Urban household adaption to natural hazards in Hangzhou City, China

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Abstract
Household adaption to natural hazards has been critical in disaster prevention and mitigation in disaster-prone regions. However, the adaption of urban household to natural hazards is not yet fully understood, especially in the subtropical forested region of Southeast China. In this study, we investigated the urban household adaption to natural hazards in the forested region of southeastern China by using a multinomial logistic regression model to analyze 763 urban household questionnaire responses from 6 districts in Hangzhou City, Zhejiang province.

The results indicated that (1) from high to low, the top 6 natural hazards deeply concerned by urban household of Hangzhou City were typhoon, rainstorm, lightning, flood, low temperature disaster and snow disaster and (2) gender, length of family residence, disaster awareness and household satisfaction all significantly influenced the urban household adaption to natural hazards. This study suggested that Government should improve channels for disaster publicity, strengthen community management and promote social emergency construction in future decades.

Keywords: Urban household, adaptive behavior, natural hazards, Logistic model, Southeast China.

Introduction

Natural hazards refer to all kinds of natural events occurring on the Earth induced by natural or man-made factors which have caused serious losses to human beings, economy or environment[21,36]. Every year, natural hazards have resulted in huge losses and casualties all over the world which seriously restrict the sustainable development of human society[3,8,18]. According to the reports of United Nations Office for Disaster Risk Reduction (UNDRR), there have been 7,255 natural hazards worldwide, among which 91% of all disasters were caused by floods, storms, droughts, heatwaves and other extreme weather events between 1998 and 2017. The climate-related and geophysical disasters killed 1.3 million people and left a further 4.4 billion injured, homeless, displaced or in need of emergency assistance (https://www.undrr.org/publication/economic-losses-poverty-disasters-1998-2017). How to reduce the impact and adapt to natural hazards has become a focus issue. In this context, understanding the regional household adaptation to natural hazards associated with climate change is fundamental to effective disaster prevention and mitigation and is also strengthening the ability and foundation of regional sustainable development.

There are many studies on the adaption analysis referred to adjustments made by human society or the ecological environment in response to natural hazards from the perspective of the different research field[4,10,24,25,29,32]. With the adjustment of global strategy, adaptation to environmental change is the criterion to maintain social sustainable development[6], especially in the research field of both natural sciences and humanities which have respectively studied the adaptation of social and natural systems, enhancing the adaptive capacity of social and natural systems as well as reasonably avoiding risks[1,2,23].

In recent years, the study has mainly focused on two aspects. First, it has explored the risk perception of natural hazards and adaptive capacity in vulnerability research. For example, the German scholars evaluated the coastal flood damage and adaptation costs under 21st century sea-level rise[14] and the Chinese scholar revealed the disturbance mechanism of urban fringe applied to the social vulnerability-adaptation integrated framework[12]. Second, it has explored adaptation to climate change. For example, based on empirical data from a three-year multi-sectoral study of climate change adaptation for human settlements in the South East Queensland region, Australia, Serrao-Neumann et al[22] drew on multi-sectoral perspectives to propose enablers for maximising synergies between disaster risk reduction and climate change adaptation to achieve improved planning outcomes.

On the other hand, since the 1990s, Chinese scholars have begun to pay attention to the field of adaptive research and have done many studies on the adaptability of man-earth system under the background of global change. For instance, from the field of adaptive theory.

Ye et al[30] discussed the relationship between sustainable development and adaptation in the context of global change by taking the western and coastal regions of China as examples and Chen[5] believed that an important way for mankind to cope with the negative effects of global change is to adapt to global change and raise the research on the adaptability of global environmental change to the level of sustainable development.

Jiang et al[17] comprehensively analyzed the implementation of the water diversion scheme and evaluated its adaptability in the Heihe River under the changing background from the

field of regional adaptability; From the field of industrial adaptability. Wang et al[28] presented the evaluation method of agricultural drought adaptability, build assessment index and model of agricultural drought adaptability. Guo et al[11] built the environmental adaptability evaluation index system of industrial system and established an evaluation model in the perspective of the adaptive elements. Additionally, from the field of adaptive capacity assessment. He et al[13] applied the adaptation analytical framework to the case of land-lost farmers in the urban fringe of Xi'an and defined the concept and adaptation framework of land-lost farmers.

Yin et al[31] explored adaptive capacity and adaptive actions of farmers in the Minqin Oasis area by constructing an adaptive capacity assessment index system of farming households. Li et al[19] systematically studied the process of differentiation of adaptation behavior, the state of adaptation result, the difference of adaptation ability and the influencing factors of farmers and herdsmen adapting to climate warming and drying, urbanization, ecological engineering and tourism development and quantitatively discriminates the logical relationship among farmers and herdsmen's adaptation ability, adaptation behavior and adaptation result, summarizing the evolution mechanism of farmers and herdsmen's adaptation respectively.

In summary, under the background of frequent natural hazards, the study of disaster prevention and reduction is very important to realize sustainable development and the study of adaptability plays an important role in disaster reduction.

At present, the study of adaptability based on natural hazards mainly explores the adaptability of farmer household to natural hazards[9,13,15,19,27,34] and seldom studies the adaptability of urban household to natural hazards from the quantitative perspective[20]. But there have been few reports on urban household to natural hazards in Zhejiang province. In recent years, the urbanization process in Zhejiang province has been speeding up. With the increase in the frequency of natural hazards, it is prone to natural hazards and highly vulnerable to climate change, rapid industrial development and urbanization[26].

Natural hazards have caused many casualties and direct economic losses in Zhejiang province, thereby increasingly threatening the safety of life and property of urban households. Therefore, it is very important for the sustainable development of cities to study the adaptability of urban households to natural hazards in Zhejiang province by taking Hangzhou City as an example.

Material and Methods

Study area: Hangzhou City, the capital city of Zhejiang province, is located in the south wing of Yangtze River Delta and the west end of Hangzhou Bay and is an important traffic hub in Southeast China. It covers a total area of 16,596 km^2, with 8 districts and 5 smaller administrative units, of which the total area of mountains and hills and plains accounts for 65.6% and 26.4% respectively; others account for 8.0%[7]. Hangzhou City includes ten districts, two counties and one sub-city: Shangcheng, Xiacheng, Jianggan, Gongshu, Xihu, Binjiang, Xiaoshan, Yuhang, Fuyang and Lin'an Districts, Tonglu and Chun'an Counties and Jiande city (Figure 1).

The city has a subtropical monsoon climate with four distinct seasons, plenty of sunshine and rainfall, short spring and autumn as well as long summer and winter. The annual average temperature in the city is 17.8 °C, the average relative humidity is 70.3% and the annual precipitation is 1454 mm. The city has a total population of 10.36 million or a total household of 2.01 million (2019).

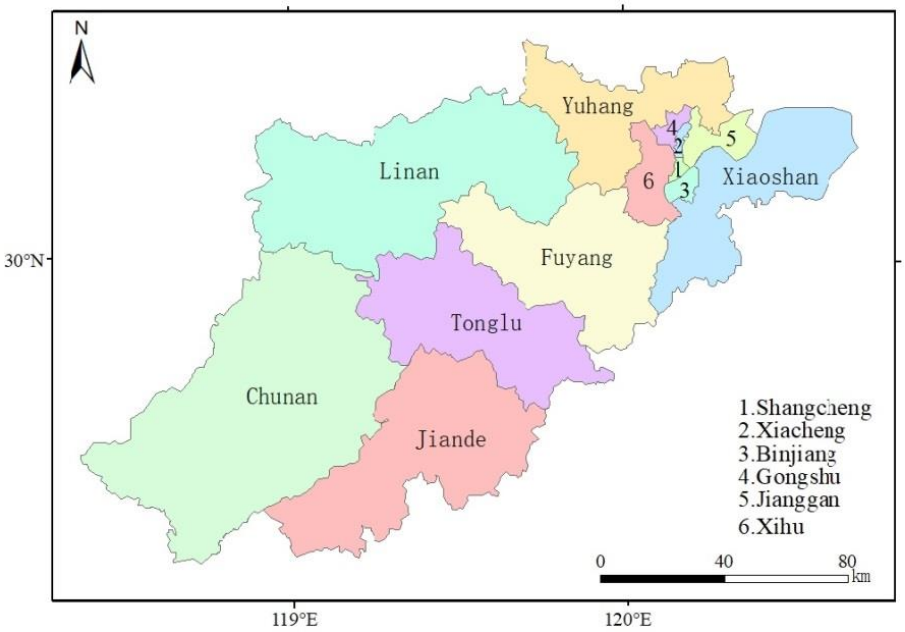

Figure 1: Location and administrative divisions of Hangzhou City

On the other hand, Hangzhou City is also highly exposed to the occurrence of multiple natural hazards in recent years. According to the classification standards of natural hazards in China[33], the natural hazards in Hangzhou City mainly include four types from 2010 to 2018, that is, geological hazards (landslide, collapse, debris flow, earthquake hazard and ground collapse), meteorological and hydrological hazards (lightning) and biological hazards (plant diseases and pests, forest fire), all of which have caused many casualties and direct economic losses during 2010–2018. For example, from 2010 to 2018, the occurrences of geological hazards were 610 times in Hangzhou City, causing direct economic losses over RMB 61.493 million yuan and 21 casualties, among which landslides were 231 times, collapses were 280 times, debris flow were 95 times, ground collapse were 3 times and earthquake was 1 times[35].

Research Methods

Collection of the data and sampling: The data in this study were mainly collected through the questionnaire survey to investigate the current situation of urban household's adaptability in Hangzhou City based on the adaptive nature of natural hazards. This survey was carried out in 2020 and adopted the method of stratified random sampling. First, a 3-day pre-survey was conducted in Wangjiang and Hubin communities of Shangcheng district in Hangzhou City from 1 September to 3 September of 2020. A total of 100 questionnaires were distributed to 40–60 households randomly selected from each community.

Then, the questionnaires were improved and refined following the pre-survey. Second, from 10 September to 20 September of 2020, formal survey was distributed to residents of 16 communities in 6 districts: Shangcheng, Xiacheng, Jianggan, Gongshu, Xihu and Binjiang districts in Hangzhou City. Each community was randomly selected from 40 to 60 households. The distribution of valid samples was shown in table 1. A total of 800 questionnaires were distributed and 763 valid questionnaires were collected on gender, age, level of education, occupation, average annual urban household income and length of urban household residence.

Analytical method: A software of SPSS 21.0 was used to analyze the adaptive behaviors (measures) of urban household to natural hazards and its influencing factors in Hangzhou City from both descriptive and inferential levels.

The binary logistic model: A binary logistic (BL) model was established to analyze the adaptability of urban household in this study. The BL model was established as follows:

$$\ln\left[\frac{p}{1-p}\right] = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4$$

where p is the probability of adaptive behavior for a urban household; 1-p is the probability of no adaptiving behavior for a urban household. β is a regression coefficient and x is the independent variables among which x1 represents the basic status of samples (gender, age, level of education, occupation), x2 is the characteristics of urban household (average annual urban household income, length of urban household residence), x3 represents the disaster awareness to natural hazards (experience of natural hazards, types of natural hazards experienced, types of losses caused by natural hazards, ways of understanding hazards, time for learning about hazards) and x4 is the satisfaction of urban household (trust level of urban household for resilience to local hazards, satisfaction of urban household for response measures to local hazards, satisfaction of urban household for community solidarity).

Table 1
Distribution of valid samples

District	Valid number of urban households	Percentage	Number of community	Valid number of urban households	Percentage
Shangcheng	145	19.00%	Hu-Bin	51	6.68%
			Qing-Bo	45	5.90%
			Wang-Jiang	49	6.42%
Xiacheng	143	18.74%	Wu-Lin	47	6.16%
			Tian-Shui	53	6.95%
			Wen-Hui	43	5.63%
Jianggan	139	18.22%	Si-Ji-Qing	57	7.47%
			Kai-Xuan	54	7.08%
			Cai-He	28	3.67%
Gongshu	141	18.48%	Mi-Shi-Xiang	48	6.29%
			Hu-Shu	41	5.37%
			Xiao-He	52	6.82%
Xihu	140	18.35%	Bei-Shan	46	6.03%
			Xi-Xi	52	6.82%
			Ling-Yin	42	5.50%
Binjiang	55	7.21%	Xi-Xing	55	7.21%
Total	763	100.00%	16	763	100.00%

Descriptive analysis of the data and sampling and definition of variables

Basic status of samples and characteristics of urban household: Based on the analysis of the questionnaire, we obtained the basic status of samples and characteristics of urban household in this study. The former included gender, age, level of education as well as occupation and the latter included average annual urban household income and length of urban household residence (Table 2). As shown in table 2, we can see that the sex ratio is more balanced, the middle-aged population was predominant, the surveyed people have higher educational qualifications, more than half of the people are company employees, the average annual income level of the urban household is high and the length of urban household residence is mostly between 11 and 30 years among 763 valid questionnaires.

Disaster awareness of urban household to natural hazards: The disaster awareness of urban household consisted of experience of natural hazards, types of natural hazards experienced, types of losses caused by natural hazards, ways of understanding hazards and time for learning about hazards (Table 3, Figure 2). From figure 2, it is obvious that urban households in Hangzhou City pay more attention to typhoon, rainstorm, thunder and lightning, floods and low temperature disaster among the 14 kinds of natural hazards, which belong to the meteorological and hydrological hazards, thereby indicating that urban households in the study area pay more attention to meteorological and hydrological hazards.

Satisfaction of urban household: The satisfaction of urban household consisted of the trust level of urban household for resilience to local hazards, satisfaction of urban household for response measures to local hazards and satisfaction of urban household for community solidarity (Figure 3).

On the one hand, 47.05% of urban households trusted the response ability to local hazards, 34.21% considered the response ability to local hazards to be average and 18.74% did not trust the response ability to local hazards (Figure 3a), indicating that the urban households in the study area have higher degree of trust in the response capacity to local hazards. On the other hand, 38.93% of urban households were satisfied with the response measures to local hazards, 20.31% considered to be average and 40.76% were not satisfied with the response measures to local hazards (Figure 3b), showing that urban households were not satisfied with the response measures to local hazards in this study.

Table 2
Descriptive statistics and characteristics of samples and urban households

Variable set	Variable		Number of persons	Percentage
Basic status of samples	Gender	Male	385	50.46%
		Female	378	49.54%
	Age	Under 20 years old	74	9.70%
		20-40 years old	281	36.83%
		41-60 years old	310	40.63%
		Over 60 years old	98	12.84%
	Level of education	Below level of primary school	83	10.88%
		Middle school	115	15.07%
		High school/Technical secondary school	129	16.91%
		University/Junior college	370	48.49%
		Postgraduate	66	8.65%
	Occupation	Student	141	18.48%
		Worker	82	10.75%
		Company clerk	435	57.01%
		Personnel of public institution	74	9.70%
		Other occupation	31	4.06%
Characteristics of urban household	Average annual urban household income	Under 50,000 yuan	0	0
		50,000-100,000 yuan	62	8.13%
		110,000-150,000 yuan	122	15.99%
		Over 150,000 yuan	579	75.88%
	Length of urban household residence	1-10 years	117	15.33%
		11-20 years	244	31.98%
		21-30 years	256	33.55%
		Over 30 years	146	19.13%

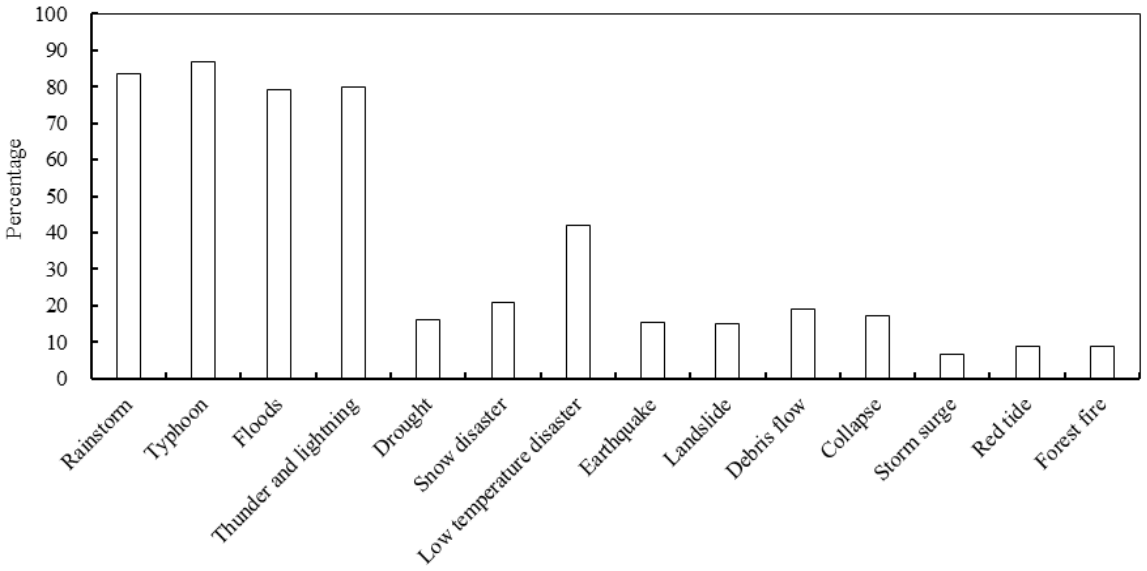

Figure 2: More attention of urban household in Hangzhou City to natural hazards

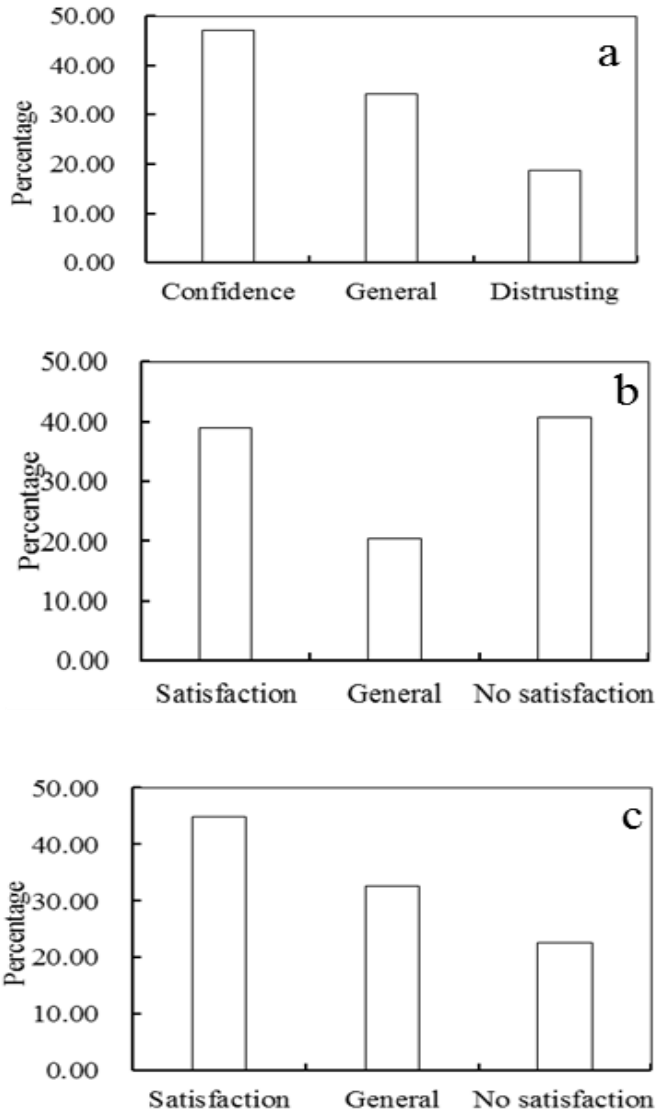

Figure 3: Satisfactions of urban households in Hangzhou City (a) trust level of urban household for resilience to local hazards (b) response measures to local hazards and (c) community solidarity.

Furthermore, 44.82% of urban households were satisfied with the community solidarity, 32.64% were considered to be average and 22.54% were not satisfied with the community solidarity (Figure 3c), revealing that urban households have higher degree of satisfaction.

Adopted measures/Adaptive behaviors of urban household to natural hazards: In this study, the measures adopted by urban household to deal with natural hazards are mainly reflected in the following aspects, namely whether urban household have learned knowledge of disaster prevention and mitigation, whether urban household have participated in disaster emergency response exercises and whether urban household have learned disaster emergency rescue techniques etc. comprehensively reflecting the adaptability of urban household to natural hazards.

Among 763 valid questionnaires, on the one hand, 44.04% of urban households have taken measures to deal with natural hazards but 55.96% have not taken measures (Figure 4), showing that most urban households have not taken measures to deal with natural hazards in this study. On the other hand, only very few urban households have not taken measures to deal with natural hazards in this study (Table 4). Further, 74.71% of urban households have chosen to seek help from relatives and friends, 44.82% of urban households have chosen to seek help from banks/credit unions, 41.55% of urban households have chosen to seek help from governments, 16.25% of urban households have chosen to seek help from social organizations and 5.50% of urban households have chosen to seek other help (Figure 5a), showing that most urban households have chosen to seek help from relatives and friends in this study. Moreover, 50.07% of urban households have considered the emergency response training for natural hazards to be the most effective form of rescue, 34.99% of urban households have considered the financial aid to be the most one, 10.75% of urban households have considered the material relief to be the most one, but only 4.19% of urban households have considered the medical services to be the most one (Figure 5b).

Table 3
Descriptive statistics for disaster awareness of urban household

Variable	Total of samples	Description of variable	Number of samples	Percentage
Experience of natural hazards	763	Yes	299	39.19%
		No	464	60.81%
Types of natural hazards experienced	299	Meteorological and hydrological hazards	276	92.31%
		Geological hazards	10	3.34%
		Marine hazards	8	2.68%
		Biological hazards	5	1.67%
Types of losses caused by natural hazards	299	Loss of business	39	13.04%
		Damaged buildings	27	9.03%
		Missed work	191	63.88%
		Damaged appliances	17	5.69%
		Other loss	25	8.36%
Ways of understanding hazards	763	Network/TV	510	66.84%
		Books/Newspapers	20	2.62%
		Community/School education	8	1.05%
		Other ways	225	29.49%
Time for learning about hazards	763	No study time	466	61.07%
		Under a year	187	24.51%
		1-5 years	68	8.91%
		Over 5 years	42	5.51%

Table 4
Adaptive behaviors of urban household to natural hazards

Adaptive behavior	Yes		No	
	Number of samples	Percentage	Number of samples	Percentage
To learn the knowledge of disaster prevention and mitigation	114	14.94 %	649	85.06 %
To participate in disaster emergency response exercises	105	13.76 %	658	86.24 %
To learn the techniques of disaster emergency rescue	99	12.98 %	664	87.02 %
To develope a disaster response programme	106	13.89 %	657	86.11 %
To stock up on emergency supplies for natural hazards	103	13.50 %	660	86.50 %
To buy insurance	93	12.19 %	670	87.81 %
To reinforce a house	94	12.32 %	669	87.68 %

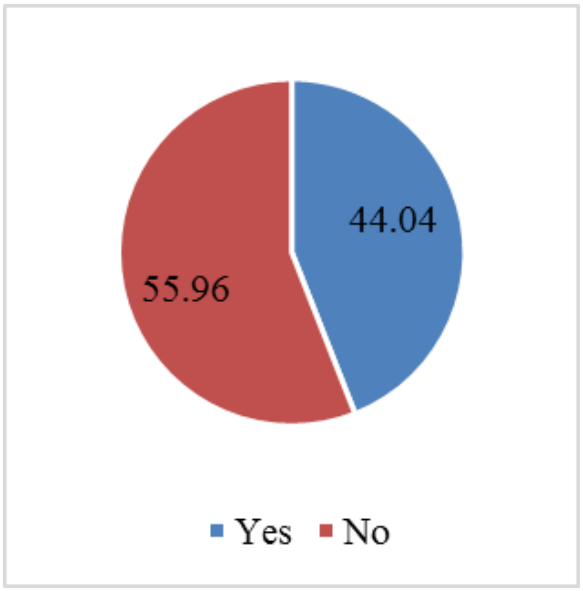

Figure 4: Adopted measures of urban household to natural hazards

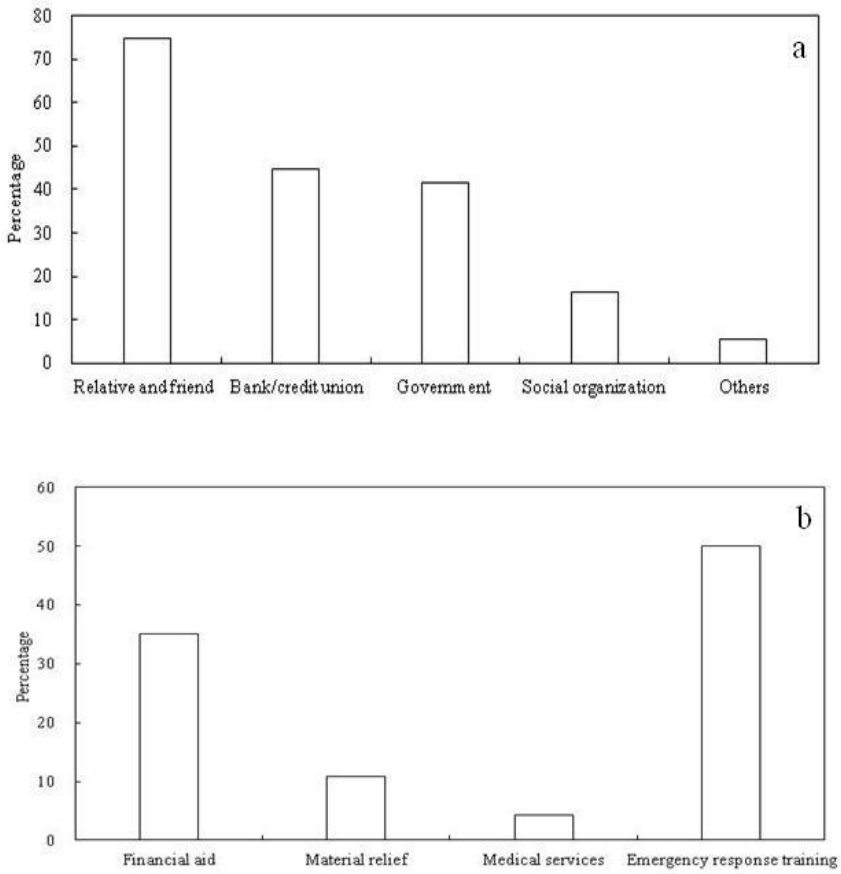

Figure 5: Ways to help in the event of natural hazards (a) and most effective ways of rescue (b)

Descriptive analysis of variables

Definition of variables: In this study, based on the analysis of the questionnaire, we obtained 4 independent variables and a dependent variable. The former included the basic status of samples, characteristics of urban household, disaster awareness of urban household and satisfaction of urban household and the latter included the measures of urban household to natural hazards (Table 5).

Description of variables: Because the independent and dependent variables are most classified variables in this study, a cross-table can be established to describe the relations between independent and dependent variables (Table 6). As shown in table 6, from the aspect of basic status of samples, the proportion of male taking countermeasures is higher (40.78%), people between 41-60 years old are more likely to adopt measures for natural hazards, the proportion

of people with middle school education who take measures for natural hazards is relatively higher (49.57%) and the proportion of personnel of public institution is higher (48.65%).

From the aspect of characteristics of urban household, urban households with an average annual income of 50,000-100,000 yuan are more likely to adopt measures for natural hazards (51.61%) and the proportion of urban households whose length of urban household residence is over 30 years, is higher (45.21%).

Table 5
Definition and statistical analysis of independent variables

Classification independent variables	Independent variable	Minimum value	Maximum value	Mean value	Standard deviation	Definition of independent variable
Basic status of samples	Gender	1	2	1.50	0.50	1=Male; 2=Female
	Age	1	4	2.57	0.83	1= Under 20 years old; 2=20-40 years old; 3=41-60 years old; 4= Over 60 years old
	Level of education	1	5	3.29	1.15	1= Below level of primary school; 2= Middle school; 3= High school/Technical secondary school; 4= University/Junior college; 5= Postgraduate
	Occupation	1	5	2.70	1.01	1= Student; 2= Worker; 3= Company clerk; 4= Personnel of public institution; 5= Other occupation
Characteristics of urban household	Average annual urban household income	1	4	3.68	0.62	1= Under 50,000 yuan; 2=50,000-100,000 yuan; 3=110,000-150,000 yuan; 4= Over 150,000 yuan
	Length of urban household residence	1	4	2.56	0.97	1=1-10 years; 2=11-20 years; 3=21-30 years; 4= Over 30 years
Disaster awareness	Experience of natural hazards	1	2	1.61	0.49	1=Yes; 2=No
	Types of natural hazards experienced	1	4	1.14	0.52	1= Meteorological and hydrological hazards; 2= Geological hazards; 3= Marine hazards; 4= Biological hazards
	Types of losses caused by natural hazards	1	5	2.87	0.99	1= Loss of business; 2= Damaged buildings; 3= Missed work; 4= Damaged appliances; 5= Other loss
	Ways of understanding hazards	1	4	1.93	1.36	1= Network/TV; 2= Books/Newspapers; 3= Community/School education; 4= Other ways
	Time for learning about hazards	1	4	1.59	0.87	1= No study time; 2= Under a year; 3=1-5years; 4= Over 5 years
Satisfaction of urban household	Satisfaction for the trust level of urban household for resilience to local hazards	1	3	1.72	0.76	1=Confidence; 2=General; 3=Distrusting
	Satisfaction for the response measures to local hazards	1	3	2.02	0.89	1=Satisfaction; 2= General; 3=No satisfaction
	Satisfaction for community solidarity	1	3	1.78	0.79	1=Satisfaction; 2= General; 3=No satisfaction

Table 6
Cross-table of independent and dependent variables

Independent variable	Definition of variable	To adopt measures for natural hazards		Not to adopt measures for natural hazards		Total
		Number of samples	Percentage	Number of samples	Percentage	
Gender	Male	157	40.78%	228	59.22%	385
	Female	134	35.45%	244	64.55%	378
Age	Under 20 years old	32	43.24%	42	56.76%	74
	20-40 years old	117	41.64%	164	58.36%	281
	41-60 years old	145	46.77%	165	53.23%	310
	Over 60 years old	42	42.86%	56	57.14%	98
Level of education	Below level of primary school	37	44.58%	46	55.42%	83
	Middle school	57	49.57%	58	50.43%	115
	High school/Technical secondary school	54	41.86%	75	58.14%	129
	University/Junior college	159	42.97%	211	57.03%	370
	Postgraduate	29	43.94%	37	56.06%	66
Occupation	Student	57	40.43%	84	59.57%	141
	Worker	37	45.12%	45	54.88%	82
	Company clerk	196	45.06%	239	54.94%	435
	Personnel of public institution	36	48.65%	38	51.35%	74
	Other occupation	10	32.26%	21	67.74%	31
Average annual urban household income	Under 50,000 yuan	0	0.00	0	0	0
	50,000-100,000 yuan	32	51.61%	30	48.39%	62
	110,000-150,000 yuan	47	38.52%	75	61.48%	122
	Over 150,000 yuan	257	44.39%	322	55.61%	579
Length of urban household residence	1-10 years	51	43.59%	66	56.41%	117
	11-20 years	110	45.08%	134	54.92%	244
	21-30 years	109	42.58%	147	57.42%	256
	Over 30 years	66	45.21%	80	54.79%	146
Experience of natural hazards	Yes	126	42.14%	173	57.86%	299
	No	180	38.79%	284	61.21%	464
Types of natural hazards experienced	Meteorological and hydrological hazards	126	45.65%	150	54.35%	276
	Geological hazards	3	30.00%	7	70.00%	10
	Marine hazards	2	25.00%	6	75.00%	8
	Biological hazards	1	20.00%	4	80.00%	5
Types of losses caused by natural hazards	Loss of business	14	35.90%	25	64.10%	39
	Damaged buildings	11	40.74%	16	59.26%	27
	Missed work	83	43.46%	108	56.54%	191
	Damaged appliances	7	41.18%	10	58.82%	17
	Other loss	5	20.00%	20	80.00%	25
Ways of understanding hazards	Network/TV	209	40.98%	301	59.02%	510
	Books/Newspapers	8	40.00%	12	60.00%	20
	Community/School education	1	12.50%	7	87.50%	8
	Other ways	76	33.78%	149	66.22%	225

Time for learning about hazards	No study time	39	8.37%	427	91.63%	466
	Under a year	187	100.00%	0	0.00	187
	1-5 years	68	100.00%	0	0.00	68
	Over 5 years	42	100.00%	0	0.00	42
trust level of urban household for resilience to local hazards	Confidence	301	83.84%	58	16.16%	359
	General	26	9.96%	235	90.04%	261
	Distrusting	9	6.29%	134	93.71%	143
Satisfaction for the response measures to local hazards	Satisfaction	297	100.00%	0	0	297
	General	10	6.45%	145	93.55%	155
	No satisfaction	29	9.32%	282	90.68%	311
Satisfaction for community solidarity	Satisfaction	299	87.43%	43	12.57%	342
	General	21	8.43%	228	91.57%	249
	No satisfaction	16	9.30%	156	90.70%	172

On the other hand, from the aspect of disaster awareness of urban household to natural hazards, urban households with experience of natural hazards are more likely to adopt measures (42.21%), the proportion of urban households who have experienced the meteorological and hydrological hazards is the highest (45.65%), the proportion of urban households with missed work caused by natural hazards is higher (43.46%), urban households who have understood natural hazards through the way of network/TV, are more likely to adopt measures (40.98%) and the proportion of time spent on learning about natural hazards is higher among all urban households except those who do not learn.

In addition, from the aspect of satisfaction of urban household, urban households with confidence level for resilience to local hazards are most likely to take measures. The proportion of urban households with satisfaction for the response measures to local hazards is the highest (100.00%) and urban households with satisfaction for community solidarity are most likely to take measures for natural hazards.

Results and Discussion

Based on the stepwise regression method of forced entry and the conditional parameter estimated likelihood ratio test method in this study, we have estimated the effects on adaptive behavior of urban households to natural hazards in Hangzhou City from the basic status of samples, characteristics of urban household, disaster awareness of urban household and satisfaction of urban household (Table 7). The regression results of the BL model indicate that the likelihood ratio is 1198.121, the Chi-square test value is 196.742 and the significance level is 0.000 (<0.05), showing that the fitting degree of the BL model is good and the regression result is reliable in this study.

As shown in table 7, among the basic status of the samples, only the independent variable of gender has significant influence on adaptability of urban household, but the other variables have no significant influence. The probability that male has adopted the response measures to natural hazards is 1.035 times of female's, showing that male residents are more likely to take adaptive behavior than female residents. Additionally, because men are physically better than women, they have a greater advantage in engineering adaptive behavior for natural hazards.

From the aspect of characteristics of urban household, only the length of urban household has a significant effect on family adaptability. The probability that urban households are over 30 years of residence has adopted the response measures to natural hazards is 1.313 times of ones with 1-10 years of residence.

This may be due to the fact that urban households with longer periods of residence have established adaptive programs that allow immediate response when threatened by natural hazards, so those urban households with longer periods of residence are more likely to adopt adaptive behavior to natural hazards.

On the other hand, among the disaster awareness to natural hazards, the other variables have a significant impact on the adaptability of urban households in addition to the five variables of geological hazards, marine hazards, biological hazards, other losses caused by hazards and other ways of understanding hazards. First, the probability of urban households adopting the response measures to natural hazards who had experienced a disaster is 1.274 times than those who had not.

Meanwhile, the probability of urban households adopting the response measures to natural hazards who had experienced the meteorological and hydrological hazards is 1.535 times than those who had not. Secondly, the probability of urban households adopting the response measures to natural hazards who had undergone the damaged buildings resulting from natural hazards, is 1.325 times than those who had undergone the loss of business; the probability of urban households adopting the response measures who missed work because of the hazards, is 1.847 times than those who had undergone the loss of business and the probability of urban households adopting the response measures who had undergone the damaged appliances, is 1.364 times than those who had undergone the loss of business.

Table 7
Results of the BL model analysis

Independent variable set	Independent variable		B	S.E.	Wald	Sig.	Exp (B)
Basic status of samples (x_1)	Gender		0.035	0.174	0.040	0.004	1.035
	Age	Under 20 years old			1.262	0.520	
		20-40 years old	-0.289	0.230	1.579	0.378	0.705
		41-60 years old	-0.384	0.252	2.322	0.264	0.603
		Over 60 years old	-0.549	0.319	2.962	0.207	0.562
	Level of education	Below level of primary school			2.847	0.235	
		Middle school	-0.458	0.236	3.766	0.169	0.564
		High school/Technical secondary school	-0.418	0.384	1.185	0.398	0.591
		University/Junior college	-0.375	0.295	1.616	0.371	0.615
		Postgraduate	-0.364	0.318	1.310	0.382	0.632
	Occupation	Student			1.397	0.518	
		Worker	0.083	0.064	1.682	0.473	1.083
		Company clerk	0.074	0.047	2.479	0.312	1.074
		Personnel of public institution	0.030	0.052	0.333	0.775	1.031
		Other occupation	0.047	0.068	0.478	0.658	1.047
Characteristics of urban household (x_2)	Average annual urban household income	Under 50,000 yuan			1.813	0.385	
		50,000-100,000 yuan	0.167	0.121	1.905	0.285	1.175
		110,000-150,000 yuan	0.175	0.134	1.706	0.467	1.184
		Over 150,000 yuan	0.158	0.123	1.650	0.542	1.167
	Length of urban household residence	1-10 years			4.698	0.034	
		11-20 years	-0.167	0.183	0.833	0.661	0.816
		21-30 years	-0.494	0.261	3.582	0.084	0.591
		Over 30 years	0.309	0.163	3.594	0.023	1.313
Disaster awareness (x_3)	Experience of natural hazards		0.268	0.162	2.737	0.002	1.274
	Types of natural hazards experienced	Meteorological and hydrological hazards	0.529	0.174	9.243	0.001	1.535
		Geological hazards	-0.021	0.352	0.004	0.885	0.985
		Marine hazards	-0.025	0.296	0.007	0.973	0.980
		Biological hazards	0.037	0.354	0.011	0.942	1.039
	Types of losses caused by natural hazards	Loss of business			9.781	0.007	
		Damaged buildings	0.441	0.287	2.361	0.005	1.325
		Missed work	0.585	0.341	2.943	0.002	1.847
		Damaged appliances	0.486	0.297	2.678	0.005	1.364
		Other loss	-0.179	0.198	0.817	0.074	0.791
	Ways of understanding hazards	Network/TV			9.413	0.000	
		Books/Newspapers	-0.621	0.399	2.422	0.034	0.518
		Community/School education	-0.667	0.432	2.384	0.039	0.475
		Other ways	-0.563	0.427	1.738	0.615	0.540
	Time for learning about hazards	No study time			6.528	0.001	
		Under a year	0.274	0.142	3.723	0.028	1.352
		1-5 years	0.347	0.319	1.183	0.031	1.426
		Over 5 years	0.265	0.256	1.072	0.035	1.344
Satisfaction of urban household (x_4)	Satisfaction for the trust level of urban household for resilience to local hazards	Confidence			8.971	0.007	
		General	-0.315	0.117	7.249	0.076	0.683
		Distrusting	-0.365	0.138	6.996	0.020	0.625

	Satisfaction for the response measures to local hazards	Satisfaction			8.954	0.005	
		General	-0.541	0.250	4.683	0.097	0.571
		No satisfaction	-0.670	0.257	6.796	0.029	0.473
	Satisfaction for community solidarity	Satisfaction			8.139	0.006	
		General	-0.603	0.241	6.260	0.071	0.549
		No satisfaction	-0.757	0.286	7.006	0.035	0.412

Thirdly, the probability of urban households adopting the response measures who learned about natural hazards through books, newspapers and periodicals is 0.518 times than those who learned about natural hazards by the ways of Network/TV but the probability of urban households adopting the response measures who learned about natural hazards through community or school education, is 0.475 times than those who learned about natural hazards by the ways of Network/TV.

Lastly, the probability of urban households adopting the response measures whose time for learning about hazards is under a year, is 1.352 times than those who had no study time; yet the probability of urban households adopting the response measures whose time for learning about hazards is 1-5 years, is 1.426 times than those who had no study time; but the probability of urban households adopting the response measures whose time for learning about hazards is over 5 years, is 1.344 times than those who had no study time.

Further, from the aspect of satisfaction of urban household, the probability of urban households adopting the response measures who do not trust the response capacity to local hazards is 0.625 times than those who trust; the probability of urban households adopting the response measures who are not satisfied with the response capacity to local hazards is 0.473 times than those who are satisfied with and the probability of urban households adopting the response measures who are not satisfied with community solidarity, is 0.412 times than those who are satisfied with.

Conclusion and Recommendations

Based on the data of the questionnaire on the adaptability of urban households in Hangzhou City, this study analyzed the current situation of the adaptability of Hangzhou's urban households and probed into the factors influencing the adaptive behavior of urban households in Hangzhou City. The major findings and conclusions from this study are as follows:

(1) Natural hazards with high attention for urban households in Hangzhou City are typhoon, rainstorm, thunder and lightening, flood and low temperature disasters which account for 87.02%, 83.75%, 79.95%, 79.29% and 42.07% of total attention times respectively. All these five natural hazards belong to meteorological and hydrological hazards. In addition, Hangzhou's urban households have a high degree of trust in the ability to deal with local hazards and satisfaction with community solidarity, but have low satisfaction with response measures to local hazards. Moreover, the response measures adopted by urban households are to learn about disaster prevention and mitigation, accounting for 14.94%. When seeking help, most urban households turn to relatives and friends for help. At the same time, most urban households believe that disaster emergency training is the most effective means of relief.

(2) In the basic status of samples, male is more likely to take adaptive behaviors than female. Among the basic characteristics of urban households, the length of residence has a significant impact on family adaptability.

(3) From the aspect of disaster awareness to natural hazards, experience of natural hazards, the types of natural hazards experienced (meteorological hazards), the types of losses caused by natural hazards (loss of businesses, damaged buildings, missed work, damaged appliances), the ways of understanding hazards (network/TV, books/newspapers, community/school education) and the time for learning about hazards all have significant effects on family adaptability.

(4) In the satisfaction of urban household, the urban households who trust the response ability to local hazards, are satisfied with the response measures to local disaster and are satisfied with the community solidarity degree, have the higher probability to adopt the adaptability for dealing with natural hazards.

Therefore, from the current situation of the urban household's adaptation to natural hazards in Hangzhou City and influencing factors, we can improve the adaptation of urban households natural hazards from three aspects, namely emergency publicity, community construction and emergency capacity.

(a) To improve the publicity channels of natural hazards, to release timely and effectively the warning and risk analysis of natural hazards, to unite dissemination of knowledge about natural hazards and response measures, to enhance public training in disaster emergency response and to release timely the disaster warning and prevention measures using the micro blog, short message and other means.

(b) To strengthen community management and establish a social system of mutual help between neighbors in the community, to carry out actively a variety of activities to promote neighborhood relations, create a warm, united, harmonious community environment, to enhance urban household's satisfaction with community solidarity. Special trainings on disaster prevention and reduction have been

actively carried out in communities to disseminate knowledge on disaster response and to enhance the adaptive capacity of families to cope with natural hazards.

(c) To promote social emergency response and improve the response ability to natural hazards, to strengthen local infrastructure for disaster prevention and reduction and to improve response capabilities and response measures to local hazards, to allocate rationally the disaster emergency materials and to improve the allocation of disaster emergency materials in communities and to strengthen the ability of disaster emergency response in communities.

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