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Analysis of Household Vulnerability and Adaptation Behaviors to Typhoon Saomai, Zhejiang Province, China

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Tropical cyclones, induced by climate change, are happening more frequently and cause serious damage almost every year in China. For this reason, it is necessary to improve the ability of government, communities and households to adapt to climate change and tropical cyclones. Typhoon Saomai was the most powerful typhoon ever to hit Pingyang County, Zhejiang Province, and this report looks at the vulnerability of households as a result of the Saomai disaster and analyzes the factors that influenced vulnerability.. The report analyzes the adaptive capacity of households using the following indicators: infrastructure, economic factors, technology, social factors, skills and knowledge. These indicators, and the factors that influence them, were analyzed using an econometric model analysis. The report also discusses the different adaptive options households could take and the reasons why some options, rather than others, were taken, including those which should have been taken before the typhoon struck, those which should have been performed during the typhoon, and those which were implemented after the typhoon. Finally, the report looks at the gaps between household needs and the reality of coping with typhoon disasters, and gives strategies to improve the ability of households to adapt to typhoons.

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ANALYSIS OF HOUSEHOLD VULNERABILITY AND ADAPTATION BEHAVIORS TO TYPHOON SAOMAI, ZHEJIANG PROVINCE, CHINA

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ABSTRACT

Tropical cyclones, induced by climate change, are happening more frequently and cause serious damage almost every year in China. For this reason, it is necessary to improve the ability of government, communities and households to adapt to climate change and tropical cyclones. Typhoon Saomai was the most powerful typhoon ever to hit Pingyang County, Zhejiang Province, and this report looks at the vulnerability of households as a result of the Saomai disaster and analyzes the factors that influenced vulnerability.. The report analyzes the adaptive capacity of households using the following indicators: infrastructure, economic factors, technology, social factors, skills and knowledge. These indicators, and the factors that influence them, were analyzed using an econometric model analysis. The report also discusses the different adaptive options households could take and the reasons why some options, rather than others, were taken, including those which should have been taken before the typhoon struck, those which should have been performed during the typhoon, and those which were implemented after the typhoon. Finally, the report looks at the gaps between household needs and the reality of coping with typhoon disasters, and gives strategies to improve the ability of households to adapt to typhoons.

1.0 INTRODUCTION

1.1 Tropical Cyclones

Out of all the recurring natural disasters that take place along the coastal areas of China, tropical cyclones pose the most dangerous threat to life and property. Zhejiang Province is vulnerable to natural hazards because of its geographical location and socio-economic distribution. Of all the losses caused by natural hazards in this province, 90% are a result of extreme weather. Tropical cyclones are the primary natural hazard in Zhejiang in terms of potential damage and frequency (Wang,

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2006). Zhejiang suffers from tropical cyclones almost every year. In the 59 years from 1949 to 2007, 40 typhoons made landfall. Typhoon Saomai was the most powerful typhoon to hit Mainland China since 1951. Its pathway can be seen in Figure 1.

Figure 1: Typhoon Saomai's pathway

Source: *Tropical Cyclone Yearbook 2006*, Weather Publisher, Beijing

There are many measures that can be taken to adapt to tropical cyclones, such as the relocation of homes, changes in land use, crop diversification, mixed cropping and livestock farming systems, increasing savings, and purchasing insurance. The government and communities can build shelters, set-up warning systems, and provide public information, financial support and emergency rescue services. However, what people have already done, what actions are effective, what more could have been done, and what more still could be done to adapt to climate change related disasters have not been adequately investigated. The research areas explored in this report include:

- Measuring risks, vulnerability, and adaptive capacity.
- Why are some communities more adaptive to tropical cyclones? Have particular adaptive actions been taken?
- What can we learn from past events to increase the resilience and adaptive capacity of households and communities at risk?
- What measures can we implement that will remove or minimize barriers to enhanced adaptive capacity to tropical cyclones?

Tropical cyclones present an important climate hazard to many countries so addressing the areas of research outlined above could provide valuable lessons and insights that can be applied to strengthen adaptive capacity to climate change in other regions of the world.

1.2 Study Objectives

The objectives of the study are as follows:

- To measure vulnerability to extreme typhoons in the study areas.
- To measure the adaptive capacity of households to climate change (CC) related events in the study areas.
- To analyze which adaptation behaviors are undertaken and which adaptive behaviors are not undertaken and the reasons for this at both household and community levels, with reference to specific climate change events.
- To identify adaptation gaps and suggest measures to bridge these gaps.

1.3 Research Area: Pingyang County

This study was conducted in Pingyang County, Zhejiang Province, China. Zhejiang consists mostly of hills, which account for about 70% of its total area. Its nominal GDP for 2008 was USD 273.53 billion, with a per capita of USD 4,883. The county is located in the southeast corner of China and the total area of Pingyang County is about 1051.17 km ^{2}, including a 22-km coastline. Pingyang has a total population of 0.85 million people. Most of Pingyang county is in the Aojiang River watershed, one of eight major river systems in Zhejiang Province. The case study sites are shown in Figure 2.

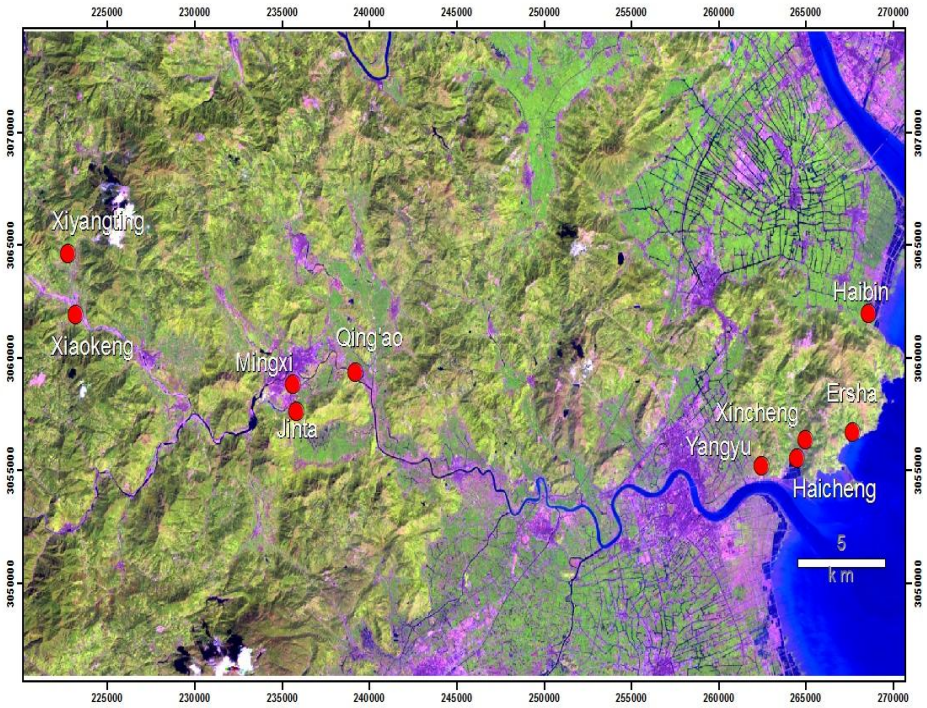

Figure 2: Locations of the study villages, Pinyang County, Zhejiang Province

Figure 2 shows the locations of villages where household surveys were conducted. Ten villages were selected, each a different distance from the ocean. The distribution of sampled households is shown in Table 1.

Table 1: The distribution of sampled households in Pingyang County

Township	Village	No. of households
Shuitou (108 households)	Qing'ao	29
	Jinta	35
	Mingxi	44
Xiaokeng (99 households)	Xiaokeng	51
	Xiyangting	48
Aojiang (128 households)	Haicheng	37
	Xincheng	49
	Yangyu	42
Xiwan (79 households)	Ersha	38
	Haibin	41
Total		414

1.4 Research Methods

1.4.1 Questionnaire methods

In total, 414 households were selected from ten villages across four townships. Questions to households addressed the following: (a)Adaptive capacity indicators; (b) Typhoon Saomai and its impacts;(c)Typhoon Saomai and adaptation behaviors; and (d) Gaps in adaptation.

In the household interviews investigators guided the process according to the questionnaire and took notes of the answers on a one-to-one basis.

1.4.2 Methods of analysis

Descriptive statistics method

This method assessed the damage caused by Typhoon Saomai and the adaptive capacities of households in response to the typhoon at the different study sites.

Comparative analysis

This method compares the loss and damage caused by Typhoon Saomai at the different study sites and identifies the reasons for variations in losses and damage. The method also explores effective approaches to, and strategies for, adaptive capacity building (particularly with regard to awareness and preparedness). It compares the different adaptive capacities of households and identifies and formulates potential options for building the adaptive capacities of households.

Spatial analysis

Spatial analysis compares the locations and topography of households to determine if these conditions influence their adaptive capacity and vulnerability.

Econometric model analysis

This model analyzes the factors which influence the vulnerability and adaptive capacities of households.

2.0 ANALYSIS OF THE VULNERABILITY OF HOUSEHOLDS DURING TYPHOON SAOMAI

2.1 Analysis of Household Vulnerability

Vulnerability is the degree of the damage or harm to a system caused by climatic change. Vulnerability is not only decided by the sensitivity of a system to climatic change, but also by the related ability of the system to adapt to the new climatic conditions (IPCC, 1996).

2.1.1 Household vulnerability

Our investigation found that the study area suffers from typhoons every year. Typhoon Saomai caused great damage to households in terms of damage to property, loss of household produce, lost income, injuries and loss of life (Table 2).

Table 2: Damage to household properties and income from Typhoon Saomai

Item		**Effected households**	**Average damage (**USD**)**	**Max (USD)**
Household property	House	288 (69.6%)	318	7,353
	Appliances	62 (15.0%)	530	10,588
	Vehicles	9 (2.2%)	13,586	117,647
	Amenities	27 (6.5%)	83	441
	Others	3 (0.7%)	69	74
Household products/ Produce	Crops	208 (50.2%)	100	4,471
	Livestock	17 (4.1%)	1,824	14,705
	Aquaculture	3 (0.7%)	5,882	8,824
	Fishing	24 (5.8%)	85	735
Lost income	Wages	111 (26.8%)	48	1,765
	Business	46 (11.1%)	3,611	58,824
	Others	1 (0.2%)	17,647	17,647
Injury	Injured	1 (0.2%)	735	735

Table 2 shows the percentages of households that suffered damage to their homes, crops, land, loss of income, damage to appliances, loss of business, damage to amenities (water supply, electricity, communications), and losses to fishing.

Forgone income

The income a household has had to forgo cost more than any other damage. The survey found a number of related reasons for this – the raw materials and equipment of a large number of small-scale household factories were damaged during the typhoon and the subsequent flooding resulted in serious losses. These household factories then had to pay penalty fines due to the fact that they could not deliver their goods in time because of the typhoon.

Household property damage

In terms of the extent of damage suffered, household property losses were the most serious losses caused by the typhoon. The intensity of Saomai was so significant that any measures taken before the typhoon hit, such as improvements to houses or the strengthening of homes, were less effective. Most roofs in the study area are covered with tiles, which were swept away by the typhoon, leading to further damage to homes.

Next in the order of severity, is loss of vehicles (USD 13,586 per HH). The main losses in this area occurred in households in coastal townships where the main livelihood is fishing and most households own large fishing vessels. When the typhoon came, fishing vessels were damaged in the harbor. The engines of cars were also damaged by floodwater.

Damage to appliances (USD 530 per HH) was also severe. Floodwater from the typhoon was so heavy that households did not have enough time to move property to higher ground. Electrical appliances are expensive and many could not be repaired after the typhoon.

Damage to household produce

Damage to household produce was significant for farmed crops, livestock and poultry. It is difficult for households to protect crops planted in the field from typhoon and households could not rush and harvest their crops as the typhoon approached because the crops were not ripe. There was also damage to livestock and poultry. Poultry, such as pigeons, were blown away when the typhoon arrived and the disease that came after the typhoon killed poultry. Large livestock, such as cows, which provide important capital for households, were washed away by floodwater.

Injury and loss of life

The lives of household members were safeguarded during Typhoon Saomai because the case study area is coastal and suffers from typhoons every year, so households have traditional experience and knowledge when it comes to dealing with typhoons – they know to escape to safe places as early as possible. Local government took effective measures to protect people before and during Saomai. For example, local government informed households as early as possible that they needed to move out of harm's way. In addition, local government and community members helped households in danger to move to safer places.

2.1.2 Vulnerability characteristics of households

The survey shows that average losses were different in each of the four case study townships: Shuitou (USD 3073.34 per HH), Xiwan (USD 2140.03 per HH), Aojiang (USD 707.96 per HH), Xiaokeng (USD 374.78 per HH). Different household conditions and characteristics influenced average losses. These variables were as follows: geographical setting; the permanence of houses; and income and income structure.

Different geographical settings, different vulnerabilities

Geographical setting has an important effect on household vulnerability. Generally speaking, households on the coast are more vulnerable to typhoons than those far away from the sea. As typhoons always come from the sea, their effect on coastal areas is severe. Households in mountainous areas are more vulnerable than those in plains areas because households in mountainous areas receive typhoon-related information later than other households and it takes time to move property to safer places and escape. Households in low-lying areas are more vulnerable than those that are built at a higher elevation, because the floodwater that follows typhoons submerges houses in low-lying areas.

The households in Xiaokeng township (Xiaokeng and Xiyangting) are mainly located in mountainous areas. The elevations of the two villages are 89.53 m for Xiaokeng village and 132.71 m for Xiyangting village. These townships mainly suffered secondary disasters due to mud and rock falls caused by Typhoon Saomai. The average elevations of Aojiang (Yangyu, Haicheng and Xincheng), Shuitou (Qing'ao, Mingxi and Jinta) and Xiwan (Ersha and Haibin) are 7.26 m, 21.56 m and 9.80 m, respectively. Aojiang and Xiwan are both located on the coast with no obstacles before them to dampen the intensity of the typhoon. As a result, the damage, particularly the loss of people's homes, in these two townships was serious. Shuitou is located in a low-lying area, surrounded by higher ground. The damage in Shuitou was serious because the floodwater which followed the typhoon overran many properties. Shuitou experienced the highest water level in people's yards and also at floor level. The vulnerability of a household is partly related to excessive flooding conditions and these tend to be worse in low-lying areas.

Different types of houses, different vulnerabilities

A house is not only the most important possession a household has, it is also a safe shelter during typhoons. The solidity and permanence of a house is intrinsic to the vulnerability of the household. The average permanence of houses in the four case study townships is shown in Figure 3.

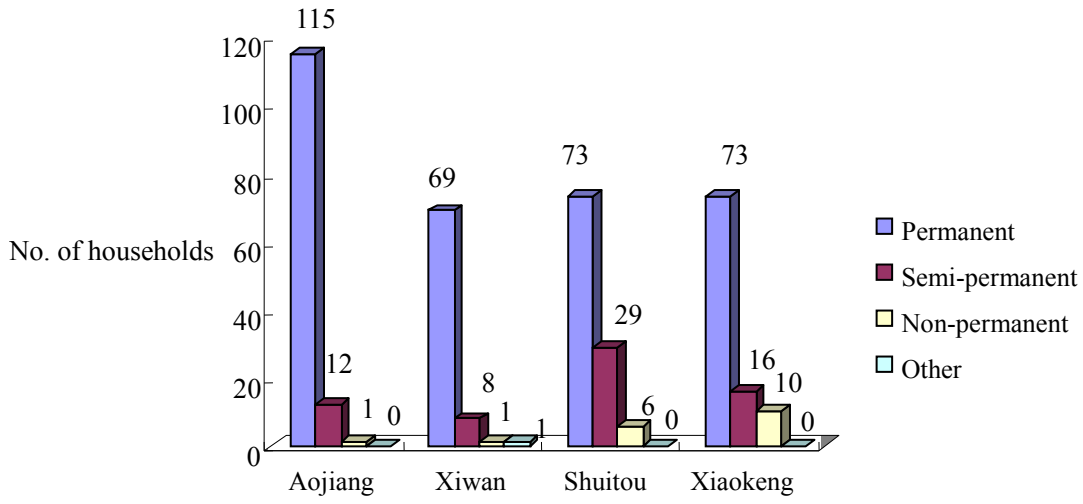

Figure 3: The average permanence of houses

Figure 3 indicates that Aojiang has the greatest number of permanent houses, with 115 households, accounting for 89% of the total number of households sampled in Aojiang. Xiaokeng has the most non-permanent houses, with 10 households classed as non-permanent. In fact, only a small number of households were classed as non- or semi-permanent across the four case study areas. Houses that are less permanent are more susceptible to the damage inflicted by typhoons. This analysis makes it clear that in order to reduce the vulnerability of households, it is necessary to build houses that are strong enough to withstand typhoons.

Different income and income structures, different vulnerabilities

The household income and its structure also have impacts on household vulnerability. Shuitou has the highest average household income, together with the highest losses from Saomai. Xiaokeng has a relatively lower income and the lowest losses as a result of Saomai. These results indicate that household income is an important factor in the degree of damage inflicted by typhoons. The reason for this is that people who have more possessions require more time to move them to safer places. However, Xiwan suffered greater losses than Xiaokeng but the two townships have nearly the same income level. According to our investigation, the reason for this disparity is that Aojiang is closer to the coast and is at a lower elevation, which explains the higher level of damage to property in Aojiang.

Household income structure and relative losses are given in Figure 4 and Figure 5, respectively.

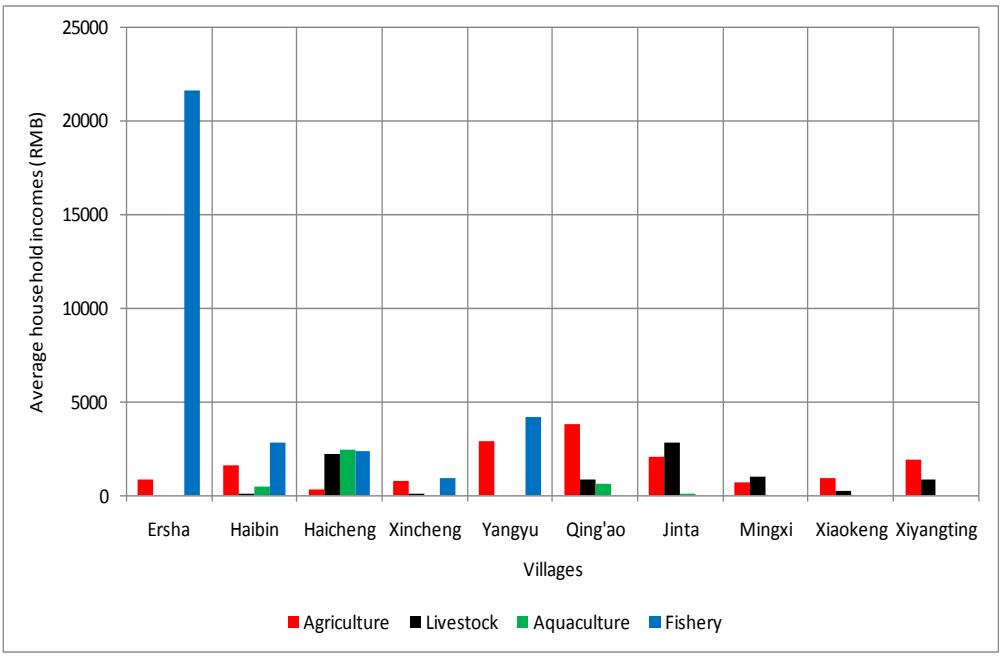

Figure 4: Income structure

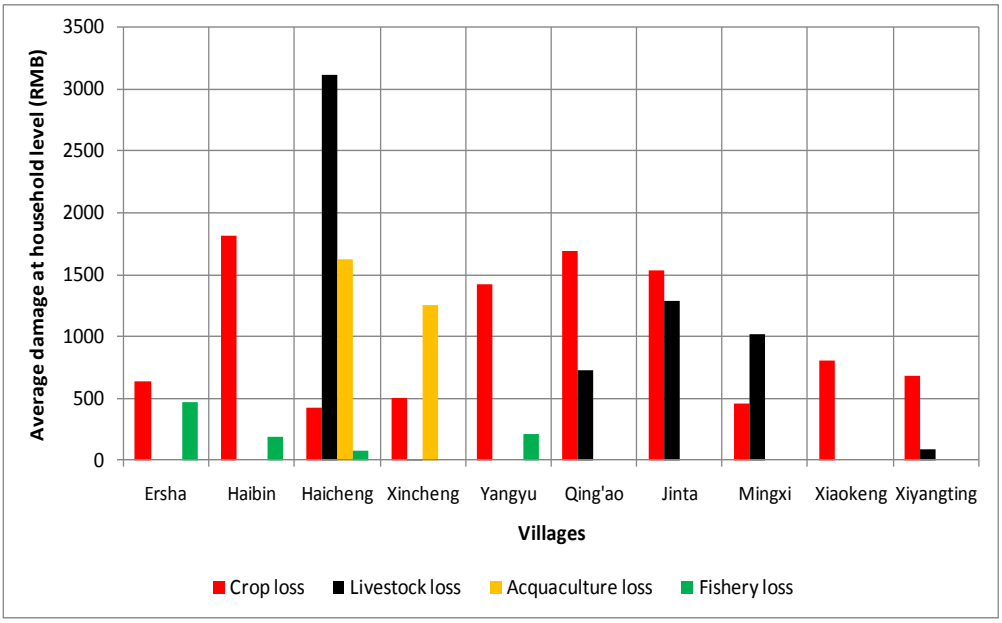

Figure 5: Loss structure

Figure 5 shows that Haibin and Ersha of Xiwan, and Yangyu of Aojiang suffered serious fishing losses. Households in these three villages live on fishing. Typhoon Saomai damaged many large boats and the fishermen could not go fishing. This had a significant economic impact on households in Haibin, Ersha and Yangyu. Haicheng in Aojiang, and Jinta and Mingxi in Qing'ao experienced relatively higher losses of livestock and poultry, and suffered a relatively higher loss in income from livestock and poultry.

In summary, income and income structure have an impact on the

vulnerability and vulnerability performance of households. Generally speaking, households with a higher income suffer higher losses during typhoons when they do not take effective measures in time. The fishing industry, agriculture, and the care of livestock and poultry depend on local resources and are vulnerable to typhoons. If a high proportion of household income comes from these industries, then the household will suffer greater losses as a result of typhoons.

2.2 Analysis of the Factors Influencing Household Vulnerability

2.2.1 Awareness of typhoons

Awareness of typhoons has an impact on household vulnerability. Households with higher awareness will take more effective measures to reduce the potential damage caused by typhoons. Lower awareness leads to fewer measures being taken to deal with typhoons and subsequent greater losses. Household awareness of typhoons includes whether or not households think that the typhoon can be controlled and whether or not households have plans to prevent the damage caused by typhoons in the future.

Attitudes to the impacts of typhoons

According to the study, the percentage of households that consider a typhoon-induced disaster to be "completely out of our control", "almost out of our control", and "could be controlled" are 66% (275 HH), 33% (135 HH), and 1% (5 HH), respectively. The data indicates that most households believe that the damage caused by typhoons is beyond their control, with only a small percentage of households thinking that losses can be reduced if effective measures are taken before the disaster. As a result, the measures households took before Typhoon Saomai were generally from traditional knowledge such as fixing houses and escaping to safer places. Most people do not take effective long-term measures in response to typhoons.

Assessment of damage related to future typhoons

The investigation indicated that the percentage of households that thought that damage from future typhoons would be "more severe", "almost the same", or "not sure" was 29% (131 HH), 44% (183 HH), and 26% (109 HH), respectively. This analysis indicates that most households are not aware that climate change is partly related to human activity, instead they think that disasters such as typhoons are solely a natural phenomenon. People are unaware that some activities could reduce losses due to typhoons in the future.

Reasons for more severe climate change-related damage in the future

Different households hold different opinions about the severity of future climate change-related damage (Figure 6).

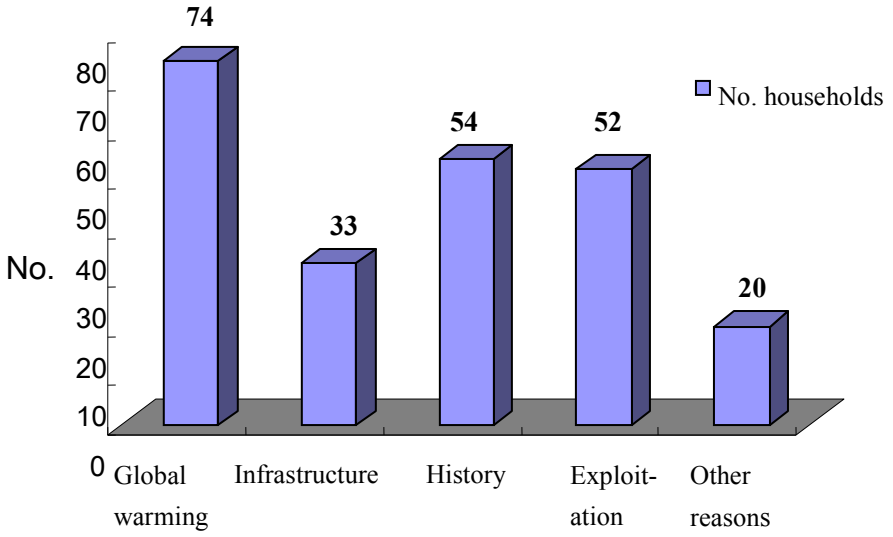

Figure 6: Opinions regarding the severity of future damage due to climate change

Figure 6 shows the reasons households think that future environmental damage will be more severe than present levels of environmental damage. Seventy-four households, out of a total of 131, think future environmental damage will be more severe, stating that they think that climate change/global warming will cause more rainfall. A total of 54 households believe that climate change is a historical trend, and 52 households think that the over-exploitation of natural resources will be responsible for increased environmental damage. Some 33 households think that increases in the amount of built infrastructure will block waterways, causing further environmental damage. Twenty households think that other reasons, such as natural law, will be responsible for increased environmental damage. This data indicates that most households think that the impacts of disasters will be more severe in the future and that this is related to global warming. According to this investigation, information about global warming is obtained from the mass media, such as television.

Preparations for the future

Typhoon Saomai caused great damage to households and forced local people to acknowledge that effective preparations are very important for reducing the damage caused by typhoons in the future. Of the households surveyed, 21% have made some preparations for the future, 12% of which are specific plans. A total of 9% of households have no specific plans because of government policy limitations or other reasons. Specific plans include moving to live in other places, improving or renovating existing homes, moving to a relative's house, farming in another area, or finding a job somewhere else (Figure 7).

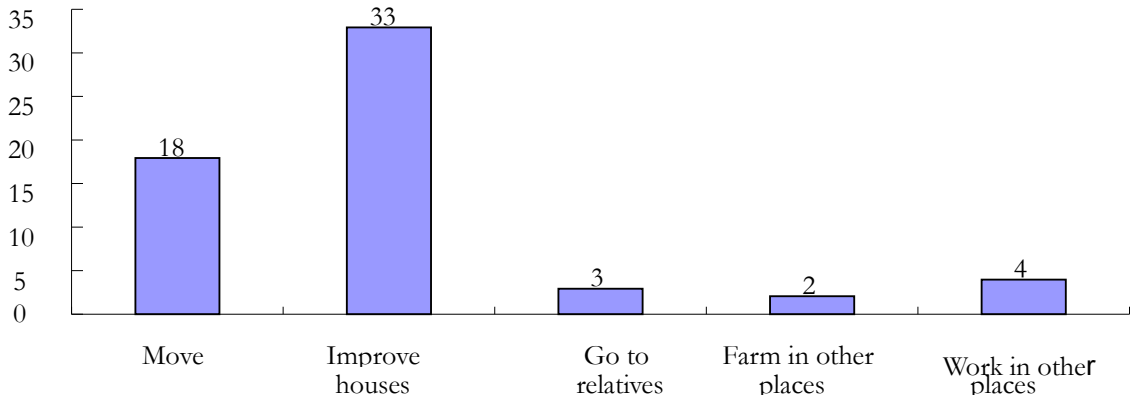

Figure 7: Specific plans

Figure 7 shows that a small number of households have some plans for reducing damage in the future. Most households have no plans yet. Households with specific plans mostly take traditional measures, such as improving or renovating their homes, to deal with typhoons. These measures are passive adaptation measures, leading to the relatively high vulnerability of these households.

2.2.2 Analysis of factors influencing the vulnerability of households

The amount of vulnerability a household is exposed to was used to assess the sensitivity of the system to extreme changes in circumstances. Different indicators are needed to assess different systems. Vulnerability indicators have a great impact on vulnerability assessment. To get a good assessment result, we selected indicators that are sensitive to extreme changes in circumstance.

Research hypotheses

Many indicators can be used to assess the vulnerability of a household. In this paper we look at total household income and the proportion of that income that was lost to typhoon damage. This was used as an indicator.

According to our survey, other vulnerability indicators include: the population structure of the household; household income structure; the level of permanence of the house; the degree of social relations enjoyed by the household; typhoon awareness; the speed of early warning information; and the amount of traditional and specialized knowledge about typhoons within a household.

In order to construct an econometric model, this paper selected the following indicators of factors influencing the vulnerability of a household.

• The number of members of the household who can work is an important factor: generally speaking, this has an inverse relationship to household vulnerability. The more labor a household can mobilize, the more labor can support household adaptations to the typhoon before it comes.

• The proportion of income a household obtains from agriculture is related to

its vulnerability because agriculture is more susceptible to damage inflicted by typhoons.

• The degree of permanence of a household's home is important – it has an inverse relation to household vulnerability. This means that the higher the degree of the permanence of the house, the lower the losses inflicted by typhoons and the lower the household's vulnerability.

• Whether or not a member of a household joins a community organization (except for an old people's association) is an indicator of social ability: in general, this has an inverse relation to household vulnerability. This means that if someone in the household joins a community organization, then the household has a wider social network to call on to assist with adaptation to typhoons.

• The assessment of damage to households recognized that awareness of typhoons, generally speaking, has an inverse relation to vulnerability. This means that if households have a good awareness of typhoons, they take more effective measures before and after the disaster, leading to a reduction in losses suffered.

• There needs to be an easy way for households to access early warning information before typhoons make landfall. In general, this has an inverse relation to vulnerability. Rapid and accessible early warning information gives households more enough time to adapt to typhoons. This leads to a reduction in losses and vulnerability.

• If households have traditional knowledge about typhoon adaptation it has an inverse relation with vulnerability – the more traditional knowledge they have, the better they can protect their properties.

• If households have knowledge that is specific to typhoon adaptation, it has an inverse relation to household vulnerability. Specific knowledge about typhoons helps households to respond well to typhoons.

Model Specification::

To make sure of the validity of the measurement analysis and of the factors affecting household vulnerability, this paper obtained 407 valid household samples after rejecting invalid household samples using the Grubbs method. The established semi-logarithmic model is as follows:

$$Ln(lost) = c + \beta_1 Ln(labor) + \beta_2 permanent + \beta_3 Ln(agricultur e) + \beta_4 member + \beta_5 Ln(warnings) + \beta_6 traditiona l + \beta_7 training + \beta_8 assessment + \beta_9 D + \varepsilon_i$$

Of which *lost* represents the proportion of the total income that was lost due to Typhoon Saomai; *labor* represents the proportion of labor supplied by every family member; *agriculture* represents the proportion of family income derived from agriculture; *warnings* represents the amount of time a household received due to early warning information before Typhoon Saomai struck (number of days); *permanent*, *member*, *traditional*, *training* and *assessment* are all dual dummy variables, representing the degree of permanence of a home, whether or not someone in the

household is a part of a community organization, whether or not households have traditional knowledge of typhoon adaptation, and whether or not households have specific knowledge and awareness of typhoons. D presents the regional dummy variable, with Xiaokeng as the reference group; ε_i presents the stochastic disturbing term, and; c, β_i are parameters to be estimated.

Model Estimation Results

Using Eviews software, the estimated results are shown in Table 3.

Table 3: Estimated results of the model

Dependent variables		**Independent variables (proportion of loss of total income)**
Proportion of family members capable of labor		-0.3426 (-1.0585)
Proportion of income derived from agriculture		0.3411** (4.6789)
Amount of time given by early warning information (no. of days)		-0.8146** (-2.6967)
Degree of permanence of home (1 = Yes, 0 = No)		-0.9296 (-1.7477)
Organization member? (1 = Yes, 0 = No)		0.4704 (0.9347)
Traditional knowledge of typhoon adaptation? (1 = Yes, 0 = No)		-0.1634 (-0.6858)
Specific typhoon adaptation training? (1 = Yes, 0 = No)		-0.1893 (-0.1653)
Awareness of typhoons? (1 = Yes, 0 = No)		-0.0776 (-0.2659)
Regional dummy variables	Aojiang	0.2787 (1.0682)
	Xiwan	0.6018 (1.7858)
	Shuitou	0.7025 (1.9876)
Constant		4.7021** (3.0765)
Revised R^2		0.1338
Sample numbers		407

Notes: * significant at 5% level; ** significant at 1% level. The number in parenthesis means T statistics, representing the significance level.

The estimated results in Table 3 confirm the research supposition. Only the coefficient of membership of a community organization is not consistent with the original research supposition, assuming it has an inverse relation to vulnerability, requiring the coefficient to be a minus sign, but here we achieved a plus sign.

Income structure has significant impacts (0.3411**) on household vulnerability at 1% level. Assuming other factors remain the same, the loss proportion in the total income would increase by 0.3411% when the proportion of income derived from agriculture increases by 1%. This confirms the original research supposition, which is that agriculture is highly sensitive to the impacts of typhoons.

The speed of early warning information has significant impacts (-0.8146**) on household vulnerability at the 1% level. Assuming other factors remain the same, the proportion of loss drops by 0.8146% if the speed of early warning information rises by 1%. Government departments should provide prompt and accurate information about typhoons so that households can take effective measures to protect their property.

The degree of permanence of a household's home has an inverse correlation to household vulnerability, meaning that a high level of permanence leads to low losses as a result of typhoons and, therefore, lower vulnerability. But the impact is not significant. According to the investigation, the reason for this is that the difference in degrees of permanence in the case study areas is not obvious, and almost all of the houses have two floors. Damage to houses in the case study areas is almost the same.

The labor structure of households has an inverse correlation to vulnerability. The more labor a household can mobilize, the greater its ability to more property to safer places and, therefore, the lower its vulnerability. But the impact of variable labor on household vulnerability is not statistically significant. The reasons for this can be explained: the difference due to labor is not obvious; households have extensive traditional knowledge of how to deal with typhoons; it does not take too much time to prepare for a typhoon before it comes; and the elderly and children can also help to fix doors and windows.

Traditional knowledge and specific training has an inverse relation to vulnerability, meaning that knowledge and training helps households to reduce the losses caused by typhoons. Non-local workers who do not have enough traditional knowledge about dealing with typhoons suffered high losses as a result of Typhoon Saomai and were very vulnerable. But the impact is not statistically significant. The reasons for this can be explained: most households have not taken part in any specific training courses; and almost every household has some traditional knowledge of dealing with typhoons.

Awareness of the impacts of typhoons has an inverse relation with vulnerability. This means that typhoon-aware households take effective measures to protect their property and experience less loss, and so have lower vulnerability. But the impact is not significant. The reasons can be explained as follows: most of the case study households do not have a high level of education so they do not know a great deal about typhoons; knowledge about typhoons is, in part, obtained from the mass media, such as radio and television, which does not have a comprehensive understanding of adaptations to typhoons; even though households know that future typhoons will have severe impacts on them, policy limitations and other reasons

restrict the amount of adaptation that they do.

Membership of a community organization is related to vulnerability but is not consistent with the original research supposition. According to the investigation, the reasons can be summarized as follows: almost none of the households join community organizations; households that do have someone as a member of a community organization also respond to typhoons by themselves, with no organization members helping them; members of village committees and leaders of villages are kept busy helping other local people in danger to move to safer places and do not have enough time to move their own property to safety; most members of village committees have small processing factories, which suffered great losses as a result of Typhoon Saomai and the flood that came after it.

There are regional differences in vulnerability. In case of the factors outlined above, socio-economic conditions are the same but the proportion of losses in total income between Aojiang, Xiwan and Shuitou are 0.2787%, 0.6018% and 0.702% higher than Xiaokeng. These differences are due to geographical factors: Xiaokeng is located in the west, in a mountainous area, while Xiwan and Aojiang are located on the coastline, which always experiences more severe damage as a result of typhoons. Shuitou is located in a flood-prone low-lying area that suffers more when the flooding which follows typhoons arrives.

In summary, income structure and the rapid delivery of early warning information are two significant factors that affect household vulnerability. The permanence of a household's home, the labor available within the household, knowledge of traditional methods of dealing with typhoons, specific training, and awareness of typhoon disasters are also related to household vulnerability. But the impact of these factors on household vulnerability were not significant in the case of Typhoon Saomai, which was exceptionally severe.

3.0 ANALYSIS OF THE ADAPTIVE CAPACITY OF HOUSEHOLDS

Typhoon disasters have a significant effect on the local economy and society. The vulnerability of system to a typhoon disaster depends on "adjustments in a system's behavior and characteristics that enhance its ability to cope with external stress" (IPCC , 2001). Adaptation research gives support to decision-makers, communities and households for planning and responses to extreme climate change events (Smit, 1997; Smit et al., 2000; Smit and Pilifosova, 2001).

3.1 Adaptive Capacity

Different researchers have tried to select different factors to explain the adaptive capacity of households or communities (Yohe and Tol, 2002; Adger et al., 2004; Marlin et al., 2007). Indicators which influence the adaptive capacity of households include economic capacity, technology, skills and knowledge, infrastructure, social factors, manpower and land use (Marlin et al., 2007).

3.1.1 Infrastructure

Our research team used the following indicators to assess the infrastructure capacity of a household: Home ownership; Construction qualities of home; Access to electricity; and Source of drinking water.

Home ownership

Regarding home ownership, 98% of households live in their own house, 2% rent a house, and 1% live in a relative's house.

Construction qualities of home

According to the construction qualities of homes, 80% are made of brick or strong wood, 16% have walls that are only partly brick, and 6% are constructed of only wood or bamboo (with no brick component). Of the total number of households 4% are one-storied, 48% are one-storied with an elevated ground floor, and 47% are two-storied.

Access to electricity

All households have access to electricity.

Source of drinking water

Some 98% of households use piped water or community taps, 2% of households use a well, a tube-well or a hand pump, and 1% of households buy drinking water.

From the above information we can see that most households have relatively good housing conditions.

3.1.2 Economic indicators

Our research team used the following indicators to assess the economic capacity of a household: Land ownership; Land area; Vehicle ownership; Household income; Food consumption; and Access to loans.

Land ownership

Of all the households in the case study, 99% own residential land and a garden, 342 households (82.60%) have land for cultivation, including 83%, 14% and 2%, which is contracted, owned and rented, respectively. Forestland can be accessed by 130 households, of which 82%, 16% and 2% is contracted, owned or rented, respectively. Only seven households in the sample have their own aquaculture.

Land area

Across all the townships, the average area of residential land and garden is 150.1 m^2. The area of residential land and garden in Aojiang and Xiwan is less than average, and, in contrast, the average area of residential land and garden in Shuitou and Xiaokeng is above average. The average area of land for cultivation is 1,427.3 m^2 and 1,136.9 m^2 for forestland. The average area of land for cultivation in Shuitou and Xiwan, and forestland in Shuitou, is more than average, and the average area of land

for cultivation in Aojiang and forestland in Xiwan is less than average. The average area given over to aquaculture across the seven households that have aquaculture is 11,672.5 m^2.

Vehicle ownership

A total of 6%, 40%, and 11% of households own cars, motorbikes and boats, respectively. Most households don't own modern vehicles, so there are large economic differences between households that own modern vehicles and those that do not.

Household income

Our research team investigated sources of household income between 2006 and 2008. The average income of households across the four case study townships was USD 5,223.80 in 2008, with the average income of households in Shuitou much higher than average, at USD 9,725.52. The reason for this is that the local leather industry has developed very quickly and has provided a source of income for the community that is not based on agriculture. The proportion of income from waged labor is highest in Aojiang and Xiwan (48% and 34%), however, in Shuitou and Xiaokeng, the proportion of income from non-farming self-employment business is highest (71% and 65%).

According to the valid household samples, the majority of household incomes did not change compared to the income levels of 2006. These households suffered nearly no losses as a result of Typhoon Saomai and enjoyed stable livelihoods. In households where income increased, 124 households stated that their income from crops increased by 55% between 2006 and 2008. This suggests that Typhoon Saomai destroyed crops and that income from crops in 2006 did not achieve normal levels. In households where income had decreased since 2006, the reduced income focused on crops (51%), raising livestock (100%), aquaculture (100%) and fishing (59%), all of which depend on local resources. These households suffered serious losses in the Saomai disaster and had to seek new livelihoods, with nearly 90% moving their main income source to waged labor. Two households decided to abandon livestock raising and one household abandoned livestock raising and aquaculture industries (Table 4).

Table 4: Variation in household income structure (%) between 2006 and 2008

Indicators	**Crops**	**Raising live-Stock**	**Aqua-culture**	**Fishing**	**Non-farming self-employment**	**Waged labor**	**Pension**	**Remittance**	**Others**
Average increase in income	55.31 (124)	61.11 (9)	91.67 (3)	49.53 (17)	58.75 (36)	42.51 (78)	40.8		(3)
Average decrease in income	-50.58 (11)	-100 (2)	-100 (1)	-59.25 (4)	-23.68 (14)	-33.21 (19)	-100 (1)	-10 (1)	-25 (1)
No change	0 (193)	0 (253)	0 (250)	0 (255)	0 (261)	0 (227)	0 (257)	0 (238)	0 (256)
Valid households	328	264	254	276	311	324	263	276	260
Total	414								

Note: the number of households appears in parenthesis

Food consumption

There are 185 households where 50% of the food consumed is produced by the household itself. In contrast, 35% of the total number of households said that they do not produce any of their own food (Figure 8). These households have broken away from traditional farming roles and have decided to work in other industries because this is more profitable and enables them to purchase food from markets. The livelihoods of these rural households are similar to urban households.

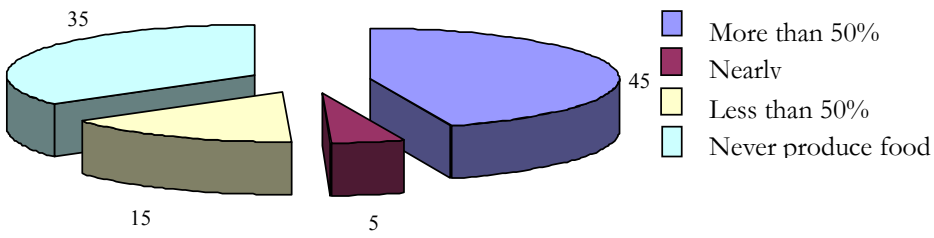

Figure 8: Proportion of food produced by household (%)

Access to loans

A total of 87% of the case study households are able to borrow money. Of these households, 97% indicated that they borrow money from relatives, with only 3% stating that they would borrow money from banks. Reasons given for not borrowing money from banks include over-complicated formalities and high interest. Only 7% of total households said that they are unable to borrow money.

3.1.3 Technology

Our research team used the following indicators to assess the technological capacity of a household: Distance between home and town center; Willingness to evacuate to safer places; and Ways of receiving information and news.

Distance between home and town center

The average distance from households to a town center (municipal hall) across the four townships is 4.5 km. In Aojiang this distance is 7.2 km, making it the farthest distance a household has to travel out of the four townships. In Xiaokeng this distance is 1.4 km, making it the shortest distance a household has to travel to a town center.

Willingness to evacuate to safer places

Households need to make a choice about whether to evacuate to safer places before a typhoon arrives. Most safe shelters are located in townships. According to our surveys, 285 households did not want to evacuate to safer places, and only 129 households did evacuate to safer places. A comparison between the four townships revealed that the proportion of households that evacuated to safer places was highest in Aojiang (48%). In Shuitou only 18% of households elected to evacuate to safer places, leaving 82% of households unwilling to move. The most common reason (82%) given for this was that households considered their homes stable enough and safe enough to withstand the typhoon. A total of 17% of households said that they had no safer place to go and that there were no shelters in the village that that could house everyone. Only 1% of households stated that it was too difficult to get to the shelters because of bad traffic. Of all the households that elected to evacuate to safer places, 10%, 13% and 77% moved to relative's homes, neighbor's houses, and government buildings, such as commune offices, schools, and clinics, respectively. A total of 95% of households said that they had easy access to shelters and 52% of total households could reach shelters by bus or by walking.

Ways of receiving information and news

Information about typhoons is received via television for 386 households, and 312 households receive typhoon information from government notices. Commune officials distribute notices about a typhoon house-to-house before it arrives. Around 250 households learn typhoon information from their neighbors, and a small number of households get typhoon information from other news media such as the internet and newspapers (Figure 9).

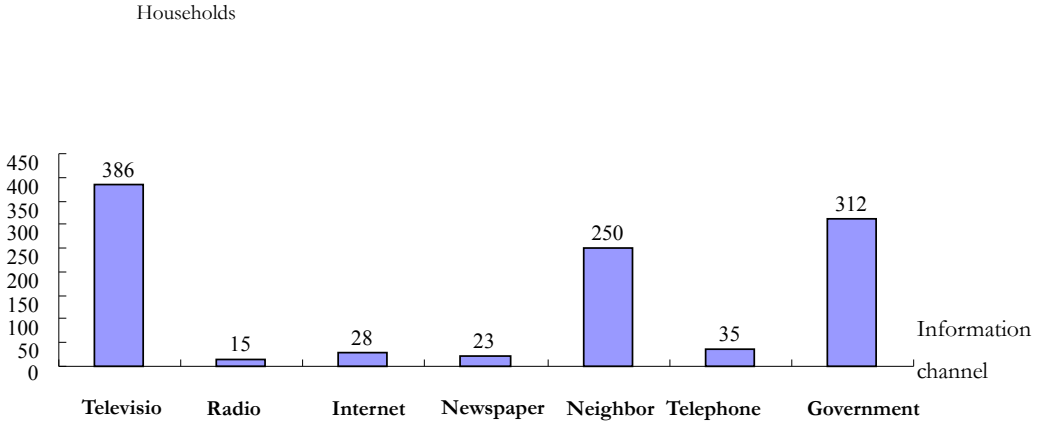

Figure 9: Ways households receive typhoon information

3.1.4 Social capital

Our research team used the following indicators to assess the social capacity of a household.

a Whether they have ever turned to the outside world for help.

b How often villagers meet to discuss common village issues.

c How often villagers exchange ideas and experiences of climate change-related disasters.

d Whether anyone in the household is a member of community organizations.

Turning to the outside world for help

According to our survey, 240 households turned to the outside world for help and 174 households said that no one could help them. Of the 240 households who sought outside help, 214, 126 and 20 households received help from relatives, friends and local or central governments, respectively.

Of the 214 households who received help from relatives, 203 households received financial support and 34 households received support in the form of labor to repair homes destroyed by the typhoon. Out of the 126 households who received help from friends, 119 received financial help and 15 households received support in the form of labor to repair houses destroyed by the typhoon. Twenty households sought help from the government, with 12 receiving subsidies to repair fields and homes, six receiving information, and two receiving food.

Meeting to discuss common village issues

The survey of households showed that 39% of households do not know whether local communities organize village meetings. A further 34% of households said that local communities organize village meetings once or twice a year. From this

data, we conclude that local communities are not particularly active (Figure 10).

In a comparison between different townships, the proportion of households who said that they do not know whether local communities organize village meetings was highest in Xiaokeng (56%). Compared to other townships, village meetings in Aojiang take place most frequently –14% of households here said that their local community organizes village meetings once every three months.

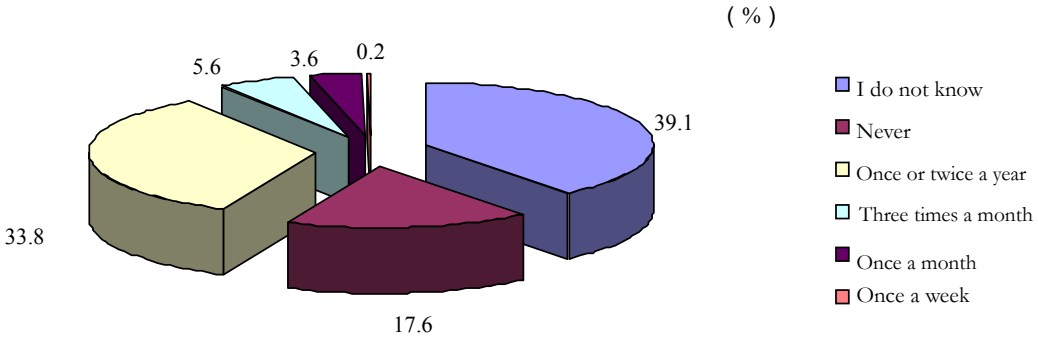

Figure 10: Household understanding of the frequency of village meetings

How often do villagers meet to exchange ideas about and experiences of climate change-related disasters?

Exchanging ideas and experiences about climate change-related disasters is useful in improving the adaptive capacity of households and social interaction between community members. The household surveys reveal that 32% of total households exchange ideas and experiences about climate change-related disasters frequently, 39% of total households sometimes exchange ideas and experiences about climate change-related disasters, 26% of total households rarely exchange ideas and experiences about climate change-related disasters, and 3% of total households never exchange ideas and experiences about climate change-related disasters. These results suggest that households are comfortable with sharing experiences related to disasters and climate change.

Household participation in community organizations

Only 19% of total households said that they had joined community organizations, with 7% of these households on the village committee and 12% as members of old people's associations and work associations. This data shows that

households who participate in community organizations are not very active because community organizations do not organize activities very frequently.

3.1.5 Skills and knowledge

Our research team used the following indicators to assess the skills and knowledge capacity of a household:

a Whether or not the household has received training in disaster preparedness.

b Whether or not the household has traditional knowledge of coping with typhoons.

Disaster preparedness training

Households with access to professional knowledge about typhoon adaptation can improve their adaptive capacity. According to the household surveys, only seven households have participated in the disaster preparedness training organized by local townships in the last five years. These seven households were predominately village leaders and the training focused on evacuating people.

Traditional knowledge of typhoons

Of the total sample, 244 households have traditional knowledge of typhoon adaptation. Traditional knowledge includes strengthening windows and doors (350 households), watching the weather to be aware of the estimated time the typhoon will make landfall (78 households), timely evacuation (225 households), and storing food before the typhoon arrives (54 households).

3.1.6 Summary

The adaptive capacity of households can be broken down into five parts.

Infrastructure

Most households (98%) live in their own home, with 80% of dwellings made out of brick or strong wood. All households have access to electricity. Most households (98%) use piped water or community taps.

Economic indicators

A total of 99% of households have their own residential land and garden. Some 130 households have forestland, which is either contracted (82%), owned (16%) or rented (2%). Some households own cars, motorbikes and boats, but most do not. The average income of households across the four townships was USD 5223.80 in 2008, mainly from non-agricultural activities. The majority of household incomes did not change compared with 2006. In 185 households more than 50% of the food consumed is self-produced but 35% of households do not produce their own food. Most households (87%) can borrow money.

Technology

The average distance of households from the municipal hall/commune center across the four townships is 4.5 km. Of all the households, 285 did not want to

evacuate to safer places and the main reason given was that they consider their houses to be stable and safe. Most people would evacuate to government buildings such as commune offices, schools, and clinics if a typhoon comes. The majority of households get typhoon information from the government and television.

Social capital

Households receive financial support and support in the form of labor from relatives, friends and the government. Many households (39%) said that they did not know whether local communities organized village meetings. People are glad to share their experiences related to disasters and climate change. Households that do participate in community organizations are not very active. Community organizations do not organize activities very frequently.

Skills and knowledge

The majority of households have not had access to the disaster preparedness training organized by townships in the last five years. Traditional knowledge, such as strengthening windows and doors, watching the weather to anticipate a typhoon's landfall, making a timely evacuation, and storing food before a typhoon arrives, is known to and is used by 244 households.

3.2 Analysis of Factors that Influence the Adaptive Capacity of Households

The number of days households need to recover from the losses caused by typhoons differ based on their adaptive capacities. According to the surveys, the average number of days a household needed to recover from Typhoon Saomai was 1.63 days. Some households recovered from the losses caused by Saomai in one day and some took as many as 60 days to recover. Almost all households needed between one and two days to recover from the destruction caused by the typhoon, but a small number of households that seriously suffered from Saomai or have limited adaptive capacity, needed a long time to recover. Comparing townships, households in Aojiang took more than 2.6 days to recover from the losses caused by the typhoon, while households in Xiwan, Xiaokeng and Shuiyou, took 1.35 days, 1.05 days, and 1.04 days respectively to recover. The adaptive capacity of households depends on several factors, including house structure, economics, social capital, knowledge and skills and geography.

3.2.1 Hypothesis

The research team made the hypothesis that the factors which influence adaptive capacity include the following.

- The structure of houses. Stable houses made of brick or strong wood can reduce the impacts of disasters and improve the adaptive capacity of households.
- Management of local resources. Land is the basic means of production for farming households. If household income derives mainly from local

resources such as agriculture and forestland then serious losses will be suffered as a result of a typhoon.

- The social capital of households. If someone in the household is a member of a local community organization, then the household will get help from other members of the community organization if they encounter problems.
- The skills and knowledge of households. If households have the benefit of professional skills and knowledge about how to respond to typhoons, they can make the right choices when typhoons come and this improves the response strategies of households.
- Technology and households. Shorter distances between shelters and houses, speedier household evacuation to shelters, and the rapid delivery of information about approaching typhoons all make a positive contribution to adaptive capacity.
- The basic characteristics of households. Age, education, and how many years household members have been living locally, influences the adaptive capacity of households. Households that are older and have lived in the community longer can help strengthen connections within the local community. A higher level of education can help households fully understand professional knowledge about typhoons. The more family members there are in a household, the more manpower is available to respond to climate change-related disasters such as typhoons.
- Geography. Different regions have different topographies and elevations and these factors influence the vulnerability and adaptive capacities of households.

3.2.2 Model settings

We analyzed 414 household samples in order to understand the capacity of households to adapt to Typhoon Saomai. To make sure of the effectiveness of the quantitative analysis, we used the Grubbs method to eliminate abnormal values, which is three times the standard deviation of whole samples and deficit value. There were 388 valid samples.

To analyze the factors that influence the adaptive capacity of households we used a semi-logarithm regression model for quantitative analysis. The model was follows:

$$Y_i = \alpha_0 + \beta_1 Eh_i + \beta_2 housetype + \beta_3 \ln land + \beta_4 organization + \beta_5 help + \beta_6\, distance + \beta_7 knowledge + \beta_8 D_i + \varepsilon_i$$

Y_i represents the adaptive capacity of households, and we used the variable of "the number of days household needed to recover from losses caused by the typhoon" to express it. Eh_i represents the basic features of households including age variables, education, family members, number of years living locally. *housetype* represents types

of homes, and it's a dummy variable to represent the infrastructure of households. *land* means land and forestland areas cultivated by households and it represents the management of natural resources. *organization* and *help* represent whether anyone in the household has joined a community organization and has received outside help. They are dummy variables and they represent the social capital of households. *distance* means the distance between houses and townships, it represents household ability to evacuate to the nearest town. *knowledge* means whether households have traditional knowledge to respond to typhoons and it represents the skills and knowledge of households. D_i represents regional variables. It is a dummy variable and we used "Xiaokeng" as a reference term. ε_i represented a random error item. β_i, α_0 represents estimated and constant parameters.

3.2.3 Model estimation and analysis

We used SPSS 16.0 software to build a semi-logarithm regression model. The results were as follows.

i) The distance between a household and the nearest township is significant to the number of days needed by a household to recover at the 1% level. Assuming other factors remain unchanged but the distance between a household and the nearest township increases by 1 km, then the recovery time needed by the household will increase by 0.155 days (four hours). This result agrees with the hypothesis. It is helpful for households to be close to townships for the purposes of evacuation to shelters and to receive up-to-date information about typhoons. Proximity to a township can also reduce the recovery time needed by households.

ii) Age and the number of years a household has lived locally is significant to household recovery at the 5% level. Assuming other factors remain unchanged but the age of the household increases by one year, then the recovery time needed by the household will decrease by 0.014 days (20 minutes). Household experience of typhoons increases along with the age of the household and older people find it easy to get help from relatives, friends and local communities. Assuming other factors remain unchanged, if the number of years a household has lived locally increases by one year, then the recovery time needed by the household will decrease by 0.009 days (12 minutes). Households can take advantage of stable relationships with local people and receive more help from their community according to how many years they have lived in the area.

iii) Assuming other factors remain unchanged, the recovery time of households in Xiwan and Aojiang were significantly longer than Xiaokeng at the 1% level. Because Aojiang and Xiwan are located on the coast and Xiaokeng is in a mountainous area, the recovery time needed by households in Aojiang and Xiwan was significantly longer than in Xiaokeng.

iv) Type of house is not significant to the recovery time needed by households. This is because the majority of households in the case study area have permanent houses made of brick or strong wood (80%), or with part-brick walls (16%). Even though many households suffered serious losses in Typhoon Saomai, the main losses

were due to broken roof tiles so houses were still fit to live in after the tiles had been repaired.

v) The area of land and forestland belonging to a household is not significant when looking at the recovery time needed by households. After 2000 the main household income was from waged work and business income, rather than from agriculture. The leather industry in Shuitou has developed very quickly and households in Shuitou that have found employment in this industry have broken away from traditional farming roles.

vi)Whether or not households receive outside help and support has no significant effect on the recovery time of households. Whether or not someone in the household is a member of a community organization is not significant to the recovery time of households. According to our surveys, a great number of households recover by themselves after a typhoon and only ask for help if they are short of labor. Responses to typhoons are led by the village committee because other community organizations lack financial support or an effective management system and so have little effect. So being a member of a community organization, such as a youth group or manna association for the elderly, is of little help to typhoon adaptation.

vii) Whether or not households have traditional typhoon-recovery knowledge is not significant when considering the recovery time needed by households. Traditional knowledge is useful before a typhoon comes. After a typhoon, traditional knowledge is of little use.

Table 5 shows the results of the regression analysis.

Table 5: Summary of the adaptive capacity of households

Independent variables	**Dependent variable (Recovery time of households)**
Age of people living in household	-0.014* (-2.435)
Education level of household	-0.015 (-0.889)
Number of years lived locally	0.009* (2.689)
Number of family members in household	-0.020 (-0.778)
Permanent house	0.030 (0.136)
Semi-permanent house	0.043

	(0.175)
Distance between house and township	0.155** (4.911)
Outside support, 1=No, 2=Yes	-0.085 (-0.804)
Membership of community organization? 1=No, 2=Yes	-0.059 (-0.428)
Ln (area of land/forestland)	0.059 (1.212)
Traditional knowledge of typhoon adaptation? 1=No, 2=Yes	-0.102 (-0.958)
Region: Aojiang	1.306** (5.592)
Region: Xiwan	0.524* (2.246)
Region: Shuitou	-0.127 (-0.854)
Constant	1.721* (3.225)
Valid samples	388
Adjusted R^2	0.562

Note: *significant at 5% level, ** significant at 1% level, T value are in brackets.

4.0 ANALYSIS OF COMMUNITY AND HOUSEHOLD ADAPTATION BEHAVIORS TO TYPHOON SAOMAI

4.1 Adaptation Behaviors of Households

How easy it is for households to obtain typhoon warning information has a direct impact on adaptive behaviors. In general, easier access to typhoon warning information leads to more successful household responses to typhoon disasters in the short term. Through surveys, our research team analyzed the following three areas: the most common routes of typhoon warning information; the amount of advance warning received by households; and the amount of time spent taking action in response to typhoon warning information.

4.1.1 Routes for receiving typhoon warning information

When asked whether they had received warnings about Typhoon Saomai before it occurred, 99% (412) of households received warning information and only 1 % (2) of households did not. Typhoon warning information is mainly communicated through relatives and friends, neighbors, the government, the media, and non-governmental organizations (NGOs) (Figure 11).

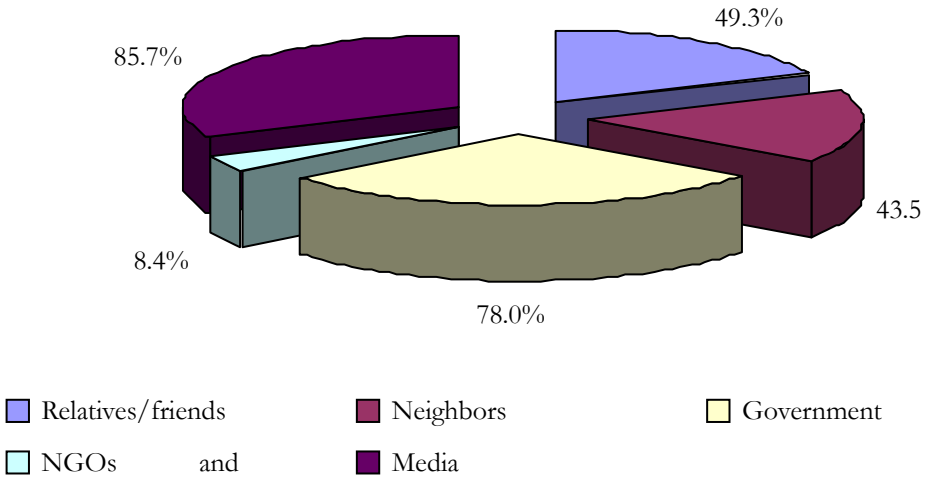

Figure 11: Routes for receiving typhoon warning information

As shown in Figure 11, most households (86%) get warning information through the media (television, radio, newspapers, etc.). This is mainly due to improvements in standards of living and the popularity of television and radio. Before a typhoon, media such as television will convey a variety of information about the typhoon. The second most important source of early warning information is the local government (49%). Before a typhoon, the government informs households through channels such as village cadres and SMS messaging to relevant groups. The third-most important method of obtaining warning information is through friends, relatives and neighbors (43%). After receiving warning information, households directly inform or call their neighbors, relatives and friends. This is a convenient and effective channel of communication. There are a few households (8%) that obtain warning information through NGOs or other channels. Local NGOs mainly include associations for the elderly and women's organizations.

After receiving the warning information, 99% of households understand the message, and only 1.0% of households are unable to understand it.

4.1.2 Amount of advance warning received by households

Household survey questions included "How many days before the typhoon hit did you receive an early warning?" and "How long did it take you to take action to cope with the typhoon?". The answers are shown in Table 6.

Table 6: Time spent coping with Typhoon Saomai

	How many days before the typhoon hit did you receive an early warning? (no. of days)	**How long did it take you to take action to cope with the typhoon? (no. of hours)**
Mean	2.5	5.1
Minimum	0.5	0.5
Maximum	7.0	48.0

Source: HH surveys

The earliest that warning information was received by households was seven days and the latest was half a day. On average, 414 households received early warning information two and a half days before the typhoon.

4.1.3 Time spent taking action in response to typhoons

After receiving early warning information, households take measures to protect their property and family members. The time spent taking action to respond to typhoon disasters averages 5.01 hours. Forty-eight hours was the longest amount of time spent preparing for Typhoon Saomai and half an hour was the shortest amount of time spent. These differences are due to the degree of permanence of a household's home, the location of each household, as well as a family's main source of income. Households whose home is permanent require less time to take action, households whose home is older and semi-permanent need more time to reinforce their houses. Households situated at higher elevations require less time to take action but houses at lower elevations need more time to transfer family assets such as furniture, boats and cars. Households that engage in aquaculture need to quickly harvest their produce and reinforce their breeding base before the typhoon arrives, all of which requires time. Households that own a factory require a longer time to transfer equipment and production materials, however households that have a waged income as their main source of revenue require less time.

4.1.4 Effectiveness of household adaptation behaviors before a typhoon

Variety of adaptation measures

The survey found that before Typhoon Saomai, households took the following adaptation options: reinforce and repair house and its vulnerable parts, such as windows and walls (83%); buy and store food, drinking water and other necessities (59%); move family members to a safer place (49%); move ships, small boats, livestock, and household items to a safer place (30%); and keep up-to-date on warning

information (20%). Specific adaptation measures and their degree of implementation are shown in Table 7.

Table 7: Adaptation measures taken by households before Typhoon Saomai

No.	Adaptation options	Frequency	Percent
1	Reinforce and repair house	342	82.61
2	Build mezzanine floor	1	0.24
3	Reinforce breeding facilities (animal husbandry facilities), ponds and dykes	4	0.97
4	Prepare a means of evacuation (buy a boat to move family)	5	1.21
5	Plant trees along rivers and around gardens to protect against wind and prevent soil erosion	0	0
6	Cut and trim trees near the house to prevent damage from falling branches	14	3.38
7	Move family members to a safe place	203	49.03
8	Move ships, small boats, livestock, and household items to safer places	124	29.95
9	Change crop pattern (adjust crop calendar from three cropping seasons a year to two)	5	1.21
10	Quick harvesting of crops; harvest aquaculture and crops before the start of the disaster season	26	6.28
11	Diversify agricultural production (plant groundnuts, plant forest, animal husbandry)	2	0.48
12	Migrate to cities to look for work; involvement in non-farm activities, waged labor, etc.	45	10.87
13	Regularly update warning information	84	20.29
14	Contribute to a local fund in cash and in kind for anti-disaster activities within communities	15	3.62
15	Buy and store food, drinking water and other necessities	244	58.94

Source: HH surveys

Reinforcing and repairing homes

Before Typhoon Saomai struck, most households (342) reinforced and repaired their homes and the reason given for taking this option by 59% of households was that everyone else was doing this. In other words, this adaptive measure has become routine. In 1% of households this measure was taken because a family ancestor or elder took the same precautions and this behavior has been passed down the generations. In 14% of households this measure was taken because it is cost-effective – compared to other measures, it is very low cost. In 3% of households this measure was taken because the government recommended it, and in 2% of households to the measure was recommended by neighbors/experts. Other reasons were given for 3% of

households adopting this measure.

This option is thought to be effective by 71% of households, with 16% of households viewing it as fairly effective, 12% of households judging it to be very effective, and 1% households thinking it not effective at all. From this data we can see that, on the whole, this option is a very effective measure against typhoons.

Buying and storing food, drinking water and other necessities

Before a typhoon households usually buy and store food, drinking water and other necessities. Most households (77%) chose this option because everyone else is doing the same thing but 9% of households take this option because their ancestors or elders have handed down the practice. Government recommendation via early warning information motivates 5% of households and 5% of households think that storing food, drink and necessities is a cheap option. About 3% of households took this measure because it was recommended by experts/neighbors, while 3% of households took this measure due to other reasons.

Of the 244 households that took this option, 70% of them believe that this option is effective, 18% of households consider it very effective, 12% of households considered it fairly effective, and only 1% of households considered it to be not at all effective.

Moving family members to a safer place

For this option, 52% of households took this measure because everyone else was doing it, 28% because the government recommended it, 11% because of ancestor/elder tradition, 5% because it was recommended by neighbors or friends, and 3% because it is cheap. A few households (2%) took this measure for other reasons, such as their house being located in a low-lying area, or being semi-permanent in structure.

This option is thought to be effective by 67% of households, while 24% considered it very effective, 9% of households considered it fairly effective, and only 1% of households considered it to be not at all effective.

Moving boats, livestock, and household items to a safer place

Safeguarding people's lives is the most important thing for households to consider before a typhoon. Once this has been achieved a great deal of effort is made to ensure the safety of family property. A total of 69% of households take measures to move boats, livestock and household items to a safer place because everyone else is doing this. Some 15% of households take these measures because it is advice that has been handed down from their ancestors or elders, and 7% of households take these options because they are cheap. Around 3% of households take these measures because of government recommendations and 2% of households are responding to the advice of neighbors and friends. Some 4% of households took this measure for other reasons, such as their house being located in a low-lying area, or being semi-permanent in structure.

This option is thought to be effective by 72% of households, with 14% of households considering it very effective, and 14% as fairly effective.

Regularly updating warning information

Eighty-four households out of 414 took this adaptation option. Before the typhoon, households paid attention to early warning information concerning the direction of the typhoon, its potential arrival time and so on. The reasons for households taking this measure were as follows: 64% of households regularly updated information because everyone else was is doing it, 21% because of government recommendations, and 6% because it is cheap and recommended by neighbors/experts. Some 2% of households took this measure for other reasons. This option was thought to be effective by 58% of households, with 34% of households considering it fairly effective, and 7% of households considering it very effective.

The reasons for households taking particular adaptation measures and their effectiveness are shown as in Table 8 and Table 9.

Table 8: Reasons for household choice of adaptation measures

Reasons (%)	**It is cheap**	**Recommended by neighbors /experts**	**Government recommended**	**Every-one is doing it**	**Ancestors or elders did it**	**Others**
Adaptation options						
Reinforce and repair house	13.5	1.8	2.6	58.5	21.1	2.6
Move family members to a safer place	3	5.4	27.6	51.7	10.8	1.5
Move ships, small boats, livestock, and household items to a safer place	7.3	1.6	3.2	69.4	14.5	4
Regularly update warning information	6.0	6.0	21.4	64.3	0	2.4
Buy and store food, drinking water and necessities	4.5	2.5	5.3	76.6	8.6	2.5

Source: HH surveys

Table 9: Effectiveness of adaptation options

Effectiveness (%)	Not effective	Fairly effective	Effective	Very effective
Adaptation options				
Reinforce and repair house's vulnerable parts (e.g. windows, walls)	0.9	15.8	71.1	12.3
Move family members to a safer place	0.5	8.8	66.7	24.0
Move ships, small boats, livestock, and household items to a safer place	0	13.8	72.4	13.8
Regularly update warning information	0	34.5	58.3	7.1
Buy and store food, drinking water and other necessities	0.4	11.9	70.1	17.6

Source: HH surveys

4.1.5 Analysis of the effectiveness of household adaptation behaviors during the typhoon

Variety of adaptation options

During the typhoon, households took the following adaptation options: stayed in shelters and waited until the disaster over (54%); kept disaster warning information and instructions (33%); reinforced the house (22%); cleaned the house or belongings when the floodwater receded (17%); moved family members to a safer place (16%); moved boats, livestock, and household items to safer places (14%); and helped injured neighbors to evacuate to safer places (12%). Some 2% of households cut and trimmed trees near their homes to prevent damage from falling branches. The survey results show that households did not take many measures during the typhoon, they mostly stayed at home or in shelters (Table 10).

Table 10: Household adaptation options during the typhoon

	Adaptation options	Frequency	Percent
1	Reinforce house	91	22.0
2	Cut and trim trees near the house to prevent damage from falling branches	6	1.5
3	Move family members to safer places	65	15.7
4	Move ships, small boats, livestock, and household items to safer places	59	14.3
5	Stay in shelters, wait until the disaster is over	147	35.5
6	Clean house or belongings when floodwater recedes	72	17.4
7	Kept warning information and instructions	135	32.6
8	Help injured neighbors to evacuate to safer places	48	11.6
9	Stay at home	154	37.2

Stay at home

Most households with a relatively strong home stayed in their homes during the typhoon. A total of 68% of households did this because everyone else did it, 9% of households took this option because their ancestors/elders did it, and 9% of households took this option for other reasons, such as there being no safe place to go, or the safe place being too hard to reach. Government recommendations influenced 7% of households and 5% of households adopted this option because it was cheap. The recommendations of neighbors and friends influenced 3% of households. Generally speaking, this option was successful, with 84% of households considering it effective, 10% of households considering it fairly effective, and 7% of households considering it very effective.

Stay in shelters and wait until the disaster is over

The main reasons for adopting this option were as follows: 56% of households did this because everyone was doing it; 22% of households were following government recommendations; 14% of households were influenced by the fact that their ancestors/elders did this; 6% of households listened to the advice of neighbors/experts; 1% of households cited other reasons; and 1% of households thought that it was cheap. This option was thought to be effective by 74% of households, with 22% of households believing the measure to be very effective, and 4% of households considering it to be fairly effective.

Keep disaster warning information and instructions

During the typhoon households retained typhoon warning information and instructions so that they could follow the progress of the typhoon. Of the households surveyed, 75% kept disaster warning information because everyone else did, 10% did so because the government recommended it, 7% of households did so because neighbors or experts recommended this action, 3% of households kept the information because it was cheap to do so, 2% of households were just following what their ancestors/elders have done in the past, and 2% of households cited other reasons. This measure was thought to be effective by 56% of households, while 24% of households considered it to be fairly effective, and 21% of households considered it very effective.

Reinforce house

Before the typhoon most households reinforced and repaired their homes but some households that had remained at home reinforced their homes during the typhoon as well. Some 77% of households reinforced their house because everyone else was doing so. A further 11% of households reinforced their home because their ancestors or elders did so in the past, 7% of households took this measure because it was cheap, and 3% of households took the advice of experts and neighbors. Some 1% of households took these adaptive measures because the government had recommended it. The main other reason given for taking this adaptation option was the seriousness of the typhoon. This measure was thought to be effective by 78% of

households, 15% of households judged it to be fairly effective, and 7% of households believed it to be very effective. Generally speaking, these measures were effective.

The reasons for, and effectiveness of, the main adaptations taken by households during the typhoon are shown in Table 11 and Table 12.

Table 11: Reasons for adaptation choice

Reasons **Adaptation options (%)**	**It is cheap**	**Recommended by neighbors/ experts**	**Government recommended**	**Everyone is doing it**	**Ancestors /elders did it**	**Others**
Reinforce house	6.6	3.3	1.1	76.9	11.0	1.1
Stay in shelters and wait until the disaster is over	0.7	6.1	21.8	55.8	14.3	1.4
Keep warning information and instructions	3.0	7.4	10.4	74.8	2.2	2.2
Stay at home	4.5	2.6	6.5	68.2	9.1	9.1

Table 12: Effectiveness of each adaptation option

Reasons (%) **Adaptation options**	**Not effective**	**Fairly effective**	**Effective**	**Very effective**
Reinforce house		3.3	1.1	76.9
Stay in shelters, wait until the disaster is over		6.1	21.8	55.8
Keep disaster warning information and instructions		7.4	10.4	74.8
Stay at home	4.5	2.6	6.5	68.2

4.1.6 Analysis of the effectiveness of household adaptation behaviors after the typhoon

Variety of adaptation options

After the typhoon, the main adaptation options households undertook were as follows: treatment of the family water source and cleaning up the surrounding environment (75%); repairing and strengthening houses and damaged belongings (69%); coping with financial shortfall (withdrawing savings, selling stock, borrowing money) (46%); getting back to production activities (by repairing dams, paddy fields, ponds, etc.) (35%); asking for aid/support from the government (16%); and asking for support from relatives (16%). There were also some options which were taken by a few households, such as reconstructing houses using more durable materials with more resilient structures (5%), contributing man hours and money to local government to repair disaster damage (5%), consolidating dykes, roads, etc. (2%), and others (2%), such as changing crop patterns, migrating to other areas for work, and working more to earn extra income to aid family recovery (2%). The adaptive options undertaken by households are shown in Table 13.

Table 13: Adaptation options taken after the typhoon

	Adaptation options	**Frequency**	**Percent**
1	Repairing/strengthening houses and belongings	285	68.84
2	Reconstructing houses using more durable materials with more resilient structures	20	4.83
3	Consolidating dykes, roads, etc.	10	2.42
4	Treating the family water source and cleaning the environment	311	75.12
5	Getting back to production activities (by repairing dams, paddy fields, ponds, etc.)	146	35.27
6	Migrating to other areas in search of work; working more to earn extra income to aid family recovery	8	1.93
7	Coping with financial shortfall (withdrawing savings, selling stock, borrowing money)	19	45.89
8	Selling assets such as gold, motorbikes, land, livestock; selling means of production such as seeds and machines	0	0
9	Asking for aid/support from the government	66	15.94
10	Asking for support from relatives	66	15.94
11	Contributing man hours and money to local government to help repair the damage caused by the disaster	20	4.83
12	Others (please specify)	10	2.42

Treating the family water source and cleaning the environment

After the typhoon the first thing households did was treat the family water source and clean the surrounding environment. The main reason for taking these measures was that everyone else was doing it (83%), whereas 8% of households did

this because their ancestors/elders have always done it. A total of 5% of households performed these adaptive measures because they were cheap, 4% because the government recommended it, 1% because neighbors/experts recommended it. This measure was thought to be effective by 79% of households, 12% of households considered these measures to be very effective, 8% of households considered them to be fairly effective, and only 1% of households thought these measures not at all effective.

Repairing/strengthening houses and family belongings

The majority of households (68%) did this because everyone else was doing it. A total of 14% of households repaired and strengthened their homes because it was cheap, with 13% of households performing these tasks because their ancestors/elders did in the past. Some 3% of households cited other reasons for taking these measures, 2% of households were following government recommendations, and 1% of households were following the advice of experts/neighbors. These measures were thought to be effective by 80% of households, 13% of households considered these measures to be very effective, 6% of households considered them to be fairly effective, and only 1% of households thought that these measures were not at all effective.

Coping with financial shortfall

Some 42% of households took measures to cope with money shortages they experienced as a result of the typhoon because everyone was doing it, and 21% of households took measures to cope with financial shortfalls because their ancestors or elders did it. A total of 16% of households followed this course of action because it was recommended by experts or neighbors. For a further 16% of households this course of action was cheap because money was borrowed from friends or relatives without interest being levied. Some 5% of the households cited other reasons. These measures were thought to be effective by 63% of households, 21% of households considered them to be very effective, and 16% of households considered them to be fairly effective.

Restarting production activities

The majority of households (66%) restarted production activities because everyone else was doing so. Some households (14%) did this because their ancestors or elders have always done it, while 7% of households were following the recommendations of neighbors or experts, and 6% were following government recommendations. A total of 3% of households cited other reasons, and 3% of households thought these measures were cheap – it was even stated that these measures were convenient. These measures were thought to be effective by 64% of households, 30% of households considered them to be fairly effective, while 6% of households considered them to be very effective.

The reasons for, and effectiveness of, the adaptation options taken after the typhoon are shown in Table 14 and Table 15.

Table 14: Reasons for adaptation choice

Reasons (%) Adaptation options	It is cheap	Recommend-ed by neighbors/ experts	Government-recommended	Everyone is doing it	Our ancestors/ elders have always done it	Others
Repairing/ strengthen houses and damaged belongings	13.7	1.4	1.8	68.1	12.6	2.5
Treat family water source and clean the environment	4.5	0.6	3.5	83.3	7.7	0.3
Restart production activities (repair dams, paddy fields and ponds)	2.7	6.8	6.2	66.4	14.4	3.4
Cope with financial shortfall (withdraw savings, sell stock, borrow money)	15.8	15.8	0	42.1	21.1	5.3

Table 15: Effectiveness of adaptation options

Reasons (%) Adaptation options (%)	Not effective	Fairly effective	Effective	Very effective
Repair/strengthen houses and damaged belongings	13.7	1.4	1.8	68.1
Treat family water source and clean the surrounding environment	4.5	0.6	3.5	83.3
Restart production activities (repair dams, paddy fields and ponds)	2.7	6.8	6.2	66.4
Cope with financial shortfall (withdraw savings, sell stock, borrow money)	15.8	15.8	0	42.1

4.1.7 Analysis of the adaptation options households should have undertaken but did not, and the reasons for this

Before the typhoon

The adaptation options households should have undertaken before the typhoon but did not, were as follows: build houses according to the correct building codes and

standards (41%); purchase insurance (30%); evacuate to safer places (5%); change crop pattern (4%); harvest crops (3%); accurately forecast the typhoon (1%); and inform people of the movement of the typhoon (0.2%) (Table 16).

Table 16: Adaptation options households did not undertake

Options	Frequency	Percent
Build houses according to building codes and standards	168	40.6
Purchase insurance	125	30.2
Evacuate to safer places	19	4.6
Change crop pattern	17	4.1
Harvest crops	13	3.1
Accurately forecast the typhoon	4	1.0
Inform people of the movement of the typhoon	1	0.2

Source: HH surveys

Build houses according to building codes and standards

The majority of households (96%) did not take this option because they did not have enough money to do so, but other reasons were cited as well, including: "it's not my responsibility – the government should do it" (8%); "we have to act as a group or community" (7%); "we don't know how to do it" (2%); and others (2%).

Purchase insurance

The reasons why this option was not undertaken are shown in Table 17 but the most common one (90% of households) was a lack of money. Around 12% of households thought that this measure should be undertaken as a group or community, 8% of households said that they did not know how to purchase insurance, 7% of households felt that this task was not their responsibility but was within the government's remit, and 2% of households had other reasons for not undertaking this measure.

Evacuate to safer places

Over half of the households surveyed (53%) selected "other reasons" for not undertaking this adaptation option and some of these included there being no safe place to evacuate to, and that safe places were difficult to reach. Just under a quarter of households (21%) thought that they should act as a group or community, 16% of the households did not know when the evacuation took place, and 11% of households said that they did not know how to evacuate to a safer place.

Change crop pattern

The main reason households selected for not undertaking a change in crop patterns was a lack of knowledge of how to do so (65%). Around 35% of households

cited other reasons for not changing crop patterns, such as the impact of climatic conditions on farming, problems associated with geographical location, and crop patterns being hard to change.

Harvest crops

Over half of households (54%) stated "other reasons" for not harvesting crops before the typhoon made landfall. The main "other reasons" given were that the crops had not yet matured, there wasn't enough labor to complete this, or there wasn't enough time to harvest before the typhoon. Some households (46%) said that they did not know when the typhoon was due so it was not possible to conduct a timely and rapid harvest.

Accurately forecast the typhoon

Typhoon Saomai was not accurately forecast. The main reason for this is that typhoon forecasting technology needs further development in order to become more precise.

Inform people of the movement of the typhoon

People were not kept informed of the movement of the typhoon. Typhoon forecasting needs to be improved so that households can be given timely warning and information about a typhoon's movements.

The reasons given for the non-adoption of all of these options are shown in Table 17.

Table 17: Reasons given (%) for not adopting particular options

Reasons (%) / **Options (%)**	**Do not have enough money**	**Do not know how to do it**	**Have to act as a group or community**	**It is not my responsibility – the government should do it**	**Did not know when the event occurred**	**Other reasons**
Build to building codes	95.8	2.4	7.1	8.3	0	2.38
Purchase insurance	90.4	8.0	12.0	7.2	0	1.6
Evacuate to safer places	0	10.5	21.1	0	15.8	52.6
Change the crop pattern	0	64.7	0	0	0	35.3
Harvest crops	0	0	0	0	46.2	53.9
Accurately forecast the typhoon	0	0	0	0	0	100
Inform people of movement of typhoon	0	0	0	0	0	100

During the typhoon

During the typhoon there were a few measures households should have undertaken but did not – only 0.7% of households drained off water from their yard or house in enough time. The fact that this proportion is very small means that households thought that they had done everything they could have done during the typhoon. The reason for this measure is that households think that it is not their responsibility but the government's. Proposals to overcome this obstacle include government-organized activities aimed at mobilizing households to participate.

After the typhoon

After Typhoon Saomai there were fewer measures that households should have undertaken but did not, other than moving to safer places, which 20% of households did. The main reasons for this measure not being implemented are shown in Table 18. The main reason households did not implement adaptation measures was not having enough money, with 99% of households selecting this reason. A total of 8%

of households stated that they did not know how to implement the measures, and 1% of households cited other reasons. Recommendations include increasing household income, the provision of financial support from the government, as well as preferential migration policies for households whose houses are in dangerous places.

Table 18: Reasons for not adopting adaptation measures

Reasons for not adopting adaptation measures	Frequency	Percent
Do not have enough money	82	98.8
Do not know how to do it	7	8.4
Other (specify)	1	1.2

4.1.8 Summary

By analyzing responses to the typhoon we can see what adaptive behaviors have been carried out and which measures households judge to be effective. It is obvious that more measures were taken by households before the typhoon struck than during and after the typhoon, so the effectiveness of this phase is better than the other two phases. During the typhoon there are fewer adaptation measures for households to take, except to stay at home or remain in shelters and wait until the disaster over. After the typhoon, households reconstruct and recover from the losses inflicted by the typhoon. The main problem is economic – most households suffered economically as a result of Typhoon Saomai and this resulted in a lengthening of the post-disaster reconstruction period.

There are other measures that households should have undertaken but did not undertake before the typhoon. These omissions, such as changing the pattern of crop planting, were caused by technical limitations and a lack of money. During the typhoon there were a few measures households could have undertaken and should have undertaken but were unable to. After the typhoon, the main measure households should have undertaken but did not was to move elsewhere – the main reason they did not do so was a lack of money.

4.2 Household Participation in Community Adaptation Options

In addition to the measures taken by individual households, there was also household participation in collective typhoon adaptation.

4.2.1 Community collective adaptation options

Availability of collective measures

The proportion of households that agreed that there were collective measures that could have been taken in response to Typhoon Saomai was 71%. A total of 29% of households stated that there were no collective measures that could have been taken in response to Typhoon Saomai. Interviews show that all of the surveyed communities took collective adaptation measures so the difference in proportions could be related to individual views – some households understood and actively participated in collective measures, but some households did not take collective action into account.

The main reasons given by farmers who thought that no collective measures

can be taken regarding typhoons (129) were as follows: unfamiliarity with other farmers (10); because they do not know how to act collectively to deal with typhoons (65); and because of other reasons (44). These other reasons include: 66% of households stated that there was no one to take charge of the organization of collective action, 16% of households said that their losses were relatively small, and 14% of households considered collective action to be the government's responsibility. A total of 2% of households considered collective measures to be not at all effective, and 2% of households stated that their elderly household members could not participate in collective measures.

Community collective adaptation options

Before the typhoon, the main collective measures taken were to provide and disseminate early warnings (55%), to raise awareness of disaster prevention (25%), and to prepare evacuation roads (15%). During the typhoon, collective adaptation options included assisting the evacuation (37%), monitoring the situation (17%), and organizing and providing necessities at evacuation centers (15%). After the typhoon collective adaptation options included working together to clean up the environment (50%), the assessment of social conditions as a basis for relief distribution (23%), the repair and reconstruction of damaged dwellings (12%), and getting goods and disaster assistance to people affected by the typhoon (12%).

The details of collective adaptation options are shown in Table 19.

Table 19: Collective adaptation options

No.	Adaptation measures	Frequency	Percent
Before typhoon	1. Provide early warning system and disseminate early warning	228	55.1
	2. Coordinate with commune level government to provide evacuation equipment	13	3.1
	3. Raise awareness of disaster prevention	105	25.4
	4. Mobilize fund for disaster risk reduction	14	3.4
	5. Prepare evacuation roads	62	15.0
	6. Help people to secure and harvest crop	40	9.7
	7. Others, please specify	2	0.5
During typhoon	8. Assist evacuation	155	37.4
	9. Participate in rescue operation	41	9.9
	10. Organize and provide necessities at evacuation centers	61	14.7
	11. Assist in relief operation	28	6.8
	12. Monitor the situation	71	17.1
	13. Others, please specify	6	1.4
After typhoon	14. Assess social conditions as a basis for the distribution of relief	95	22.9
	15. Repair/reconstruct damaged houses	48	11.6
	16. Extend credit to members	2	0.5
	17. Send goods/disaster assistance to affected people	48	11.6
	18. Work together to clean up the environment	208	50.2
	19. Mobilize disaster goods and assistance to the community	30	7.2
	20. Others, please specify	2	0.5

4.2.2 The contribution made by households to collective adaptation options

Before the typhoon: early warning and its dissemination

Village committees and villagers spontaneously disseminated early warnings about the typhoon, so many households were involved in this collective measure. Warning information needs to be conveyed rapidly so that preparations can be made in good time to cope with typhoons. It takes different amounts of time for early warnings to get to different households, with dissemination of warning information taking an average time of 0.40 day, with a range of 0.3day. There are differences in the financial contribution made by households to disseminate early warnings, with an average contribution of USD 0.92 and a range of 0-USD44.12. Contributions were related to the individual characteristics of each household and village cadres. If households are predominately made up of old people or children, it is difficult for them to participate in collective measures. If a household is made up of village cadres,

then there is more chance that they will be involved.

Before the typhoon: raising awareness of disaster prevention

After households receive warning messages they can raise awareness and strengthen their own resilience. The amount of time households spent on this option varied, with an average time of 0.125 day (0-2 day). There were differences in financial contributions made by households to implement this adaptive measure, with an average contribution of USD 0.9 (0- USD 44.12).

Before the typhoon: preparation of evacuation roads

After receiving warning messages, households living at lower elevations or in dangerous locations should move to a safer place. The first step in implementing this action is to prepare evacuation roads. The households involved in this measure spent varied amounts of time on this activity, with an average of 0.1 days spent,(0-1 day). The average financial contribution was USD 0.16 (0-USD 14.71).

Before the typhoon: other collective measures

Other collective measures taken before the typhoon included helping people to secure and harvest crops, mobilizing a fund for disaster risk reduction, coordinating with commune level government in order to provide evacuation equipment, and helping the elderly and children to move to safe places.

During the typhoon: assisting evacuation

During the typhoon the most significant measure households were involved in was to assist evacuation. The time households spent on assisting the evacuation varied widely, with an average time of 0.22 day spent (0-2 day). There were differences in financial contributions, with an average contribution of USD 1.14 (0-USD 29.41).

During the typhoon: monitoring the situation

Households were concerned about the typhoon's movement and direction and so they kept up-to-date with news of the typhoon's progress. The amount of time households spent on this measure varied, with an average time of 0.16 days (0-1day). There were differences in the financial contributions made by households, with an average contribution of USD 0.39 (0-USD 14.71).

During the typhoon: organizing and providing necessities at evacuation centers

At public shelters good management was important to ensure people's safety and daily needs. Time spent on this varied widely, with an average time of 0.18 days, a maximum of two days. There were differences in household financial contribution, with an average contribution of USD 0.95, a maximum of USD 29.41. In addition, during the typhoon, other measures were taken, such as participating in rescue operations and assisting in the relief operation.

After the typhoon: working together to clean up the environment

After the typhoon a large proportion of households participated in the

collective activity of working together to clean up the surrounding environment. Due to flooding, the wind and other reasons, there was mud, dead animals and garbage to clear. The time households spent working together to clean up the environment varied widely, with an average time of 0.42 days, while others took three days . The average financial contribution was USD 3.26 with the maximum contribution of USD 29.41.

After the typhoon: assessing social conditions as a basis for the distribution of relief

The government and other organizations provided subsidies to aid recovery following the typhoon. The distribution of relief supplies had to be determined by assessing the damage so that reasonable distribution of relief supplies took place and households could return to normal life as soon as possible. Households spent different amount of time reporting losses to the government, with an average of 0.21 days. The financial contribution averaged USD 0.92.

After the typhoon: repair and reconstruction of damaged dwellings

Households must have skilled labor and money to afford house repairs. Collective participation was important for the repair of damaged dwellings – particularly for households that were unable to work. The average amount of time spent by households engaged in this activity was 0.70 days and the average household contribution was USD 0.92.

After the typhoon: getting goods and assistance to people affected by the disaster

People are needed to distribute relief supplies and different households have different abilities to do this. Some households were more able than others to help poorer households resume normal life as quickly as possible, so there were differences in the participation levels of different households for this adaptive measure. This measure took different amounts of time with an average time of 0.12 days while the average financial contribution was USD 1.09.

The contributions made by households to different collective measures are shown in Table 20.

Table 20: Household contributions to collective measures

Collective measures	Mean man hours	Max man hours	Min US$	Mean US$	Max US$	Min US$
Provide early warning systems and disseminate early warnings	0.4	3	0	1.15	44.12	0
Raise awareness of disaster prevention	0.1	2	0	0.93	29.41	0
Prepare evacuation roads			0	0.16	14.71	0
Assist evacuation	0.2	2	0	1.15	29.41	0
Monitor the situation	0.2	1	0	0.38	14.71	0
Organize and provide necessities at evacuation centers	0.2	2	0	0.94	29.41	0
Work together to clean up the environment	0.4	3	0	3.25	44.12	0
Assess social conditions as a basis for relief distribution	0.2	2	0	0.93	29.41	0
Repair and reconstruct damaged dwellings	0.7	2	0	0.93	29.41	0
Get goods and disaster assistance to people affected by the disaster	0.1	1	0	1.09	14.71	0

4.3 Household Acceptance of Expert-recommended Adaptation Options

4.3.1 Expert-recommended options and levels of acceptance

Through the survey, experts recommended adaptation proposals. These included:

a Build a safe community shelter.

b Develop a climate change-induced disaster insurance scheme for housing and crops.

c Relocate communities at risk to safer places.

d Provide training in climate change adaptation (CCA) and disaster risk reduction (DRR) to all households.

e Provision of emergency response equipment such as lifebuoys, life vests, medical kits, and medicine.

The options that experts recommended and their level of household acceptance are shown in Table 21.

Table 21: Expert-recommended options and levels of household acceptance

Expert adaptation proposal	**Would you undertake this measure? (%)**		
	Yes	No	Not sure
Build a safe community shelter	58.0	33.8	8.2
Develop an climate change-induced disaster insurance scheme for housing and crops	46.6	43.7	9.7
Relocate communities at risk to safer places	40.8	52.2	7.0
Provide training in CCA and DRR to all households	43.7	46.1	10.1
Provide emergency response equipment: lifebuoys, life vests, medical kits, medicine	36.5	53.1	10.4

Source: HH surveys

4.3.2 Reasons for adopting or not adopting expert-recommended options

The main reasons for adopting an option included: "yes, this can have an effect on adapting to typhoons", "it is low in cost", "it will improve awareness of typhoon adaptation", "advice from experts is useful", and "others". The main reasons for not adopting an option were: "this will not have an effect on adapting to typhoons", "it is high in cost", "this is the responsibility of the government and collectives", and "others".

Build a safe community shelter

Among the households who would take this measure, 99% believed that this measure would have an effect on adapting to typhoons. Advice from experts was thought to be useful by 2% of households. Among households that would not take this measure, 50% considered it to be the responsibility of the government and collectives. Around 28% of households gave other reasons for not adopting this measure, such as the family house being very strong, the village already having public shelters, and some households wanting to protect their property at home and not move it. Some 17% of households would not adopt this measure due to its high cost, and 7% of households think that this measure would not have an effect on adapting to typhoons.

Develop a climate change-induced disaster insurance scheme for housing and crops

Among households that would take this measure, 91% stated that it would be effective for adapting to typhoons, 4% of households felt that it would lower costs, and 3% of households thought that it was useful expert advice. Other reasons given for adopting this measure were that it would reduce losses and improve household ability to adapt to typhoons. A further 1.0% of households thought that this measure would improve awareness of typhoon adaptation. Among households that would not take this measure, 55% stated that this was because of its cost, and 17% of households cited other reasons, such as the belief that insurance has no effect, and that no appropriate insurance exists. Some 15% of households believed this measure to be the

responsibility of the government and collectives. A further 14% of households thought that this measure would not have an effect on adapting to typhoons.

Relocate communities at risk to safer places

Among households that would take this measure, 98% think it would be effective for adapting to typhoons, 2% thought that it was useful expert advice, and that it could improve awareness of typhoon adaptation. Among the households that would not take this measure, 79% believed that it would cost too much and 13% of households gave other reasons, such as they had just built a new house, or their house was very strong. A total of 7% of households believed this measure to be the responsibility of the government and collectives.

Provide training in CCA and DRR to all households

Among the households that would take this measure, 48% said that they thought it would be effective in adapting to typhoons, 40% thought that it could improve awareness of typhoon adaptation, 13% of households thought that it was useful expert advice, and 1% of households thought that it would lower costs. Among that households that would not take this measure, 48% cited other reasons such as there being no substantive effect from training, having no time to participate in training, and households having already educated themselves in these issues. Some 42% of households believe that this measure should be the responsibility of the government and collectives, 19% of households think that it will not have an effect on adapting to typhoons, and 3% of households think it is too expensive.

Provide emergency response equipment such as lifebuoys, life vests, medical kits, and medicine

Among the households that would take these measures, 90% said that they thought it would be effective in adapting to typhoons, 12% of households thought that it was useful expert advice, and 3% of households thought it could improve awareness of typhoon adaptation. Among the households that would not take the measure, 56% believe that this measure should be the responsibility of the government and collectives, and 19% cited other reasons, such as the fact that there is already an emergency center in the village, or there will not be any casualties so there is no need for emergency medicine. A total of 18% of households think this measure is too expensive, and 13% of households think that it will not have an effect on adapting to typhoons.

Details of the measures discussed above are shown in Table 24.

Table 22: Reasons given for adopting or not adopting expert-recommended options

Options / Percent / Reasons		Build a safe community shelter	Climate change-induced disaster insurance scheme	Relocate at-risk communities	CCA and DRR training	Provide emergency response equipment
Yes	Will effect typhoon adaption	99.2	91.2	97.6	48.1	90.1
	Low in cost	0	3.6	0	0.6	0
	Will improve awareness of typhoons adaptation	0	1.0	0.6	40.3	2.6
	Advice from experts is useful	1.7	2.6	1.8	13.3	11.9
	Others	0	2.6	0	0	0
No	Will not have an effect on adapting to typhoons	7.1	13.8	0.5	19.4	13.2
	High in cost	17.1	55.2	79.2	2.6	17.7
	It is the responsibility of the government and collectives	50.0	14.9	6.9	41.9	55.5
	Others	27.9	16.6	13.0	47.6	19.1

5.0 ANALYSIS OF THE NEEDS OF HOUSEHOLDS WHEN COPING WITH TYPHOONS AND STRATEGIES TO IMPROVE HOUSEHOLD CAPACITY TO ADAPT TO TYPHOONS

Year after year typhoons are the most common disaster in Zhejiang Province. The household response to typhoons is relatively weak, particularly in low-income households that are vulnerable to severe impacts. Therefore, it is particularly important to analyze what it is that households need in order to cope with typhoons.

5.1 Analysis of the Needs of Households when Coping with Typhoons

What support a household needs in order to cope with typhoons varies according to the impacts the household suffers, household vulnerability due to economic conditions, and the source of household income. The ten survey villages are located in coastal areas, on low-lying land and in mountainous areas and all of them are vulnerable to typhoons. Households would like to get help. Household needs include: financial assistance for adaptation expenses, the construction of solid houses to prevent impacts from typhoons, an insurance market that deals with typhoons, and the provision of technology, knowledge, and information that will help households to cope with typhoons (Table 23).

Table 23: The needs of households when coping with typhoons

Help needed	Frequency	Percent
Financial assistance for adaptation expenses (economic indicator)	270	65.2
Building solid houses to prevent the impacts of typhoons (infrastructure indicator)	164	39.6
The establishment of an insurance market that deals with typhoons (institution indicator)	155	37.4
The provision of technology/knowledge/information to assist in coping with typhoons (knowledge/skills indicator)	106	25.6
Others	9	2.2

5.1.1 Financial assistance for adaptation expenses (economic indicator)

Financial assistance is needed to facilitate responses to typhoons. Some households are poor and have limited financial resources for pre-disaster prevention measures. Funds for post-disaster reconstruction are difficult to secure. When households were asked “what is the most important assistance required to respond to typhoons?”, 65% responded that they were most in need of financial assistance. The overall economic condition of this region is poor and financial assistance is currently available to only a few households. Lack of funding is the main issue for households trying to cope with post-disaster reconstruction. A limited amount of money was given out in the form of post-disaster subsidies after Typhoon Saomai.

5.1.2 Building solid houses to prevent the impacts of typhoons (infrastructure indicator)

The need for assistance to build solid houses to prevent the impacts of typhoons was cited by 40% of the households surveyed. Many of these respondents live in non-rigid or semi-permanent houses, mostly because they have a low income or are financially over burdened and so cannot afford to build permanent homes (96%). The survey team found that some of these households lived in low and dark houses which are not capable of withstanding a typhoon – the whole roof was torn off by Typhoon Saomai in one such home and part of the roof was still only covered by a piece of waterproof cloth. In addition, the conditions for construction in rural locations are limited, making it is more difficult to build permanent structures. Therefore joint townhouses should be built because they are stronger and can withstand the impacts of typhoons. This type of construction should be legislated for new buildings.

5.1.3 Establish an insurance market dealing with typhoons (institution indicator)

The need for the establishment of an insurance market dealing with typhoons was cited by 37% of households. In addition, 30% of households believed that insurance was important to mitigate the losses incurred by typhoon disasters, but most households did not purchase insurance. Reasons for this included: there is not enough money to buy insurance (90%); insurance is the responsibility of the government and also a collective responsibility (19%); and they do not know how to purchase insurance (8%). These households did not know who was responsible for purchasing insurance or how to choose the right insurance. Public knowledge and education is needed to change these gaps in knowledge.

5.1.4 Provision of technology, knowledge, and information to assist in coping with typhoons (knowledge/skills indicators)

Households that moved to Zhejiang Province within the last ten years (26%) cite “the provision of technology, knowledge, and information to assist in coping with typhoons” as a need because these households lack the experience to cope with typhoons. They urgently need help from the government and experts on how to cope with typhoons. Local households deal with typhoons every year and have their own knowledge of typhoons to fall back on.

In addition, the experience gained by households (Table 24) shows that many households reinforce doors and windows and use other aspects of traditional knowledge to prevent the impacts of typhoons – all of which tend to be effective. It is also important that households can help themselves. Unfortunately, typhoons are now strengthened by global environmental problems, climate change, and the abnormal weather it brings about. When an abnormally strong typhoon, such as Typhoon Saomai, comes along households find it difficult to combat it with traditional

knowledge alone. In these circumstances, households may suffer losses, even severe losses, because they are unaware of the strength and destructive power of the approaching typhoon. Only a few households have long-term coping strategies – such as changing their source of income or relocating to another place to live. Most local households that use traditional countermeasures to cope with typhoons become more and more vulnerable.

Table 24: Lessons learned via experience of typhoons

Lessons learned	Frequency
Close doors and windows	414
Move property to higher ground in good time	359
Stay at home if the house is safe	358
Evacuate to a safer place in time	34
Prepare enough food in advance	75
Reinforce the house	16
Dredge the river and irrigation facilities	2
Keep information up to date	4
Roads and bridges should be built higher up	1

5.2 Strategies to Improve the Ability of Households to Adapt to Typhoons

Generally speaking, typhoon-prevention measures should be people-oriented and focus on the prevention of impacts. Coping strategies should emphasize three areas: "making sure" households are fully prepared before the typhoon arrives to withstand the impacts of strong winds, rainstorms, large waves of water, flash floods and water damage; "avoiding the impacts" of typhoons on households; and "guaranteeing" a swift return to normal life so that people's basic livelihoods can be safeguarded.

The damage caused by Typhoon Saomai meant that 129 households (31%) had to receive various forms of assistance, including manpower, financial assistance, construction materials, emergency response equipment (lifejackets, medical kits, medicines, etc.), basic necessities such as water, food and clothing, as well as farming supplies (seeds and fertilizer). Typhoon prevention systems need to be strengthened to meet the needs of households.

Household ability to adapt to typhoons would be improved by greater financial capabilities, increased technical capacity, more knowledge, more skills, improved infrastructure, and increased social capacity.

5.2.1 Economic capacity

Economic capacity is the primary factor that affects the vulnerability and adaptation of households. Wealthy households are in a better position to prepare for and survive disasters – their recovery is fast and adaptable. So, improving economic capacity is the most fundamental measure that needs to be taken to strengthen household resilience to disasters and to enhance their recovery capabilities. Improving economic capacity encompasses many aspects, such as adjusting income structure,

broadening sources of income, raising special funds to deal with typhoons via multiple channels, increasing economic support for vulnerable groups, and making full use of market-based instruments.

Adjust income structure and broaden sources of income

Economic capacity is fundamental to the adaptability of households. The surveys show that households that depend on agriculture and fishing are highly vulnerable to super typhoons because these are the most at-risk industries from a typhoon. Therefore, the most important countermeasure to this situation is to achieve a multiple income structure within households, thereby broadening sources of income. In this way households can build more wealth and enhance their resilience.

The government should take action to promote this change in employment structure, to strengthen technical training to enhance household employability, to increase non-agricultural employment opportunities, and to reduce the proportion of household income that derives from agricultural and fishing.

Utilize multiple channels to raise special funds to increase economic support for vulnerable groups

The government of Zhejiang Province always attaches great importance to typhoon disaster prevention and relief work. After the National Civil Affairs Conference (2006), Zhejiang Province emerged as a leader of the "government-led, community participation, local household self-help" mechanism. This mechanism was created to ensure emergency assistance and subsidies for people whose homes were ruined. However when compared to the needs of households coping with the impacts of typhoons, there is a gap between their needs and state provision, which has to close if households are to continue to strengthen in their responses to typhoons.

Funds for defense against typhoons should be taken into account in the government budget and relevant departments need to establish special funds. It would also be advisable to make full use of social networks and promote the "one person in difficulty should be helped by all the others" spirit, to raise funds from home and abroad.

Make full use of market-based instruments to increase credit and insurance

Credit and insurance are the major market-based instruments that can alleviate typhoon disaster losses and enhance the adaptability of households. Credit may be needed for short-term post-disaster funding to ease the shortage of homes and to speed up post-disaster recovery. For relatively small disadvantaged households, post-disaster loans that have government discounts or low interest rates reduce the burden of households in repaying their loans, and also widen the limited financial resources of these households.

Disaster insurance is an effective way of achieving disaster risk management and plays an important role in integrated disaster risk management. Insurance is an important measure for reducing disaster losses and enhancing resilience. However our research showed that many local residents (19%) did not want disaster insurance or

did not know of the existence of this kind of insurance (8%) and therefore had to wait for government support after Typhoon Saomai.

Many people think that insurance is a matter for the government and village collectives. Therefore, the creation of an insurance system would require publicity in rural areas so that insurance information is widely available to communities. This is essential if households are to understand that insurance is their responsibility rather than the responsibility of the government. Communities need to be informed about insurance and how to make claims so that these market-based instruments can be used to reduce the extent of losses from typhoon disasters.

5.2.2 Technological capacity

Technological capability is a prerequisite for typhoon adaptation. Technical capacity can be defined as having access to an effective early warning system, the dissemination of community knowledge of the nearest safe shelter, maintaining evacuation routes, and the provision of additional emergency vehicles.

Improve early forecasting and the dissemination of information

The dissemination of accurate and timely information is a fundamental aspect of typhoon prevention. Improving the accuracy of typhoon forecasting is a priority. Timely and accurate typhoon early warning information enables the government to take accurate typhoon prevention measures and allows households to know as soon as possible when and where the typhoon will make landfall and how strong it will be. This information helps households to make psychological preparations and to take practical response measures. The government plays an important role in the provision of early warning information and households, on the whole, receive this information quickly through various channels. But accurate information on the scale of Typhoon Saomai was inadequate and households need the accuracy of typhoon forecasting to be improved so that they can put better prevention work in place. Before a typhoon lands, the meteorological department needs to make timely and accurate forecasts to improve their monitoring capabilities. Radio, television, newspapers, the internet, and mobile phone SMS can be used to quickly and effectively release early warning information to large numbers of people.

Since 2006 China has strengthened typhoon planning and preparation and typhoon management from central right down to local government levels. A typhoon planning system was set up in 2007 and Zhejiang Province leads the way in making operable and fast-moving typhoon emergency plans at village level. Plans include the following types of measures: ascertaining the number of people in the village that need to be transferred to a safer place; where to transfer them to; and how to transfer them.

However, when surveying the community, it was found that it was difficult to engage community cadres and community members in the plan preparation and implementation process. Community planning around typhoons tends to apply a standard template and targets are unclear. The government and experts in typhoon

disaster risk need to strengthen their research and develop different grades of typhoon and associated disaster risks. Zoning maps would be useful and community cadres and community members should be encouraged to participate in the development of contingency plans and the establishment of regional integrated disaster reduction and risk transfer mechanisms. It is necessary to strengthen communication between the government, experts and local people so that there is multi-stakeholder involvement in the preparation of mechanisms to ensure the effectiveness of plans.

Preparation work should focus on geographical characteristics such as the terrain a community is located in. Key work in coastal areas includes strengthening seawall construction to prevent storm surges due to strong winds. This measure could prevent the destruction of houses, casualties, loss of property and sunk fishing boats. In low-lying areas people need to be educated about building safe houses in strict accordance with building standards. In mountainous areas people need to be educated in the prevention of secondary disasters such as landslides and the dangers posed by the flow of debris.

Sound contingency plans must be established that detail preparatory work against typhoons. Contingency plans for managing and directing households in accordance with emergency requirements should be strengthened. Contingency plans should be fine-tuned to local conditions, should make reference to case-study evidence, and should avoid combining conflicting approaches. At grassroots level contingency plans have to be realistic and people's responsibilities have to be clear, concise, and easy to understand. Management plans need to be strengthened according to what has actually happened in the past – this would expose problems that arose during emergencies and approaches could be revised to improve the relevance, feasibility and practicality of planning (Miao 2007). Plans formulated at grassroots level particularly need to be fine-tuned to specific circumstances so that organizations can actively train their staff, conduct practice drills, and put mechanisms in place for training and educating the wider community. Local households need to be organized to participate in these plans. This involvement will improve the functioning of government and organization plans as well as improve the capability of households to deal with typhoons.

Build safe community shelters in convenient places to ensure safe and rapid evacuation

When a typhoon strikes it is important to ensure the safety of vulnerable groups by evacuating them to shelters. There were some communities in the case study areas, such as Xiyangting village, where there are no safe shelters. Even in communities that have a place of refuge, the refuge is often weak and lacks the necessary facilities.

The location of shelters should take into account the conditions of poor households in order to facilitate their withdrawal to the nearest building. The refuge should be accessible via a number of evacuation routes and should be well signposted. The evacuation routes should be constructed with people in mind and the width of the

route should allow the greatest number of people to travel along it in the shortest possible time. This preparatory work must be done outside the typhoon season because it is impossible to do during the typhoon season.

Purchase additional emergency vehicles to ensure the timely transfer of households that are at risk

The survey found that the rural road infrastructure is sound due to the government's long-standing policy of supporting agriculture and rural communities. However there are some households that should be moved when a typhoon the strength of Typhoon Saomai occurs. In order to preserve their property, some households are unwilling to leave their homes to avoid danger, so when the typhoon comes they find that they are at risk. High-quality emergency transport, such as vehicles and speed boats, are needed to make sure that scattered households and fishermen leave their homes in enough time. In the survey, it was found that emergency transport was absent in some remote communities. Community leaders often need to use their own private vehicles or that of others to organize emergency transport. Therefore, in order to ensure the timely transfer of people, the purchase of additional emergency vehicles is of paramount importance.

5.2.3 Knowledge and skills

Knowledge and skills are key to improving the adaptive capacity of households. Training improves household skills rapidly. Enhancing training in rural communities would change and enhance the ability of households to deal with typhoons. The following measures could be taken: build education about disasters into every aspect of society; enhance social awareness and knowledge in response to typhoons; and implement a special training education network to upgrade specific adaptive skills within households.

There are different training priorities for different households. Some 44% of households believe that there is a need for training and 48% of households think that training can effect typhoon adaptation. Some 40% of households stated that training can improve awareness of typhoon adaptation for 40%, and 13% of households think that expert advice is useful. A large number of the respondents that hold these views have been relocated from other areas, so are relatively new to Zhejiang Province. A total of 46% of households consider training unnecessary, and all of these respondents are older local farmers who have lived in the area all their lives. They believe that training is the responsibility of the government and village collectives (42%), and that they have mastered the skills needed to defend themselves against typhoons. These findings illustrate that training would be most pertinent for the people who lack traditional knowledge of typhoon defense.

Improve typhoon awareness training and education in rural communities

Training and education is not the only important way of improving typhoon defense skills; it is also important to improve levels of awareness. Government at all levels should strengthen knowledge of typhoon disaster prevention and reduction.

Before a typhoon arrives, it is necessary to implement defensive typhoon education and typhoon response drills. These will improve the on-the-spot response capabilities of households, and will minimize the panic households experience when actually dealing with typhoons. While actively engaging communities in typhoon training they can be taught to deal with unforeseen circumstances. After a typhoon, there should be a review where lessons can be learned, holes can be plugged, and knowledge of defense against typhoons can be constantly improved.

Training and education about typhoon disasters in the community is important, especially for residents that are relatively new to the province. Radio, television, movies, books and other promotional tools can be used to organize the spread of knowledge about typhoon disaster prevention, self-help, how to help others, and emergency responses, in order to enhance the whole of society's ability to cope with typhoons.

As far as the content of training is concerned, different groups of people should tackle different subject matter. For local residents who have extensive experience of typhoons, especially for the elderly who live in low-quality housing, training and education should increase their awareness of risk prevention and inform them about where they should evacuate to in order to avoid danger. For more recent residents, training and education should spread knowledge of how to prevent the impacts of typhoons, how to adapt to typhoons, and how to protect themselves against typhoons.

Build a society-wide disaster education system

A society-wide disaster education system should include staff training and primary and secondary education.

External staff training should teach self-protection when a typhoon strikes. Measures would include reserving food and daily necessities, and using common sense to judge the feasibility of evacuation (by equipping oneself with emergency lights, etc.).

For primary and secondary school students, knowledge of disaster prevention should be a part of the curriculum, and students should practice emergency drills. Teaching disaster prevention and self-reliance during a disaster to primary and secondary school students has a knock-on effect – they will influence and educate their family members and the surrounding population, resulting in an improved response to typhoons throughout society.

Implement a specialized training and education network

Specialized typhoon training and education networks are needed primarily for households that are relatively fragile and are heavily dependent on agriculture and fishing.

Agriculture-based households need strengthened training and education in areas such as: fast planting techniques; rapid harvesting; post-disaster recovery related to agricultural production technology; and changing traditional business models in

order to avoid the typhoon season altogether.

Fishermen need to be educated about the following issues:

• As soon as they receive warnings about a typhoon they need to find the nearest safe haven, then they need to anchor their boat and disembark as soon as possible.

• Alternatively they should haul in their catch as quickly as possible and then get back to shore.

• Life is an individual's most important asset but many fishermen put their boat first. Boats can be salvaged, repaired, or bought. Fishermen must be persuaded not to "go down with the boat".

5.2.4 Infrastructure

Infrastructure is a major casualty of typhoon disasters, and loss of infrastructure affects local disaster capacity. Strengthening the construction of infrastructure is conducive to enhancing household resilience to typhoons. An important aspect of strengthening infrastructure is strengthening people's homes.

Strengthen the construction of housing

Part 3.1.1 showed that although the majority of households live in brick and concrete structures (80%), there are a small number of households living in semi-solid brick and wood structures (16%), and some households still live in non-solid structures (6%). The households that live in non-permanent structures should have their homes strengthened. Improved construction is a primary measure that can ensure the safety of households and must also include housing reform and the construction of homes according to official building standards.

Housing reform

The construction of roofs and roof tiles needs to be reinforced or changed. Sloping roof tiles are the part of a house most vulnerable to typhoon-inflicted damage – often a typhoon can rip off all of the roof or can cause tiles to flip off the roof and be blown away.

Construct houses that meet official standards

A house is the most important asset a family has. Improving the strength of housing can effectively reduce household vulnerability to typhoons. Zhejiang Province has developed construction standards for rural residents but because these standards are so high, many households cannot afford to comply with them. The government supports the transformation of old buildings via subsidized loans and multi-family guarantees, which increase financial support, so that housing conforms to building standards.

Relocate housing

As households diversify their revenue structure, a large number would like to relocate but suffer from planning constraints, which force them to live in

typhoon-prone and disaster-prone traditional accommodation. The government should formulate a policy to support households that wish to relocate, so that the people hardest hit by typhoons can be gradually relocated and fewer people have to live in typhoon and flood-prone areas.

Strengthen flood control projects and infrastructure

The study area demonstrates that infrastructure such as urban flood control, seawalls, roads and ditches all need to be strengthened in response to the threat of typhoons. Urban flood control can enhance the capacity of regional defenses against typhoons and can reduce pressure on households in their fight against the impacts of typhoons. Improved seawall construction must include dredged channels, and reinforced levees to cope with river obstacles and to ensure the unimpeded flow of rivers. These measures improve the capabilities of urban defenses against typhoons, particularly in low-lying areas such as Ming Town Creek.

5.2.5 Social capacity

Social capacity is indicated by a number of things, such as: what households do when they run into financial difficulties; how households find assistance when they encounter typhoons or if they look for assistance at all; how frequency households engage in community activities; whether members of a household exchange experiences of natural disasters; and the willingness of a household to join community organizations. The establishment of multiple participation mechanisms and the strengthening of community participation by non-governmental organizations (NGOs) benefits household social capacity.

Mechanisms for the establishment of multi-participation

Zhejiang Province has always focused on multi-stakeholder involvement in disaster relief, but experts should be more aware of, and do a better job of, tapping into multi-stakeholder involvement mechanisms – "government-led, expert guidance, community involvement, victims of self-help" mechanisms. It is mostly the government that is responsible for directing disaster relief policy, decision-making, and technical and advocacy support. Communities are encouraged to participate by making material contributions and by donating time and money to disaster relief and victim self-help groups. Communities are also encouraged to believe in the "one person in difficulty should be helped by all the others" philosophy.

Strengthening the participation of non-governmental organizations

Non-governmental organizations (NGOs) and local communities will be more important in future defense against typhoons. Local NGOs were instrumental in mobilizing communities at risk to evacuate during Typhoon Saomai. There is a need to strengthen NGOs in order to enhance the effectiveness of disaster prevention work.

Figure 18 presents a summary of the ways to improve household ability to adapt to typhoons based on the findings of this research.

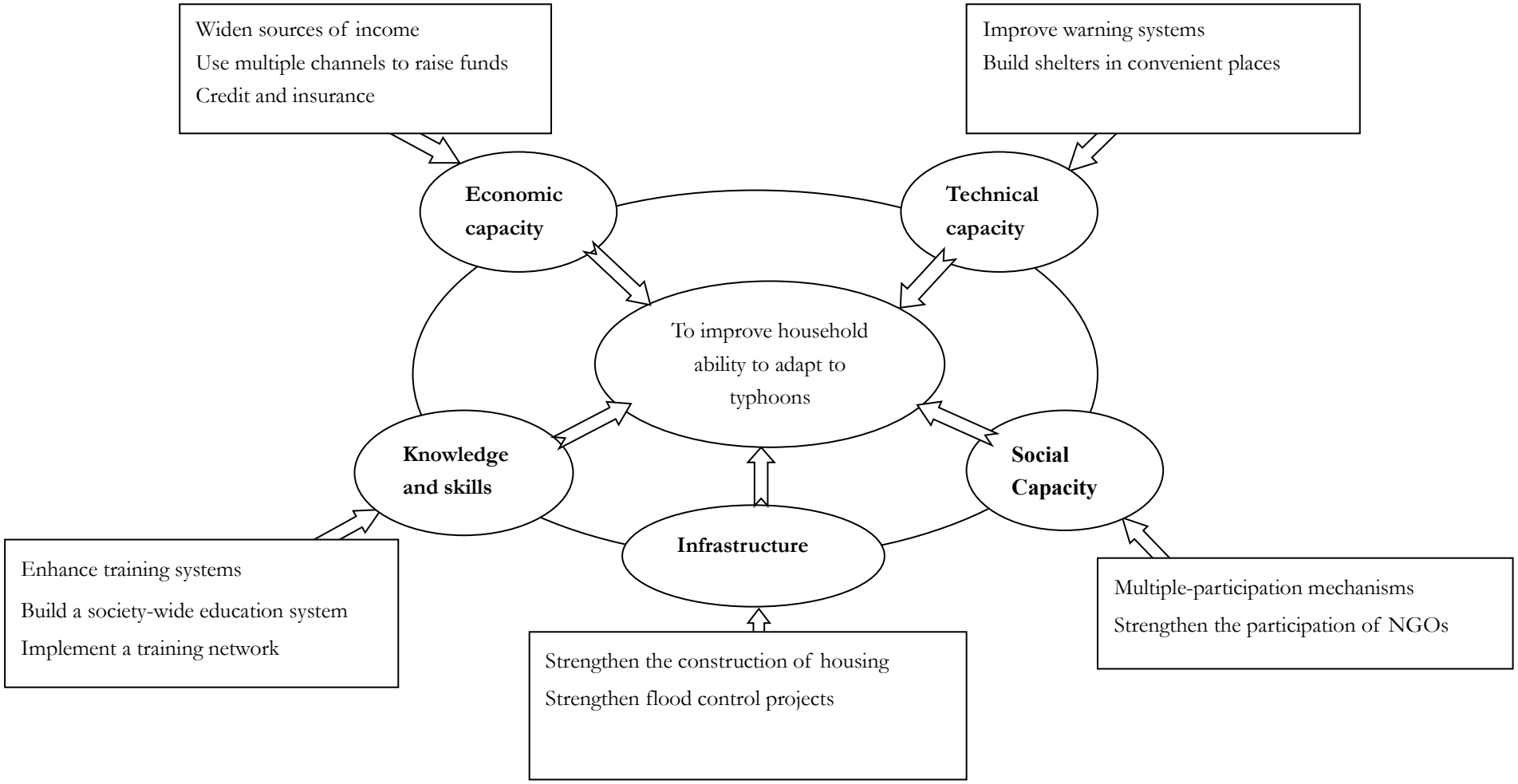

Figure 12: Strategies to improve household ability to adapt to typhoons

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