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A Study of Flood Disaster Risk Communication Model and Adaptive Behaviours for River-Watershed residents in Taiwan

Di Hu[1*], Jen Te-Pai[1], Yu-Yun Chen[1]
1 Department of Land Economics,National Chengchi University
** Corresponding Author, Email: 657080884@qq.com*

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Abstract: Due to global climate change, rainfall patterns have become more centralized and are causing serious damage more frequently and heavily. After the experiences of typhoons in Taiwan, the importance of risk communication with residents, especially in the vulnerable river watershed area, has become the main issue of disaster prevention policy; however, this effort is frustrated by the lack of related academic research. This study aims to analyse key factors in risk communication mechanisms and how they influence the decision-making of adaptive behaviours. Firstly, this study builds a conceptual framework of the risk communication process to determine how adaptive behaviours are triggered and guided by risk communication. Questionnaires based on this framework were sent to households in the Kaoping River watershed area to verify its utility using a structural equation model (SEM). Based on the framework, an empirical analysis was performed to analyse the key factors influencing decision-making of adaptive behaviours using multinomial logistic regression. The results show that adaptive behaviours are affected by internal awareness of disaster and by risk communication mechanisms and the external environment. The crucial communication channels through family, friends, neighbours and local governments are highly effective. The key factors influencing decision-making of adaptive behaviours are awareness of disaster and adaptive behaviours. People with higher awareness of disaster and adaptive behaviours are more likely to have positive adaptive behaviours. Furthermore, due to the interaction of environments, risk communication patterns and socioeconomic attributes, people from different communities have different adaptive behaviours. Based on the empirical results, some risk communication measures are proposed to improve disaster-prevention strategies.

1. INTRODUCTION

Due to the increasingly apparent influence of global climate change and the greenhouse effect, the steeply rising and rugged terrain of Taiwan, the complex distribution of its hydrological model, combined with development in the watershed area, the watershed area faces extreme precipitation that often results in major disasters during typhoons. Statistics have revealed that the severity of disasters caused by typhoons is related to an increase in extreme precipitation. Moreover, the frequency of typhoons related to extreme precipitation is trending significantly upwards and contributing to the rising

number of major disasters (e.g. Nari, Morakot, Fanapi); during the period between 1970 and 1999, there was a major disaster on average once every 3-4 years, which increased to once per year during the 10 year period after 2000 (*Figure 1*) (Hsu & Chou, 2011).

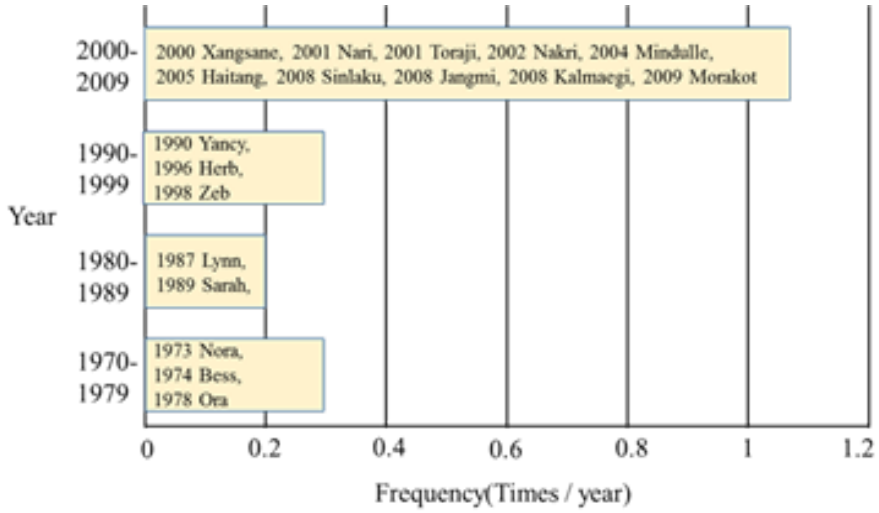

Figure 1. Changes in The Number of Typhoons Hitting Taiwan With Extreme Precipitation

It was also revealed in the International Panel on Climate Change's *Fourth Assessment Report* that past carbon emissions have contributed to global warming. To adequately respond to the impact, adaptive behaviours have therefore become increasingly necessary, and the most pressing task is to form adaptive strategies for climate change. The Executive Yuan of Taiwan officially approved the *Adaptation Strategy for Climate Change* in Taiwan in June, 2012, declaring the provision of disaster related information and improvement of warning systems and adaptability as the key climate policy for the future (Hong & Lu, 2015); it emphasises local level participation and implementation of adaptive concepts. While this is an important direction, prior work related to disaster risk management has often neglected the aspects of public awareness and disaster response, instead focusing narrowly on form and design at a technical level and information provision, such as the production and supply of disaster potential maps. As a result, the government in practice often makes crucial mistakes when launching policies related to disaster prevention and reduction, warning response systems and adaptive strategies.

In the case of Typhoon Morakot in 2009, despite the astonishing total forecast rainfall, and due partially to inadequate public disaster warnings, the public had a low perception of threat levels and did not take adequate emergency measures. Additionally, there was a red alert issued in the debris flow alert for the settlement of Xiaolin Village and the Kaohsiung/Pingtung area, but the population there failed to understand the severity represented by such an alert, which led to difficulty with the advisory evacuation and the withdrawal of the village, ultimately resulting in large-scale devastation. It is clear that any disaster risk governance policy, steered by the government and other experts, will remain inadequate in the absence of a comprehensive risk communication mechanism. Moreover, the public should be properly informed of the relevant policies and governance mechanisms for disaster risk. Hence, due to increasingly intense and diverse disasters, proper risk communication and participation mechanisms will be required so that the government, relevant organisations and households can jointly participate in

disaster risk management. Adaptive policies for outreach and disaster will help to mitigate the impact of disasters under extreme weather.

Unfortunately, there is a scarcity of Taiwanese research on the relationship between risk communication and household adaptive behaviour or the relationship between the different factors in the risk communication process. Taiwan will effectively improve its household and community adaptive capacity and mitigate the impact caused by extreme weather under climate change if it achieves the following: a thorough assessment should be undertaken for current flood disaster related risk communication, and the state should control risk awareness, attitude and adaptive behaviour in targets of communication, and thereby improve the risk communication and adaptive strategies in its current practice. To this end, this paper analyses households in the sensitive area of the Kaohsiung and Pingtung watershed to discover their views on risk communication, disaster risk awareness and adaptive behaviours. A structural equation model (SEM) will be used to verify the conceptual framework of risk communication for household adaptive behaviour, and detail the relevance of factors in the risk communication process and their relationship to adaptive behaviour. The analyses then utilises multinomial logistic regression to build the adaptive behaviour decision-making model and determine the key factors affecting adaptive behaviours. Finally, the results of the analysis are given along with further suggestions for the drafting of effective risk communication and adaptive household strategies directed towards the government or relevant departments responsible for flood disaster response.

2. LITERATURE REVIEW

2.1 Risk Communication Related Literature

The National Institute of Health defines risk communication as “the interaction of mutual exchange of information and opinions by relevant individuals, groups or agencies to collectively determine how to prevent or manage risk” (Yuan, 2007). Risk communication is closely related to risk awareness, risk attitudes and the use of risk management methods. The risk communication between the residents, local communities, government agencies, and other stakeholders is indispensable in terms of effective risk management (Tigere, 2013). Risk communication covers a wide range of activities and meanings, including discovering discrepancies over risk awareness, presenting and explaining risk information, promoting the focus on environmental or health related issues, enhancing public risk awareness, changing risk attitudes, affecting personal risk behaviours and promoting protective actions, providing strategies for emergency information, improving disaster warning systems, and developing risk management cooperation protocols, as well as resolving conflicts (Covello, Slovic, & Von Winterfeldt, 1986; O’Riordan et al., 1989).

Poussin, Botzen, & Aerts (2014) analysed the influencing factors of adaptive behaviour based on the protection motivation theory (PMT). The study suggests that the availability of information related to adaptive measures enhances individual coping appraisal and thereby promotes the adoption of adaptive behaviours. Lindell & Perry (2003) proposed the information communication process in protective behavioural decision modelling and stressed the dual importance of timely supply of correct risk information by

the risk communicator and understanding of the requirement for risk information by the receiver, which serves as their main reference for making behavioural decisions using the proper channels and message content. Rohrmann, (2000) proposed the risk communication process framework (*Figure 2*) and suggested a high correlation between the process of how people cope with hazards, how risk information is processed and evaluated, and how the perception of information changes risk awareness, risk assessment and behavioural decisions. Although the model mostly focuses on the correlation between the message and behaviour, successful risk communication must be regarded as an interactive process (Leiss, 1996; Renn, 1992) and hence the query, feedback and mechanism for interaction with risk managers is highly important (Rohrmann, 2000).

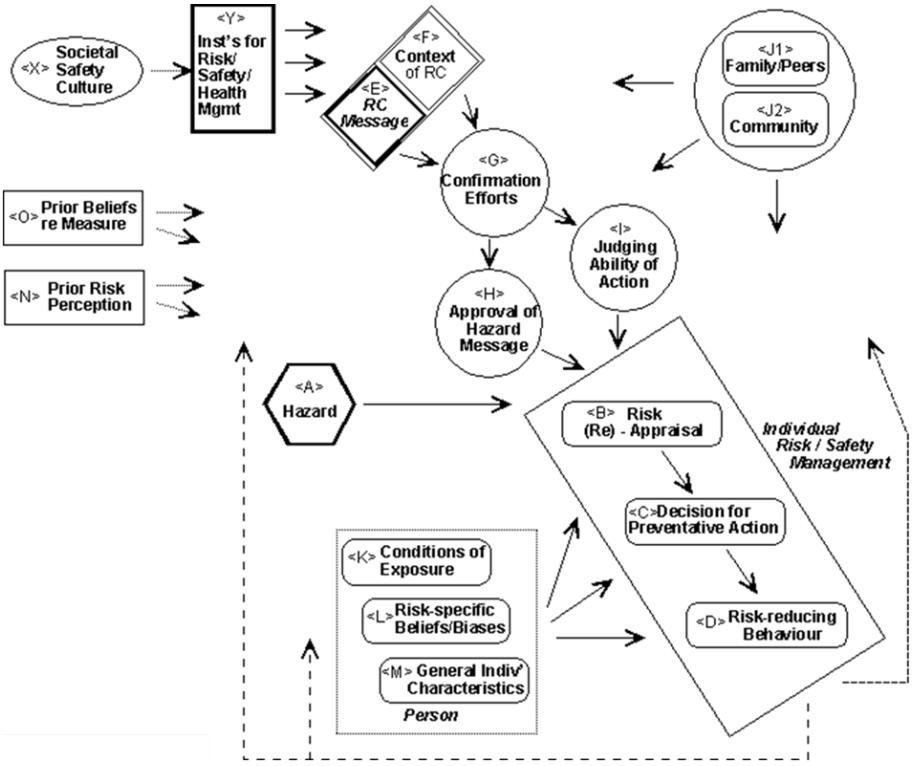

Figure 2. Risk Communication - Process Framework

Prior literature regarding the analysis of risk messages mostly focuses on the message source, message transmission channel, and the analysis of message content, exploring the influence of different message sources, channels and content on the message perceivers. Li (2011) stated in their study that more explicit information content on disasters would help the residents understand disaster information and enhance disaster risk awareness. Moreover, the resident valuation of demand for disaster information would affect government intent in the supply of disaster information and increase participation in community disaster prevention campaigns. Kuo (2014) analysed whether the availability of risk information could enhance public risk perception and the results suggest that emergency evacuation maps would help to raise public awareness for threats to life and safety and personal property loss. There also exists a significant relationship between flood risk perception and prior experience and education. The study conducted by Lindell, Lu, & Prater (2005) reveals that although the public most commonly acquire typhoon related information via local media (particularly from local TV

stations), the emergency evacuation decisions in times of disasters are mostly influenced by peers and local government. Driscoll & Salwen (1996) discovered that the public differentiates between different communication channels, regarding TV and radio as more professional and placing more trust in them. This paper therefore analyses the correlation between risk communication and adaptive behaviours for message source, channel and content.

2.2 Influencing factors for adaptive behaviours

Parry et al. (2007) define an adaptive behaviour as an adjustment in natural or human systems, in response to actual or expected climatic stimuli or their effects, that moderates harm or exploits beneficial opportunities. Grothmann & Patt (2005) applied PMT as the basis for their model of private proactive adaptation to climate change (MPPACC) (*Figure 3*), which explores the factors affecting individual decision-making for adaptive behaviours with emphasis on the significance of psychological cognition in private adaptive behaviours.

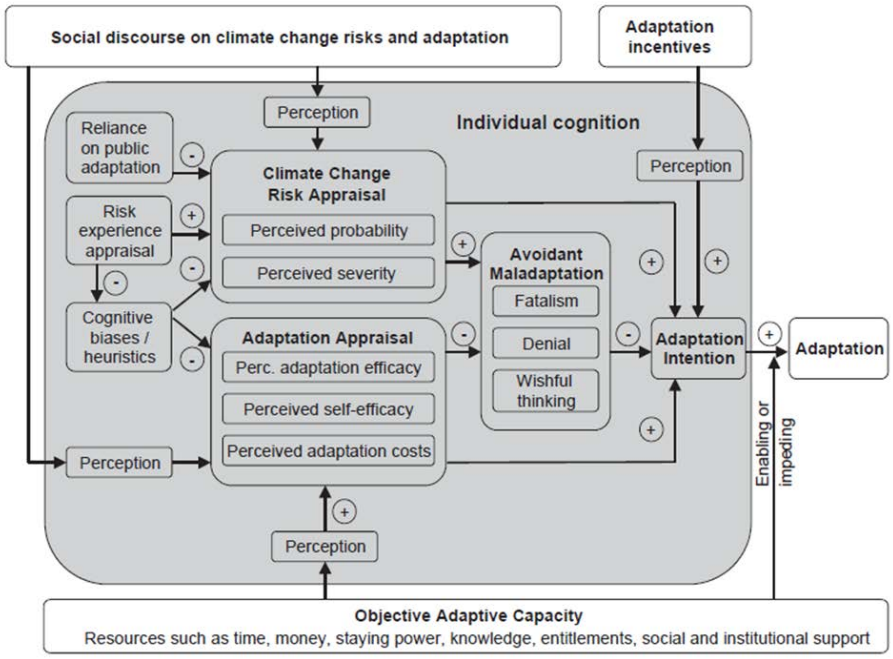

Figure 3. Process Model of Individual Proactive Adaptation to Climate Change (MPPACC)

The literature suggests that people observe signs in the natural environment to determine the level of disaster and whether or not to adapt their behaviour correspondingly (Liao & Teng, 2012). Moreover, the level of community participation or frequency of contact with friends and relatives also enhances information perception and risk awareness (Drabek & Boggs, 2018; Lindell & Perry, 2003). Furthermore, individuals with higher risk awareness will more intensively learn about disaster risk, disaster prevention and relief related knowledge, disaster prevention measures, local resources and routine training (Beringer, 2000), which will thereby facilitate proper individual adaptive behavioural changes. Rogers (1997) believes that human awareness of the environment comes from experience of disaster and will produce adaptive behaviours for the environment through learning from prior

experience in disasters. Psychological factors such as optimistic bias, fatalism and perceived responsibility will also affect adaptive behaviours. Bočkarjova, van der Veen, & Geurts (2009) pointed out in their study that the public tends to have lower risk perception if they perceive that preparation for floods and disasters is the responsibility of the government, and are therefore less likely to prepare for disasters. Additionally, socioeconomic conditions, such as gender, occupation, race and education level, all influence adaptive behaviour, according to many studies. Research from Tsao & Chang (2008) indicates that females are more proactive than males in adapting their behaviour. Griffin, Dunwoody, & Neuwirth (1999) suggest that older age is associated with fear of disaster and hence higher risk perception and likelihood of adaptive behaviours. Edwards (1993) discovered that families with higher education levels, higher family income, and with children are more inclined to take preparation measures. In summary, the prior literature suggests that the influence factors of adaptive behaviours can generally be divided into external environmental factors and internal private factors. External environmental factors include the natural and social environment and risk communication mechanisms, while internal individual factors include risk perception and adaptive behaviour perception. Moreover, risk perception and adaptive behaviour perception are not only affected by external environmental factors but also differ by demographic characteristics, experience in disasters and individual psychology.

3. CONCEPTUAL FRAMEWORK AND RESEARCH DESIGN

3.1 Conceptual Framework of Risk Communication for Household Adaptive Behaviour

The paper refers to the research of Lindell & Perry (2003), Rohrmann (2000), and Grothmann & Patt (2005) to establish the conceptual framework of risk communication for household adaptive behaviour, as shown in *Figure 4*.

First, risk communication mechanisms and environmental factors affect individual psychological factors and collectively affect the formation process of perception and attitude through private socioeconomic attributes, experience in disasters, and the interaction of psychological factors. Based on the influence of aforementioned factors, in the process of disaster cognition, the individuals will determine disaster risk, behavioural effect and costs, as well as self-efficacy of adaptive behaviours, supported by individual familiarisation with the disaster prevention plan - including the adaptive map for the disaster site and emergency evacuation route - integrated with their disaster risk attitude; all of which affect subsequent decisions in adaptive behaviours.

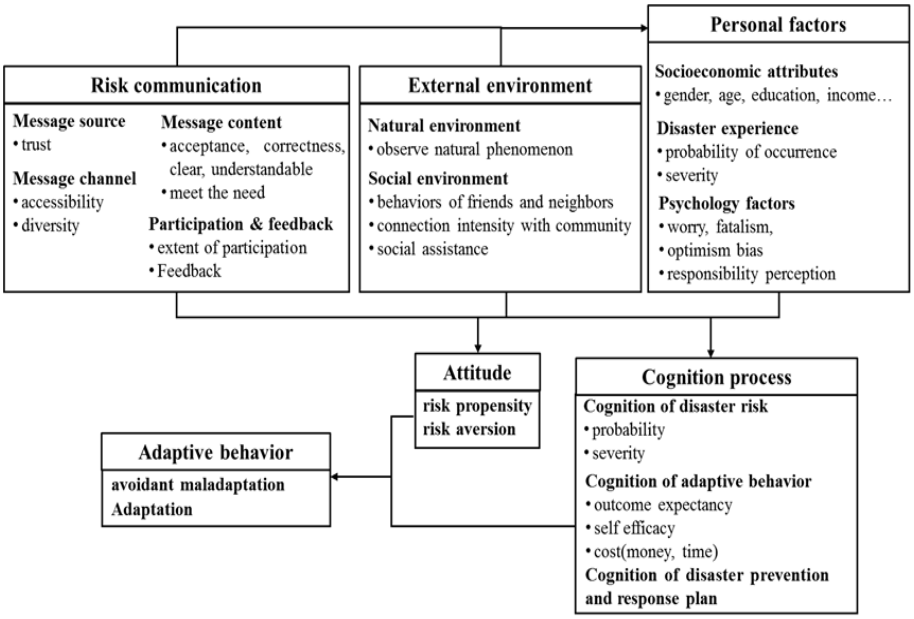

Figure 4. Conceptual Framework of Risk Communication Process

3.2 Questionnaire drafting and sampling design

The interview content of the questionnaire was drafted in accordance with the conceptual framework of risk communication for household adaptive behaviour, including (1) disaster perception and experience in disasters, (2) psychological factors of disasters, (3) risk communication mechanisms and socio-environmental factors, (4) evaluation and decision-making of adaptive behaviours, and (5) socioeconomic attributes.

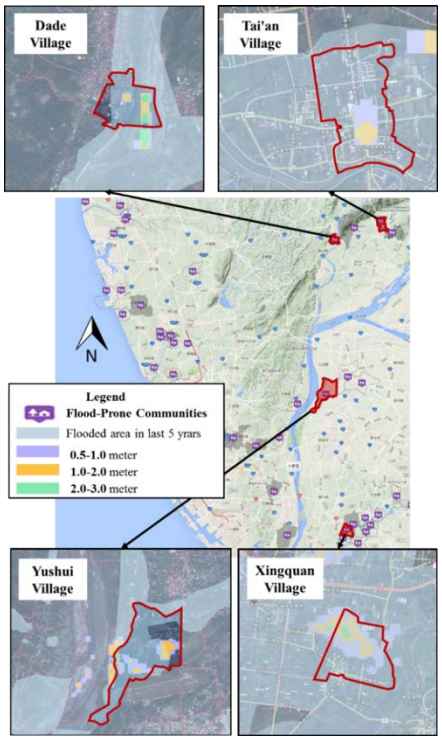

Figure 5. Position and Potential Flooding Map of Surveyed Village

The paper conducted an investigation in different areas, including Dade village in the Qinshan district and Tai'an village in the Meinong district of Kaohsiung city, and Yushui village in the Jiuru district and Xingquan village in the Wandan district of Pingtung County (*Figure 5*). The questionnaire was distributed by random sampling of household units and the principal decision makers of the households completed the questionnaire, as representatives of the overall household adaptive behaviour. Field tests were conducted on January 11, 2016. As of February 27, 2016, a total of 239 questionnaires were recovered, including 195 valid questionnaires; the effective recovery rate was 81.25%.

4. RISK COMMUNICATION FRAMEWORK AND DECISION-MAKING ANALYSIS

The questionnaire data underwent proper sorting and conversions before simplifying the variables to yield a better fit for the model in accordance with the parsimony principle and principal component analysis. The SEM model was applied to test the risk communication framework for household adaptive behaviour and to determine the relation of variables in the framework. After this, the multinomial logistic regression model was applied to build the adaptive behaviour decision-making model and find out the key influencing factors affecting adaptive behaviour decision-making.

4.1 Factor Analysis – Principal Component Analysis

After establishing the conceptual framework through the theory and logic of the relevant literature, this paper takes those aspects as the latent variables in the SEM model and simplifies the questions pertaining to those aspects through principle component analysis to yield the measured variables. *Table 1* shows the variables of aspect questions after principle component analysis.

Table 1. SEM Model Variable Description Table

Latent variable	**Measured variable**
External environment	Community connection
	Natural & social environmental cues
Risk communication mechanism	Message content
	Accessibility of channels & trust of sources--- Local community
	Accessibility of channels & trust of sources--- Electronic & print media
	Accessibility of channels & trust of sources--- Modern communication
Internal cognition	Cognition of disaster
	Cognition of adaptive behaviour
	Psychology factors
Adaptive behaviour	Emergency measures
	Adaptive measures

4.2 Empirical Analysis on the Risk Communication Framework for Household Adaptive Behaviour

This paper adopts SEM to test the conceptual framework of risk communication for household adaptive behaviour, which yields the final model after multiple model simulations (*Figure 6*). The overall model fit reaches a GFI value of 0.87, compared with the ideal value of 0.8 (Bagozzi, 1988; Browne & Cudeck, 1992; Seyal, Rahman, & Rahim, 2002).

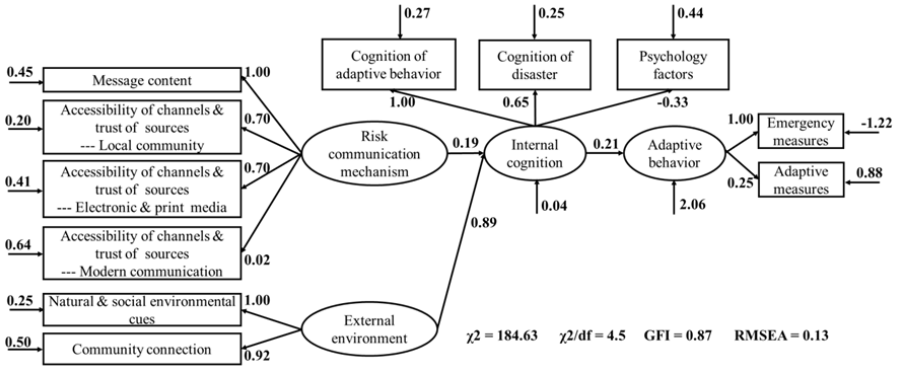

Figure 6. SEM Empirical Model Results

In the structural model, "risk communication mechanism" and "external environment" significantly affect internal cognition and further affect the household adaptive behaviour. This suggests that risk communication mechanisms and the external environment can strengthen the internal cognition of the individuals in the adoption of subsequent adaptive behaviours. It is notable that "external environment" (factor loading 0.89) is stronger in terms of influence of internal cognition compared with "risk communication mechanism" (factor loading 0.19), which further highlights the significance of the community environment on household adaptive behaviour.

For the risk communication mechanism, "message content" (factor loading 1.00) has the greatest influence, suggesting that household awareness of the message content, clearness of content and the facilitation of household adoption of adaptive measures are highly important factors for the risk communication mechanism, followed by "media channel accessibility and trust" and "communication channel accessibility and trust" (both factor loadings are 0.70). It is apparent that public accessibility to and trust in media channels such as the TV and newspapers is relatively higher, while media still acts as one of the practical channels. Moreover, a high level of "community channel accessibility and trust" similarly suggests that the public consider acquiring relevant messages from friends, relatives, neighbours, village heads and local government agencies convenient and highly trustworthy. Moreover, community channels play considerably important roles in the risk communication process while "the accessibility and trust of communication and new types of channels" appeared insignificant in the test, with factor loading of merely 0.02. It can be inferred that the public are both widely unfamiliar and have low trust in the communication channels of telephone and text messages via mobile phone and newer types of communication channels like internet and mobile phone apps.

Among the environmental aspects, "Natural Social Sign" (all factor loadings 1.00) and "community connection" (all factor loadings 0.92) show

significant and strong influence, suggesting the public observe natural phenomenon and the behaviour and conduct of friends, relatives and neighbours as references in the awareness formation process. Moreover, the intensity of the community connection positively influences internal cognition; the frequency of exchange with friends, relatives and neighbours, and the level of community preparation for flooding help the formation of disaster awareness.

Regarding internal cognition, "adaptive behaviour cognition" (factor loadings 1.00) shows the greatest influence, followed by "disaster cognition" (factor loadings 0.65) and finally the "psychological factor" (factor loadings -0.33). This shows that individual awareness of adaptive behaviours plays an important role in the internal cognition formation process, including the consideration of the projected adaptive behaviour effect, self-efficacy cognition, and the costs of adopting adaptive behaviours. Moreover, disaster awareness positively influences the process of internal cognition formation. In contrast, individual psychological factors, including fatalism, optimistic bias and perceived responsibility have a negative influence.

Finally, the factor loading parameters for adaptive behaviour aspects shows that "emergency measures" (factor loading 1.00) has greater factor loading than "adaptive measures" (factor loading 0.25). This phenomenon suggests that the overall responding public still prefers to take emergency measures in times of disaster and still neglects routine adaptive measures – a situation that requires further improvement.

4.3 Empirical analysis for the decision-making model of household adaptive behaviour

After testing the risk communication framework for household adaptive behaviour through the SEM model, the framework helps to clarify the correlation between various key influencing factors in the process from conducting disaster risk communication to adopting adaptive behaviours. Nonetheless the model does not analyse the key factors affecting the decisions in household adaptive behaviour. Hence, the paper further applies multinomial logistic regression to analyse the relation between variables and adaptive behaviour decisions, in addition to establishing the decision-making models for emergency measures and adaptive measures.

4.3.1 Variables Selection

The selection of independent variables takes the principal component from the results of principle component analysis as the variables and adds socioeconomic variables in addition to setting the emergency measures and adaptive measures as the independent variables. The category of intensity for facing disaster response proposed by Burton, Kates, & White (1993) is taken into consideration for dividing the dependent variables into emergency measures and adaptive measures. The specific emergency and adaptive measures are concluded and subdivided into "inactive or low level of activeness", "medium level of activeness" "and "high level of activeness" under the emergency measures or adaptive measures (as shown in *Table 2* and *Table 3*). The details of variable selection and description of variables as shown in *Table 4* show the analysis of the relationship between independent variables and emergency measures with the corresponding level of adaptive measures.

Table 2. Types of household emergency measures for this study

Level of Response		Specific Adaptive Behaviour
Inactive Emergency		Not adopting any measures
Active Emergency	Low level of activeness	Store water and food, prepare flashlights, emergency lighting, battery and other equipment
	Medium level of activeness	Pile up sand bags, set up flood-prevention gate, activate water pump, relocate valuables to higher-level floors
	High level of activeness	Emergency evacuation

Table 3. Types of household adaptive measures for this study

Level of Response		Specific Adaptive Behaviour
Inactive Adaptation		Not adopting any measures
Active Adaptation	Low level of activeness	Purchase accident insurance and reclaim compensation from the government
	Medium level of activeness	Strengthen building structure, do not place valuables in lower-level floors, and request the local government to improve flood prevention facilities
	High level of activeness	Move to a place less likely to flood

Table 4. Multinomial Logistic Regression Variables Description Table

Type of Variable		Variable Names	Variable Description
Independent variable	Risk communication mechanism	Message content	continuous variable
		AC&TS - Local community	continuous variable
		AC&TS - Electronic & print media	continuous variable
		AC&TS - Modern communication	continuous variable
	External environment	Natural & social environmental cues	continuous variable
		Community connection	continuous variable
	Internal cognition	Cognition of adaptive behaviours	continuous variable
		Cognition of disaster	continuous variable
		Psychology factors	continuous variable
	Socioeconomic attributes	Gender	Categorized variable: 1 = Male, 2 = Female (reference group)
		Age	Categorized variable:1 = Under 26, 2 = 26-50 ,3 = 51-75, 4 = Over 75 (reference group)
		Education level	Categorized variable: 1 = Under junior high school, 2 = Above Junior high school and ,under College, 3 = Above College(reference group)
		Household monthly income	Categorized variable: 1 = Under 20,001, 2 = 20,001-40,001, 3 = Above 40,001 (reference group)

Type of Variable		Variable Names	Variable Description
		Village	Categorized variable: 1 =Yushui Village, 2 = Xingquan Village, 3 = Dade Village, 4 = Tai'an Village (reference group)
	Adaptive behaviour	Emergency measures	Categorized variable: 1 = Inactive or low level of activeness in emergency measures, 2 = Medium level of activeness in emergency measures, 3 = High level of activeness in emergency measures (reference group)
		Adaptive measures	Categorized variable: 1 = Inactive or low level of activeness in adaptive measures, 2 = Medium level of activeness in adaptive measures, 3 = High level of activeness in adaptive measures (reference group)
Dependent variable	Adaptive behaviour	Emergency measures	Categorized variable: 1 = Inactive or low level of activeness in emergency measures (reference category), 2 = Medium level of activeness in emergency measures , 3 =High level of activeness in emergency measures
		Adaptive measures	Categorized variable: 1 = Inactive or low level of activeness in adaptive measures (reference category), 2 = Medium level of activeness in adaptive measures, 3 = High level of activeness in adaptive measures

Note: Accessibility of channels & trust of sources abbreviated as AC&TS

4.3.2 Emergency Measures Decision-Making Model

For model fit, the *p*-value of the Chi-squared test is smaller than 0.01 and establishes the final model significance. Regarding the test for correlation between independent variables and dependent variables, Cox and Snell R^2 and Nagelkerke R^2 reached 0.15, suggesting a correlation between independent variables and dependent variables. The emergency measures decision-making model fit test and test results summary are shown in *Table 5*.

4.3.2.1 Influence of Risk Communication Mechanism on Emergency Measures

"Community channel accessibility and trust" reaches significance in the level of activeness in emergency measures. High "communication channel accessibility and trust" means higher likelihood of adopting "inactive or low level of activeness in emergency measures". It can be inferred that most of the friends, relatives, neighbours or village heads will remind residents to store food, water, flashlights and perform other simple emergency measures before typhoons. Nonetheless, "medium level of activeness in emergency measures" and "high level of activeness in emergency measures" do not necessarily lead to such reminders and, therefore, the community channel has greater influence on low level of activeness for emergency measures.

4.3.2.2 Influence of External Environment on Emergency Measures

"Community Connection" reaches the 0.05 significance level with an odds ratio of 2.977, indicating that a stronger community connection leads to a

greater likelihood of "medium level of activeness in emergency measures." This suggests that, apart from the routine exchange with friends, relatives and neighbours, residents should voluntarily care about the community flood issues because it will deepen their knowledge of the relevant emergency measures. Therefore, beyond the average simple low level of activeness in emergency measures, the residents will additionally stack sand bags, install flood prevention gates and prepare water pumps, as well as taking other emergency measures.

4.3.2.3 Influence of Internal Cognition on Emergency Measures

Regarding internal cognition, "disaster cognition" and the "psychological factor" both reach 0.05 in significance level. Compared with other variables, "disaster cognition" has a more significant and stronger influence on the decisions of emergency measures, suggesting consistency with the literature results, while enhanced disaster awareness aids the adoption of emergency measures. On the other hand, those with higher scores in "psychological factors" will be relatively less likely to choose "medium level of activeness in emergency measures" and "high level of activeness in emergency measures," suggesting that people more inclined to negative psychological factors such as fatalism, optimistic bias or perceived responsibility are less likely to have medium level or higher activeness in emergency measures.

4.3.2.4 Influence of Socioeconomic Background on Emergency Measures

"Residence of Village" significantly influences the level of activeness in emergency measures. Tai'an Village is used as a reference group to compare with other villages and the results show that the likelihood for Yushui villagers and Xingquan villagers to adopt "high level of activeness in emergency measures" is higher. The reason could be that the people from the two villages have a greater awareness of the content of community disaster prevention and emergency evacuation routes. The number of participants from the public involved in flood control drills is also higher, explaining the higher likelihood of "high level of activeness in emergency measures" compared with other villages. Additionally, the likelihood of Dade villagers adopting a "medium level of activeness in emergency measures" is significantly lower than that of Tai'an village, which could be the result of a discrepancy in the disaster experience and demographic composition.

Results from the female reference group suggest that the likelihood of males adopting a high level of activeness in emergency measures is significantly lower than that of females. As suggested by the literature, females are more concerned with floods than males and are more likely to have high levels of activeness in taking emergency measures.

Results from the reference group aged 75 years old suggest that the likelihood of those aged below 26 years adopting "medium level of activeness in emergency measures" is significantly higher than those aged over 75 years. It is likely that those relatively younger will have greater motivation and strength, and could therefore take more active emergency measures.

Results from the reference group with monthly household incomes greater than NT$40,000 show that the likelihood of those with average monthly household incomes falling between NT$20,001 and 40,001 to have medium level or higher activeness in emergency measures is significantly smaller than those with incomes greater than NT$40,000, suggesting consistency with the literature. Since those with higher average monthly incomes own relatively

more resources, they are able to cope with the costs required for adopting emergency measures.

4.3.2.5 Influence of Active Level of Adaptive Measures on Emergency Measures

Taking "high level of activeness in adaptive measures" as a reference group reveals that the likelihood for those adopting a "medium level of activeness in adaptive measures", adopting a "medium level of activeness in emergency measures" is significantly higher than those adopting a "high level of activeness in adaptive measures." Moreover, those adopting an "inactive or low level of activeness in adaptive measures" are less likely to adopt a "high level of activeness in emergency measures" than those adopting a "high level of activeness in adaptive measures" are to adopt a "high level of activeness in emergency measures." It is apparent that the level of activeness in adaptive measures has a significant positive impact on the level of activeness in emergency measures.

Table 5. Emergency Measures Decision-Making Model Fit Test and Test Results Summary Table

	Chi-square	**df**	**significance**
-2 log-likelihood	141.59	42	0.000
Cox & Snell R^2 = 0.52	Nagelkerke R^2 = 0.60		

Variable name		**Medium Level of AEM**			**High Level of AEM**		
		estimated value	**significance**	**Exp(B)**	**estimated value**	**significance**	**Exp(B)**
Intercept		-2.662	0.375	.	-1.485	0.555	.
(AC&TS) - Electronic & print media		-0.373	0.403	0.689	0.193	0.595	1.213
(AC&TS) - Modern communication		0.133	0.767	1.142	-0.005	0.988	0.995
(AC&TS) - Local community		-1.246	0.020**	0.288	-0.177	0.703	0.838
Message content		-0.592	0.147	0.553	-0.147	0.649	0.863
Natural & social environmental cues		0.031	0.954	1.031	-0.197	0.621	0.821
Community connection		1.091	0.036**	2.977	-.017	0.958	0.983
Cognition of disaster		2.840	0.000***	17.119	1.312	0.010**	3.712
Cognition of adaptive behaviour		-0.611	0.222	0.543	-0.289	0.483	0.749
Psychology factors		-1.255	0.010**	0.285	-0.325	0.366	0.723
Village	Yushui	-0.481	0.641	0.618	2.540	0.000***	12.674
	Xingquan	-0.458	0.554	0.632	1.179	0.087*	3.251
	Dade	-3.176	0.003***	0.042	-1.367	0.128	0.255
	Tai'an	0[b]	.	.	0[b]	.	.
Gender	Male	-0.759	0.211	0.468	-0.843	0.083*	0.430
	Female	0[b]	.	.	0[b]	.	.
Age	<26	4.432	0.049**	84.123	0.242	0.901	1.274
	26-50	1.432	0.378	4.189	0.677	0.607	1.969
	51-75	-0.011	0.994	0.989	0.333	0.775	1.395
	>75	0[b]	.	.	0[b]	.	.
Education level	L	0.940	0.420	2.561	0.723	0.463	2.060
	M	-0.356	0.630	0.700	0.609	0.365	1.839
	H	0[b]	.	.	0[b]	.	.
	<20,001	-1.341	0.164	0.262	-0.905	0.261	0.404

		Chi-square	df	significance
-2 log-likelihood		141.59	42	0.000
Cox & Snell R^2 = 0.52	Nagelkerke R^2 = 0.60			

Variable name		Medium Level of AEM			High Level of AEM		
		estimated value	significance	Exp(B)	estimated value	significance	Exp(B)
Household monthly income	20,001-40,001	-1.523	0.064*	0.218	-1.129	0.099*	0.323
	>40,000	0[b]	.	.	0[b]	.	.
Adaptive measures	Inactive/low	-1.004	0.378	0.366	-3.630	0.000***	0.027
	Medium	1.458	0.072*	4.299	-0.594	0.302	0.552
	High	0[b]	.	.	0[b]	.	.

Note 1: *** p <0.01, ** p <0.05, * p <0.1

Note 2: 0[b] suggests the variable as reference group and hence the parameter is set to zero.

Note 3: Activeness in Emergency Measures (AEM)

Note 4: Accessibility of channels & trust of sources is abbreviated as AC&TS

Note 5: Education level - Under junior high school (L); Above Junior high school and under college (M); Above college (H)

4.3.3 Adaptive measure decision-making model

The adaptive measure decision-making model shows significant explanatory power if the Chi-squared test p-value is smaller than 0.01. The Cox and Snell R^2 and Nagelkerke R^2 reach 0.15, suggesting correlation between the independent variables and dependent variables. The adaptive measure decision-making model fit test and test results summary are shown in *Table 6*.

4.3.3.1 Influence of Risk Communication on Adaptive Measures

"Media channel accessibility and trust" falls below the significance level of 0.01, suggesting the likelihood of those with higher scores in "media channel accessibility trust" to adopt a "high level of activeness in adaptive measures" is far lower than the likelihood to adopt "inactive or low level of activeness in adaptive measures". The reason could be that the media channel represents passive message perception and is more likely to receive government related subsidy programs from TV news or newspapers and magazines, or flood disaster insurance information from insurance companies, with relatively less information content on the "high level of activeness in adaptive measures".

Under the significance level of 0.01, those with higher scores in "communication and new type of channel accessibility and trust" are more likely to adopt a "high level of activeness in adaptive measures" than to adopt an "inactive or low level of activeness in adaptive measures". It can be inferred that newer channels, such as internet or mobile phone apps, are proactive message channels where the public must voluntarily acquire flood disaster related information. This also suggests the possibility of achieving more proactive action for issues related to flood disasters with more diverse information matching individual requirements. For this reason, those with a higher score in "communication and new types of channel accessibility and trust" are more likely to adopt a "high level of activeness in adaptive measures".

4.3.3.2 Influence of External Environment on Adaptive Measures

The external environment variables do not significantly influence adaptive measures, suggesting that there is no significant difference between the natural social signs and community connection in terms of the activeness level in household adaptive behaviour. The statistical results of the questionnaire suggest that the responding public is speculated to show an overall unfamiliarity with the adaptive measures, and therefore the influence of the external environment on the household in terms of activeness level in adaptive measures is insignificant.

4.3.3.3 Influence of Internal Cognition on Adaptive Measures

The "adaptive behaviour cognition" corresponding to both "medium level of activeness in adaptive measures" and "high level of activeness in adaptive measures" reach the significance level of 0.05. Higher "adaptive behaviour cognition" will lead to higher likelihood of adopting "medium level of higher activeness in adaptive measures", suggesting that the projected adaptive behaviour effect and self-efficacy cognition significantly influence the household adoption of adaptive measure decisions.

4.3.3.4 Influence of Socioeconomic Background on Adaptive Measures

"Residence of village" significantly influences the level of activeness in household adaptive measures, where the likelihood for Yushui villagers, Xingquan villagers and Dade villagers to choose "high level of activeness in adaptive measures" is significantly smaller than Tai'an villagers. The reason for the high likelihood of Tai'an villagers to display a "high level of activeness in adaptive measures" compared with people from other villages is that Tai'an village is located in an area susceptible to flooding with a larger population. Approximately 98% of the public have experienced a flood within 5 years, while the demographic composition shows relatively higher education levels and incomes compared with other villages. Likelihood of the village to display "high level of activeness in adaptive measures" is higher than those in other villages.

Results for the reference group aged 75 years or older reveal that under the 0.1 significance level, the likelihood for those aged under 26 years old to adopt a "medium level of activeness in adaptive measures" is significantly less than for those aged under 75 years old, which differs from the results of the emergency measures. Younger people are more likely to neglect daily or disaster adaptive measures but are more likely to adopt proactive emergency measures in times of disaster due to higher mobility.

Moreover, "education level" also shows significant influence on the level of activeness in adaptive measures. For the reference group with education levels at university/junior college (inclusive) and under the significance level of 0.1, those with education levels below junior high school are significantly less likely to choose "medium" or "higher levels of activeness in adaptive measures" than those with education at university/junior college (inclusive) or higher levels; those with education at university/junior college and lower levels are less likely to display a "higher level of activeness in adaptive measures" than those with university/junior college (inclusive) level education and higher. The results are consistent with the literature review; people with higher education levels are more likely to adopt more proactive adaptive measures.

4.3.3.5 Influence of Emergency Measures on the Level of Activeness in Adaptive Measures

In the reference group for "high level of activeness in emergency measures," the odds ratios for those adopting "inactive or low level of activeness in emergency measures" corresponding with those adopting "medium level of activeness in adaptive measures" and "high level of activeness in adaptive measures" are 0.062 and 0.029 respectively, suggesting those that display an "inactive or low level of activeness in emergency measures" are less likely to adopt a medium or higher level of activeness in adaptive measures. Additionally, the odds ratio for those adopting a "medium level of activeness in emergency measures" to adopt a "high level of activeness in adaptive measures" is 0.047. Namely, those adopting a "medium level of activeness in emergency measures" are less likely to adopt a "high level of activeness in adaptive measures". Higher levels of activeness in emergency measures are therefore more likely to correlate with adaptive measures with higher level of activeness.

Table 6. Adaptive Measure Decision-Making Model Fit Test and Test Results Summary Table

	Chi-square	**df**	**significance**
-2 log-likelihood	141.59	42	0.000
Cox & Snell R^2 = 0.52	Nagelkerke R^2 = 0.60		

Variable name		**Medium Level of AAM**			**High Level of AAM**		
		estimated value	**significance**	**Exp(B)**	**estimated value**	**significance**	**Exp(B)**
Intercept		6.325	0.017	.	3.372	0.329	.
AC&TS - Electronic & print media		-0.341	0.404	0.711	-1.295	0.014**	0.274
AC&TS - Modern communication		-0.054	0.835	0.947	1.861	0.002***	6.430
AC&TS - Local community		0.185	0.692	1.203	-0.681	0.230	0.506
Message content		0.044	0.890	1.045	-0.121	0.761	0.886
Natural & social environmental cues		-0.702	0.140	0.496	-0.763	0.194	0.466
Community connection		0.070	0.825	1.073	0.631	0.113	1.880
Cognition of disaster		0.011	0.980	1.011	-0.003	0.996	0.997
Cognition of adaptive behaviour		0.834	0.088*	2.303	1.276	0.025**	3.581
Psychology factors		-0.491	0.194	0.612	-0.192	0.675	0.825
Village	Yushui	-2.320	.004***	0.098	-5.154	0.000***	0.006
	Xingquan	-0.452	0.562	0.636	-2.691	0.004***	0.068
	Dade	-1.348	0.160	0.260	-3.919	0.001***	0.020
	Tai'an	0^b	.	.	0^b	.	.
Gender	Male	0.146	0.748	1.157	.595	.330	1.812
	Female	0^b	.	.	0^b	.	.
Age	<26	-2.262	0.095*	0.104	-3.069	0.134	0.046
	26-50	-0.890	0.346	0.411	-1.767	0.257	0.171
	51-75	-0.010	0.991	0.990	-0.325	0.818	0.722
	>75	0^b	.	.	0^b	.	.
Education level	L	-1.588	0.070*	0.204	-2.015	0.077*	0.133
	M	-0.562	0.430	0.570	-1.562	0.060*	0.210
	H	0^b	.	.	0^b	.	.
Household monthly income	<20,001	0.186	0.783	1.204	0.251	0.783	1.286
	20,001-40,001	0.831	0.185	2.296	1.163	0.142	3.199
	>40,000	0^b	.	.	0^b	.	.
Emergency measures	Inactive / Low	-2.780	0.000***	0.062	-3.540	0.000***	0.029
	Medium	-0.915	0.392	0.401	-3.050	0.017**	0.047
	High	0^b	.	.	0^b	.	.

Note 1: *** p <0.01, ** p <0.05, * p <0.1

Note 2: 0^b suggests the variable as reference group and hence the parameter is set to zero.

Note 3: Activeness in Adaptive Measures (AAM)

Note 4: Accessibility of channels & trust of sources is abbreviated as AC&TS

Note 5: Education level - Under junior high school (L); Above Junior high school and under

5. DISCUSSION

This paper aims to analyse the relationship between disaster risk communication and household adoption of adaptive behaviour, in addition to determining the key factors affecting adaptive behaviours. The households in the Kaopingxi River watershed areas are used as the research subjects and information was acquired through questionnaire surveys. The SEM model is used to test the conceptual framework of risk communication for household adaptive behaviour established by the paper in accordance with a literature

review. The paper analyses the relationship between risk communication elements and adaptive behaviour and further adopts multinomial logistic regression to build the household adaptive behaviour decision-making model and analyse the key factors affecting adaptive behaviour decisions.

The analytical results of the SEM model also reveal that the public is more widely familiar with emergency measures in times of disasters but unfamiliar with the routine or post-disaster adaptive measures. It could be that the current direction of promotion for flood-prone communities mostly emphasises drills for emergency public response procedures; nonetheless, the decision-making model suggests a correlation between emergency measures and adaptive measures, meaning not only selling disaster insurance and strengthening building structures, but developing the high-risk areas to reduce the impact of typhoons and floods. For this reason, the public should be educated on the value of daily adaptive measures via the communication process, and in order to improve the community's disaster adaptive strategies, through disaster consequence reduction combined with emergency drills prior to disasters occurring.

Moreover, the analytical results of the SEM model show that internal cognition is subject to significant influence from risk communication mechanisms and the external environment. In particular, the community channels play an important role in the risk communication mechanism; its accessibility is convenient and has a high level of public trust. Moreover, the intensity of the connection between community residents also significantly positively influences adaptive behaviour. The analysis of the adaptive behaviour decision-making model suggests that different villages have significant differences in their level of active adaptive behaviour and such difference could result from the difference in disaster experience, the socioeconomic background of the community, the user characteristics of the risk communication channel and the relation between the community residents. Consequently, the different villages show varying characteristics across all aspects. Hence, household risk communication strategies should be formed with respect to the community scale, and only after pre-investigation on the use of communication channels by the public, their socioeconomic background, and disaster related awareness. Information should be conveyed and exchanged through the communication channels and an approach suitable for that community regarding their particular gaps in awareness for existing disasters or lowering the negative psychological factors of the public.

Disaster risk communication is part of disaster management and is a continuous process, representing the interaction of individuals, groups or agencies exchanging information and opinions with each other. Hence, assessment standards should be established after designated implementation of assessment, allowing the public to express views on risk communication, and after an evaluation of the effectiveness of risk communication, examining whether the proposed disaster awareness and adaptive behaviours appropriately match the current risk communication mechanism according to their particular requirements. The risk communication model will only be improved to adequately accommodate the local public through continuous correction and adjustment.

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