7. Moderating effect on flood preparedness.

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). Response intention also 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). Coping appraisal had a lower predictive effect on flood preparedness among females.

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

Natural Hazards and Earth System Sciences
Discussions

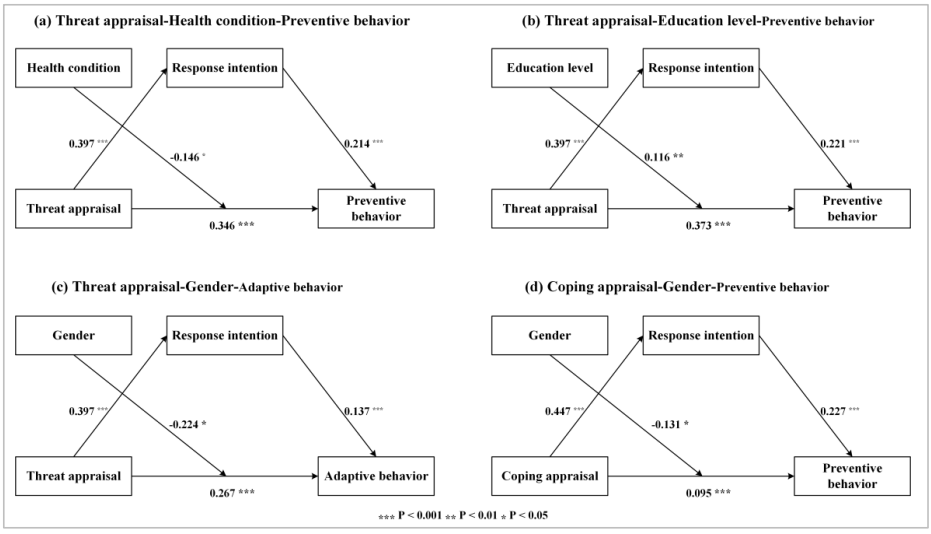


Fig. 8. Influence differences on adaptive and preventive behavior.

This study also explored 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 the moderation effect in **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 improved health condition. Additionally, 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 reduced 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

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

Natural Hazards and Earth System Sciences
Discussions

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 predicted positively preventive behavior (0.168) in **Fig. 9(d)**. When gender was female (M+1SD), coping appraisal had a weak and statistically insignificant prediction effect on preventive behavior (0.0378). Risk perception was more likely to be translated into preventive behavior among males.

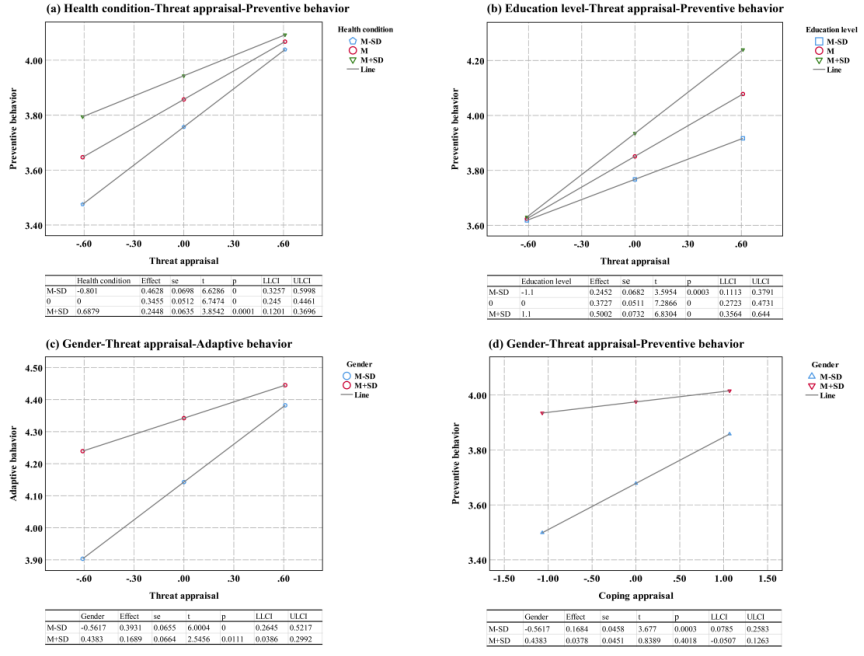


Fig. 9. Moderating effect on adaptive and preventive behavior.

4. Discussion

This study revealed no significant difference in risk perception between genders, but females demonstrated a higher level of flood preparedness, consistent with previous

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

research (Rana et al., 2020; Rasool et al., 2022). Individuals who regularly exercised exhibited higher risk perception, because adequate physical activity enhanced their response and judgment capabilities, and thereby made cognitive activities more active. The elderly, particularly those aged 51-60 and above 60, showed higher risk perception yet lower flood preparedness. Often regarded as socially vulnerable groups, the elderly were more probably perceived higher risk (Harlan et al., 2019), and due to insufficient energy 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, typically associated with lower social status, were more inclined to engage in occupations that are dangerous or risky (Bollettino et al., 2020; Kiani, Najam, & Rana, 2022), which incentivized them to proactively perceive flood risks. But highly educated people sought 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 displayed the higher risk perception and made adequate preparation for floods in our findings. Past flood experiences tended to trigger risk perception and a greater intention to take adjustment action (Ao et al., 2020). Individuals were more likely to declare higher risk perception and preparedness, when floods were associated with negative emotions or memories (Rufat & Botzen, 2022).

Enough high threat appraisal could trigger coping appraisal (Schlef et al., 2018),

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

537 which both caused the higher protection motivation and promoted the mitigation
538 measures (Kurata et al., 2022). Despite finding the high threat appraisal and the medium
539 coping appraisal, threat appraisal might not reach the necessary threshold that
540 effectively triggered coping appraisal, and coping appraisal showed no effect on flood
541 preparedness in our results. Individuals tended to rely on threat appraisal to perceive
542 risk and failed to generate an adequate coping appraisal, leading to insufficient risk
543 perception. Therefore, risk perception struggled in translating into flood preparedness,
544 resulting in the unbalanced relationship with flood preparedness. The influence of threat
545 appraisal on flood preparedness was greater in groups with low risk perception
546 compared to those with high risk perception. The transformation of low risk perception
547 into flood preparedness could be attributed to the relatively stronger effect of threat
548 appraisal on flood preparedness. The association between high risk perception and low
549 flood preparedness could arise from the weak effect of threat appraisal on flood
550 preparedness. However, due to the significant influence of other factors, such as
551 government trust, individuals were more likely to be better prepared for floods among
552 groups with high risk perception.

553 Various social-economic characteristic influenced individuals' preferences for
554 different ways to achieve risk perception and flood preparedness, based on regression
555 analysis. Females had higher flood worry and depended more on flood knowledge to
556 perceive risk than males, possibly owing to the general cognition that women were
557 more vulnerable and sensitive (Eryılmaz Türkkan & Hırca, 2021). But flood worry
558 showed lower effect on risk perception than that in males. It was suggested that females

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

559 should keep calm, and improve risk perception through flood knowledge. The elderly
560 relied on both flood knowledge and worry for risk perception. Although they exhibited
561 a greater influence of government trust on flood preparedness, lower level of
562 government trust could potentially hinder their flood preparedness efforts. People with
563 low education level preferred flood knowledge for risk perception, and were advised to
564 bolster their trust in government to improve flood preparedness. Individuals with longer
565 residency durations relied more on flood knowledge for risk perception, while those
566 with short living time, unfamiliar with local floods, depended more on government trust
567 for risk perception and favored threat appraisal to achieve flood preparedness. Groups
568 with poor health relied more on flood knowledge for flood preparedness, as adequate
569 risk knowledge could compensate for physical functional limitations. Individuals with
570 regular exercising group showed a preference for threat appraisal in preparation for
571 floods. Moreover, individuals with bad habits, considered psychologically fragile and
572 sensitive, preferred flood risk worry and knowledge, and government trust for risk
573 perception.

574 In our study, risk perception, including both threat and coping appraisal,
575 demonstrated a direct influence on flood preparedness, and response intention also
576 exhibited a mediating effect. Socio-economic factors, especially education level and
577 health condition, played a moderating effect between risk perception and flood
578 preparedness. People with high education level could better deal with complicated
579 information and act promptly during the time lag between action and outcome (Dootson
580 et al., 2022). As health condition improved, there was a negative predictive effect of

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

threat appraisal on flood preparedness. Though people reporting good health displayed confidence with physical function, overconfidence could hinder the translation of risk perception into preparedness (Bollettino et al., 2020), and these groups should attach importance to timely feedback in response to floods. Among males, despite the low level of flood preparedness, threat and coping appraisal were stronger predictors of flood preparedness. With the effect of response intention and socio-economic factors, risk perception could transform into flood preparedness, and caused the differences of preventive and adaptive behaviors. People with high education level would more probably perceive risk and engage in preventive behavior against flooding. 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 in part of factors and results may not be generalized in all the socio-economic characteristics. Rationality and reliability of influence path need further empirical validation in future studies. With the climate change, the adoption of different behaviors was significantly influenced by how individuals perceived and evaluated risk (Bodoque, Díez-Herrero, Amerigo, García, & Olcina, 2019). When risk events were associated with adequate benefits, individuals tended to exhibit a preference for adaptive behaviors (Keshun Zhang et al., 2021). Consequently, comprehensive analysis of benefits and costs was crucial in understanding risk perception and preparedness.

5. Conclusion

We designed and conducted a questionnaire survey to explore influence

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

603 relationship between risk perception and flood preparedness. Participants exhibited the
604 medium perception of food risk and demonstrated higher flood preparedness. High
605 levels of risk perception were observed on groups of regular exercising, the elderly,
606 flood experience, low education level, long living time and flood worry. Higher floods
607 preparedness was more prevalent among groups of females, the elderly and high
608 education level. Individuals tended to rely predominantly on threat appraisal to perceive
609 risk, and failed to trigger the adequate coping appraisal. This process resulted in a
610 challenging translation of risk perception into flood preparedness, accompanied with
611 unbalanced relationship. Groups with distinct social-economic features showed
612 different preferences to realize risk perception and flood preparedness. Females relied
613 more on flood knowledge to perceive risk and were suggested to keep calm and enhance
614 risk perception through flood knowledge. Elderly individuals and people with low
615 education level also depended on flood knowledge for risk perception, while lower
616 government trust possibly hindered taking flood preparedness. Path analysis indicated
617 that threat appraisal could transform into flood preparedness, influenced by response
618 intention, education level, or health status condition. Groups with high education level
619 or bad health would more probably perceive risk and engage in preventive behavior.
620 This study provided essential strategies for promoting flood preparedness in response
621 to floods. Future research should consider the benefits and costs associated with risk to
622 reveal the heterogeneity of preparedness behaviors.

623 **Author contribution**

624 **Yabo Li**: Methodology, Investigation, Writing - Original Draft. **Peng Wang**:

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

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.

Acknowledgements

This work was supported by the National Natural Science Foundation of China [Grant No. 51908249], the Natural Science Foundation of Jiangsu Province [Grant No. SBK2023022191], the Natural Science Foundation of the Jiangsu Higher Education Institutions of China [Grant No. 19KIB560012], the High-level Scientific Research Foundation for the introduction of talent for Jiangsu University [Grant No. 18JDG038], the Innovative Approaches Special Project of the Ministry of Science and Technology of China [Grant No. 2020IM020300], and the Science and Technology Planning Project of Suzhou [Grant No. ST202218].

References

Ahmad, D., & Afzal, M. (2020). Flood hazards and factors influencing household flood perception and mitigation strategies in Pakistan. *Environmental Science and Pollution Research*, *27*(13), 15375–15387. https://doi.org/10.1007/s11356-020-08057-z

Ao, Y., Zhou, X., Ji, F., Wang, Y., Yang, L., Wang, Q., & Martek, I. (2020). Flood disaster preparedness: experience and attitude of rural residents in Sichuan, China. *Natural Hazards*, *104*(3), 2591–2618. https://doi.org/10.1007/s11069-

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

020-04286-0

Bodoque, J. M., Díez-Herrero, A., Amerigo, M., García, J. A., & Olcina, J. (2019). Enhancing flash flood risk perception and awareness of mitigation actions through risk communication: A pre-post survey design. *Journal of Hydrology*, *568*(August 2018), 769–779. https://doi.org/10.1016/j.jhydrol.2018.11.007

Bollettino, V., Alcayna-Stevens, T., Sharma, M., Dy, P., Pham, P., & Vinck, P. (2020). Public perception of climate change and disaster preparedness: Evidence from the Philippines. *Climate Risk Management*, *30*(January), 100250. https://doi.org/10.1016/j.crm.2020.100250

Deng, Z., Wang, Z., Wu, X., & Lai, C. (2022). Urban Climate Strengthened tropical cyclones and higher flood risk under compound effect of climate change and urbanization across China ' s Greater Bay Area. *Urban Climate*, *44*(March), 101224. https://doi.org/10.1016/j.uclim.2022.101224

Dong, J., Shang, M., Feng, R., Song, X., Yan, D., & Xie, H. (2022). Export and risk from antibiotic remobilization from surrounding water to lake in the extreme 2020 Yangtze River basin flooding. *Science of the Total Environment*, *834*(January), 155176. https://doi.org/10.1016/j.scitotenv.2022.155176

Dootson, P., Kuligowski, E., Greer, D. A., Miller, S. A., & Tippett, V. (2022). Consistent and conflicting information in floods and bushfires impact risk information seeking, risk perceptions, and protective action intentions. *International Journal of Disaster Risk Reduction*, *70*(December 2021), 102774. https://doi.org/10.1016/j.ijdrr.2021.102774

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

669 Eryılmaz Türkkan, G., & Hırca, T. (2021). The investigation of flood risk perception
670 as a quantitative analysis from socio-demographic perspective. *Natural Hazards*,
671 *106*(1), 715–733. https://doi.org/10.1007/s11069-020-04488-6
672 Ghanian, M., M. Ghoochani, O., Dehghanpour, M., Taqipour, M., Taheri, F., &
673 Cotton, M. (2020). Understanding farmers' climate adaptation intention in Iran:
674 A protection-motivation extended model. *Land Use Policy*, *94*(February),
675 104553. https://doi.org/10.1016/j.landusepol.2020.104553
676 Guo, J., Wu, X., & Wei, G. (2020). A new economic loss assessment system for urban
677 severe rainfall and flooding disasters based on big data fusion. *Environmental*
678 *Research*, *188*(June), 109822. https://doi.org/10.1016/j.envres.2020.109822
679 Harlan, S. L., Sarango, M. J., Mack, E. A., & Stephens, T. A. (2019). A survey-based
680 assessment of perceived flood risk in urban areas of the United States.
681 *Anthropocene*, *28*, 100217. https://doi.org/10.1016/j.ancene.2019.100217
682 Huang, C. shih, & Lubell, M. (2022). Household flood risk response in San Francisco
683 Bay: linking risk information, perception, and behavior. *Regional Environmental*
684 *Change*, *22*(1). https://doi.org/10.1007/s10113-022-01875-6
685 Khani Jeihooni, A., Bashti, S., Erfanian, B., Ostovarfar, J., & Afzali Hasirini, P.
686 (2022). Application of protection motivation theory (PMT) on skin cancer
687 preventive behaviors amongst primary school students in rural areas of Fasa city-
688 Iran. *BMC Cancer*, *22*(1), 1–10. https://doi.org/10.1186/s12885-021-09142-3
689 Kiani, U. B. N., Najam, F. A., & Rana, I. A. (2022). The impact of risk perception on
690 earthquake preparedness: An empirical study from Rawalakot, Pakistan.

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

International Journal of Disaster Risk Reduction, *76*(August 2021), 102989. https://doi.org/10.1016/j.ijdrr.2022.102989

Kurata, Y. B., Prasetyo, Y. T., Ong, A. K. S., Nadlifatin, R., & Chuenyindee, T. (2022). Factors affecting perceived effectiveness of Typhoon Vamco (Ulysses) flood disaster response among Filipinos in Luzon, Philippines: An integration of protection motivation theory and extended theory of planned behavior. *International Journal of Disaster Risk Reduction*, *67*(May 2021). https://doi.org/10.1016/j.ijdrr.2021.102670

Li, C., Liu, M., Hu, Y., Wang, H., Zhou, R., Wu, W., & Wang, Y. (2022). Spatial distribution patterns and potential exposure risks of urban floods in Chinese megacities. *Journal of Hydrology*, *610*(January), 127838. https://doi.org/10.1016/j.jhydrol.2022.127838

Rana, I. A., Jamshed, A., Younas, Z. I., & Bhatti, S. S. (2020). Characterizing flood risk perception in urban communities of Pakistan. *International Journal of Disaster Risk Reduction*, *46*(July 2019), 101624. https://doi.org/10.1016/j.ijdrr.2020.101624

Rasool, S., Rana, I. A., & Ahmad, S. (2022). Linking flood risk perceptions and psychological distancing to climate change: A case study of rural communities along Indus and Chenab rivers, Pakistan. *International Journal of Disaster Risk Reduction*, *70*(February 2021), 102787. https://doi.org/10.1016/j.ijdrr.2022.102787

Rifat, S. A. Al, & Liu, W. (2022). Predicting future urban growth scenarios and

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

potential urban flood exposure using Artificial Neural Network-Markov Chain model in Miami Metropolitan Area. *Land Use Policy*, *114*(December 2021), 105994. https://doi.org/10.1016/j.landusepol.2022.105994

Roder, G., Hudson, P., & Tarolli, P. (2019). Flood risk perceptions and the willingness to pay for flood insurance in the Veneto region of Italy. *International Journal of Disaster Risk Reduction*, *37*(October 2018), 101172. https://doi.org/10.1016/j.ijdrr.2019.101172

Rufat, S., & Botzen, W. J. W. (2022). Drivers and dimensions of flood risk perceptions: Revealing an implicit selection bias and lessons for communication policies. *Global Environmental Change*, *73*(December 2021), 102465. https://doi.org/10.1016/j.gloenvcha.2022.102465

Sado-Inamura, Y., & Fukushi, K. (2019). Empirical analysis of flood risk perception using historical data in Tokyo. *Land Use Policy*, *82*(December 2017), 13–29. https://doi.org/10.1016/j.landusepol.2018.11.031

Scaini, A., Stritih, A., Brouillet, C., & Scaini, C. (2021). Flood Risk and River Conservation: Mapping Citizen Perception to Support Sustainable River Management. *Frontiers in Earth Science*, *9*(June), 1–14. https://doi.org/10.3389/feart.2021.675131

Schlef, K. E., Kaboré, L., Karambiri, H., Yang, Y. C. E., & Brown, C. M. (2018). Relating perceptions of flood risk and coping ability to mitigation behavior in West Africa: Case study of Burkina Faso. *Environmental Science and Policy*, *89*(August), 254–265. https://doi.org/10.1016/j.envsci.2018.07.013

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

735 Shah, A. A., Gong, Z., Ali, M., Sun, R., Naqvi, S. A. A., & Arif, M. (2020). Looking
736 through the Lens of schools: Children perception, knowledge, and preparedness
737 of flood disaster risk management in Pakistan. *International Journal of Disaster*
738 *Risk Reduction*, *50*(February), 101907.
739 https://doi.org/10.1016/j.ijdrr.2020.101907
740 Soetanto, R., Mullins, A., & Achour, N. (2017). The perceptions of social
741 responsibility for community resilience to flooding: the impact of past
742 experience, age, gender and ethnicity. *Natural Hazards*, *86*(3), 1105–1126.
743 https://doi.org/10.1007/s11069-016-2732-z
744 Steinhausen, M., Schröter, K., Lüdtke, S., Sairam, N., Paprotny, D., Mentaschi, L., …
745 Kreibich, H. (2021). Drivers of future flood risk change for residential buildings
746 in Europe. *EGU General Assembly Conference Abstracts*, *76*(August 2021),
747 EGU21-8300. https://doi.org/10.1016/j.gloenvcha.2022.102559
748 Sun, Y., & Sun, J. (2019). Perception, preparedness, and response to tsunami risks in
749 an aging society: Evidence from Japan. *Safety Science*, *118*(February), 466–474.
750 https://doi.org/10.1016/j.ssci.2019.05.060
751 Taylor, A. L., Dessai, S., & Bruine de Bruin, W. (2014). Public perception of climate
752 risk and adaptation in the UK: A review of the literature. *Climate Risk*
753 *Management*, *4*, 1–16. https://doi.org/10.1016/j.crm.2014.09.001
754 Thongs, G. (2019). Integrating risk perceptions into flood risk management: Trinidad
755 case study. *Natural Hazards*, *98*(2), 593–619. https://doi.org/10.1007/s11069-
756 019-03720-2

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

Ullah, F., Saqib, S. E., Ahmad, M. M., & Fadlallah, M. A. (2020). Flood risk perception and its determinants among rural households in two communities in Khyber Pakhtunkhwa, Pakistan. *Natural Hazards*, *104*(1), 225–247. https://doi.org/10.1007/s11069-020-04166-7

Valois, P., Bouchard, D., Talbot, D., Caron, M., Renaud, J.-S., Gosselin, P., & Jacob, J. (2020). Adoption of flood-related preventive behaviours by people having different risks and histories of flooding. *Natural Hazards*, *102*(3), 1155–1173. https://doi.org/10.1007/s11069-020-03950-9

van Valkengoed, A. M., & Steg, L. (2019). Meta-analyses of factors motivating climate change adaptation behaviour. *Nature Climate Change*, *9*(2), 158–163. https://doi.org/10.1038/s41558-018-0371-y

Wachinger, G., Keilholz, P., & O'Brian, C. (2018). The Difficult Path from Perception to Precautionary Action—Participatory Modeling as a Practical Tool to Overcome the Risk Perception Paradox in Flood Preparedness. *International Journal of Disaster Risk Science*, *9*(4), 472–485. https://doi.org/10.1007/s13753-018-0203-8

Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2013). The risk perception paradox-implications for governance and communication of natural hazards. *Risk Analysis*, *33*(6), 1049–1065. https://doi.org/10.1111/j.1539-6924.2012.01942.x

Wang, P., Li, Y., Yu, P., & Zhang, Y. (2021). The analysis of urban flood risk propagation based on the modified susceptible infected recovered model. *Journal of Hydrology*, *603*(PC), 127121. https://doi.org/10.1016/j.jhydrol.2021.127121

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

779 Wang, P., Li, Y., & Zhang, Y. (2021). An urban system perspective on urban flood
780 resilience using SEM: evidence from Nanjing city, China. *Natural Hazards*,
781 (0123456789). https://doi.org/10.1007/s11069-021-04933-0
782 Wang, Z., Wang, H., Huang, J., Kang, J., & Han, D. (2018). Analysis of the public
783 flood risk perception in a flood-prone city: The case of Jingdezhen city in China.
784 *Water (Switzerland)*, *10*(11). https://doi.org/10.3390/w10111577
785 Yang, D. (2019). Supplementary Material SUPPLEMENTARY MATERIAL
786 Paluskar. *Mpb*, *2*(c), 1–10.
787 Yin, Q., Ntim-Amo, G., Ran, R., Xu, D., Ansah, S., Hu, J., & Tang, H. (2021). Flood
788 disaster risk perception and urban households' flood disaster preparedness: The
789 case of accra metropolis in Ghana. *Water (Switzerland)*, *13*(17), 1–18.
790 https://doi.org/10.3390/w13172328
791 Yong, A. G., & Lemyre, L. (2019). Getting Canadians prepared for natural disasters: a
792 multi-method analysis of risk perception, behaviors, and the social environment.
793 *Natural Hazards*, *98*(1), 319–341. https://doi.org/10.1007/s11069-019-03669-2
794 Zhang, H., Yang, J., Li, L., Shen, D., Wei, G., Khan, H. ur R., & Dong, S. (2021).
795 Measuring the resilience to floods: A comparative analysis of key flood control
796 cities in China. *International Journal of Disaster Risk Reduction*, *59*(March),
797 102248. https://doi.org/10.1016/j.ijdrr.2021.102248
798 Zhang, Ke, Shalehy, M. H., Ezaz, G. T., Chakraborty, A., Mohib, K. M., & Liu, L.
799 (2022). An integrated flood risk assessment approach based on coupled
800 hydrological-hydraulic modeling and bottom-up hazard vulnerability analysis.

https://doi.org/10.5194/nhess-2024-23
Preprint. Discussion started: 14 May 2024

Environmental Modelling and Software, *148*(December 2021), 105279. https://doi.org/10.1016/j.envsoft.2021.105279

Zhang, Keshun, Parks-Stamm, E. J., Ji, Y., & Wang, H. (2021). Beyond flood preparedness: Effects of experience, trust, and perceived risk on preparation intentions and financial risk-taking in china. *Sustainability (Switzerland)*, *13*(24). https://doi.org/10.3390/su132413625

Zhu, S., Li, D., Huang, G., Chhipi-Shrestha, G., Nahiduzzaman, K. M., Hewage, K., & Sadiq, R. (2021). Enhancing urban flood resilience: A holistic framework incorporating historic worst flood to Yangtze River Delta, China. *International Journal of Disaster Risk Reduction*, *61*(May), 102355. https://doi.org/10.1016/j.ijdrr.2021.102355