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Adaptive Capacity of Households and Institutions in Dealing with Floods in Chiang Mai, Thailand

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The study shows that at the institutional level, the flood mitigation plans of the local authorities focused narrowly on structural measures and were carried out sporadically at different jurisdictions while development planning did not take into account flood adaptation and mitigation needs. It also shows that social considerations are just as important as technical ones in the early stages of flood mitigation. At the household level, most past adaptation strategies were autonomous and individual in nature. Households in the rural area, which faced recurrent floods every year, were more prepared for adaptation than households in the urban area. The barriers to adaptation were due to both financial and non-financial constraints like knowing about the floods and perceptions on flood mitigation as government's responsibility. The over-reliance on public flood protection measures may also deter households from taking precautionary action on their own. The study therefore recommends of increasing public awareness and knowledge about flood preparedness among households and institutions involved.

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ADAPTIVE CAPACITY OF HOUSEHOLDS AND INSTITUTIONS IN DEALING WITH FLOODS IN CHIANG MAI, THAILAND

Rawadee Jarungrattanapong and Areeya Manasboonphempool

EXECUTIVE SUMMARY

Climate change is a modern day concern of serious proportions. Reducing vulnerability to climate change impacts may be viewed either in terms of risk reduction or improvement in adaptive capacity, or both. At the community and household levels, lessening the risk of climate change might be impossible in some instances. Therefore, reducing vulnerability can be done only by enhancing the adaptive capacity of the affected households and communities. In Thailand, flooding is a major climate change impact. This study, carried out in Thailand, set out to determine the indicators of adaptive capacity and measure the adaptation gaps between past adaptation measures and alternative adaptation possibilities. Adaptation possibilities were not restricted to new methods of adaptation, but included improvements to previous adaptation actions in terms of level and timing. Chiang Mai Province was chosen as the study area since it had a long history of flooding. Studying how the people adapted to the floods here, regardless of whether they were climate-change induced or not, would provide valuable information on adaptation capacities and strategies of both households and local institutions.

At the institutional level, it was found that the flood mitigation plans of the local authorities focused narrowly on structural measures and were carried out sporadically at different jurisdictions while development planning did not take into account flood adaptation/mitigation needs. This sometimes resulted in negative externalities such as worsening floods in downstream areas. The study also found that social considerations are just as important as technical ones in the early stages of flood mitigation. The flood early warning system in Chiang Mai Province was well-developed and the flood risk map was very useful.

At the household level, most past adaptation strategies were autonomous and individual in nature. Households in the rural area, which faced recurrent floods every year, were more prepared for adaptation than households in the urban area which rarely experienced floods. The latter did not believe the early warnings because they did not think that such big floods would occur in their area. Increasing public awareness and knowledge about flood preparedness was essential. The evidence in both rural and urban sites showed that the poor suffered from the floods more than the rich, for example, flood damage costs accounted for 54.2% of the household income of the poor, but only 9.7% of the rich households in the urban area. Finally, barriers to adaptation possibilities were not confined to financial constraints but also comprised non-financial constraints like knowing about the floods too late to harvest crops or perceptions that flood mitigation was the government's responsibility. The over-reliance on public flood protection measures may also deter households from taking precautionary action on their own.

1.0 INTRODUCTION

1.1 Problem Statement

Chiang Mai Province has a long history of floods from way back in 1956[1] due to the low topography of the Ping River flood plain. Flooding has occurred in increasingly frequency over the years, for example, from 1994-1996; there were five floods in the city of Chiang Mai (ONEP 2006). In 2005, a series of big floods occurred from August to November both in the inner city and a number of rural districts in Chiang Mai Province. Millions of baht in losses resulted. It is widely accepted that the main cause of the 2005 floods was the high volume and long duration of rainfall which caused the Ping River to overflow its banks.

Generally speaking, climate change-related risks can be said to result from direct exposure to natural hazards such as floods and droughts. From the perspective of households, communities and even government institutions, there is no difference in responding to climate change-related or non-climate change-related disasters. Therefore, analyzing the adaptation behavior of households, communities and institutions to a natural disaster such as floods would provide useful empirical data and a valid indication of how the different sectors would adapt to a similar extreme climate change event in the future.

1.2 Research Objectives

The general objective of this study was to determine the adaptive capacities of households, communities and institutions based on their experiences in dealing with extreme flooding. The specific research objectives were:

1. To identify how many households and communities were affected by the 2005 floods.
2. To determine how households, community organizations and government institutions coped with the 2005 floods.
3. To estimate the costs associated with household/community adaptation to the 2005 floods.
4. To determine a set of adaptation possibilities in terms of the options that households, community organizations and government institutions wanted to apply but did not or could not apply due to various barriers or restrictions.
5. To examine what the adaptation gaps of households, community organizations and government institutions were.
6. To determine what kind of assistance households and communities needed from government agencies to cope with floods.
7. To gather lessons from the study and make recommendations to improve adaptive capacities and climate change adaptation strategies.

[1] As recorded by Hydrology and Water Management Center for the Upper Northern Region

1.3 Scope of the Study

The study focused on analyzing the gaps between past adaptation and a set of adaptation possibilities in terms of type, level, and timing of response. We wanted to compare the adaptation behavior and adaptive capacity in urban and rural areas. The Chiang Mai Housing Community (hereinafter called "CMHC") was selected as the urban case study site and the Mae Kong Tai (hereafter "MKT") Village of Mae Ka sub-district represented the rural areas. We also looked at the adaptive capacities of government units and community organizations in relation to floods.

1.4. Research Methodology

1.4.1 The Conceptual Framework

In this study, we defined adaptation to floods in a manner similar to the Intergovernmental Panel on Climate Change i.e., as an adjustment in ecological, social or economic systems in response to observed or expected changes in climate stimuli and their effects and impacts in order to alleviate the adverse impacts of changes or to take advantage of new opportunities (IPCC 2001). The analysis of adaptation capacity of households and communities in this study focused on their adaptation to the 2005 floods in comparison to a set of desired/recommended adaptation possibilities.

The adaptation possibilities included two subsets: (1) adaptation options that were adopted in the past and could be used again in the future, and (2) adaptation options that were new and innovative for use in the future. We sought to determine the adaptation gaps by comparing past adaptation and adaptation possibilities in terms of type, level, and timing (Figure 1). Directly observing both the pattern of adaptation in the past as well as the social and economic constraints is the first step in theorizing the nature of adaptation processes (Adger 2003).

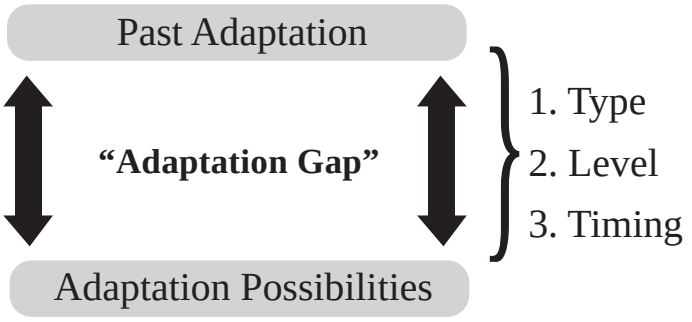

Figure 1. The conceptual framework of the study

1.4.1.2 Steps in the Adaptation Capacity Analysis

Step 1: Impact assessment

To estimate the impacts, households were asked to report the magnitude of economic loss caused by the 2005 floods, for example, property losses and income losses (due to workday losses) for households in the urban area, and production losses in the case of households in agricultural (rural) area.

Step 2: Adaptation assessment

The vulnerability of households to floods is not only dependent on flood risk/exposure, but also on their adaptive capacity. For example, while the whole affected community might be susceptible to floods, those who invested in protective structures were likely to experience lower losses than those without such structures. We took the following measures; we (a) examined the past adaptation strategies of the households in the study sites which we referred to as "past adaptation", and (b) determined a set of adaptation possibilities for households and communities. For our assessment of past adaptation, the main information required was: (a) the availability of adaptation options, and (b) the costs of the adaptation options. For the adaptation possibilities assessment, we needed to determine (a) a set of adaptation possibilities and (b) the adaptation barriers which prevented the households from applying such options.

a) Past adaptation options

   First, past adaptation options were identified. All the options were classified by type. Also, the cost of each adaptation strategy applied by the households was estimated. Households were asked how much they had spent on each of their adaptation options over time.

b) Adaptation possibilities

   Interviews with key informants and focus group discussions with households were arranged in order to gather data to develop a set of possible or appropriate adaptation options. Several adaptation possibilities were drawn up by an expert and proposed to the study households which were asked which they felt were applicable.

Step 3: Adaptation gap assessment

After carrying out the assessment of past adaptation and adaptation possibilities, adaptation gaps were determined in terms of the type, level, and timing of response as explained below.

a) Type of adaptation

   This refers to what new adaptation measures the households would like to adopt, but did not undertake in the past due to specific barriers identified by the households.

b) Level of adaptation

   Sometimes, the type of adaptation may have been appropriate but the level of adoption may not have been adequate, so the impact of floods were only offset partially.

c) Timing of adaptation

   Even though the level of adaptation may have been adequate, the timing of adaptation is significant as action may have been taken too early or too late. The result of such errors may have resulted in additional costs (Hanemann 2008). The obstacles to timely adaptation include a lack of perception of the need to act or of a benefit from the action (Hanemann 2008).

1.4.2 Data Collection

Data for the study was collected through site visits; key informant interviews (KIIs), focus group discussions (FGDs), a literature review, and a field survey. We began with key informant interviews with national and local government officers involved in flood management and academics. The purpose of the interviews was to determine the scope of adaptation options that had been undertaken and a set of adaptation possibilities for the study areas. Focus group discussions were also arranged in both study areas to find out how households had dealt with the 2005 floods namely, what kind of adaptation options they had undertaken.

At the local government unit (LGU) level, we determined a set of proposed adaptation options by interviewing engineering experts, researchers and relevant government agencies working on flood mitigation. Interviews with community leaders of both study areas were arranged to gather information related to past adaptation as well as proposed adaptation options at the community level. The authorities of Chiang Mai City Municipality and the Sub-district Administration Organization of Mae Ka were interviewed to determine what measures they had undertaken for flood prevention and alleviation. Besides these two main organizations, relevant government units and community organizations were also interviewed to obtain a holistic assessment of the capacity of the LGUs and communities to adapt to floods.

Our sample in Thailand was taken from households which had been affected by the 2005 floods in the study areas. A sample of 108 households in MKT and 200 households in CMHC or 308 samples in total were randomly selected. The survey was conducted in August 2009. Two Geographic Information System (GIS) technicians joined the enumerators to collect geographical data in the study sites.

2.0 THE STUDY SITES

The location of the two study sites in Chiang Mai Province is shown in Figure 2. The Chiang Mai Housing Community (CMHC) is under the administration of the Chiang Mai City Municipality (hereinafter called the “Municipality”). The other study site was the agricultural Mae Kong Tai (MKT) Village of Mae Ka Sub-district, San Patong District. There were three reasons for choosing CMHC and MKT as the study areas. Firstly, both study sites were located in the area that suffered the impacts of the 2005 floods for relatively longer periods than other places due to its low topography and the construction of infrastructure that had become barriers preventing the floodwaters from draining away. The second reason was the socio-economic factor whereby the populations in both study sites had relatively low incomes and thus, were likely to be more vulnerable to floods. Lastly, comparing the adaptive capacities of urban and rural areas in dealing with floods would provide valuable insights into the significance of different economic and social factors in understanding adaptation behavior and adaptive capacity.

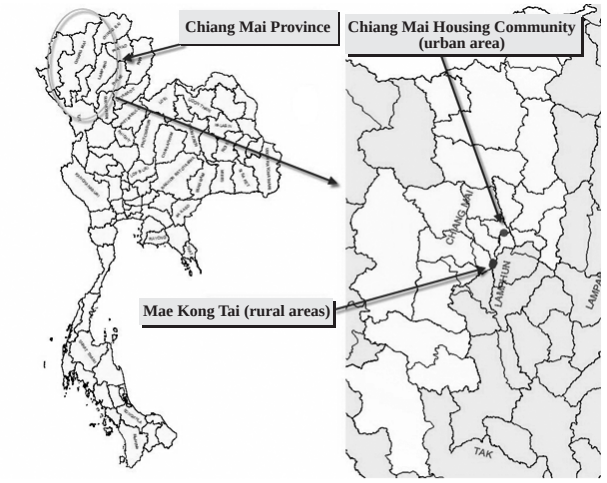

Figure 2. The two study areas in Chiang Mai Province

2.1 Urban Study Site: Chiang Mai Housing Community (CMHC)

CMHC is located in the Kawila sub-district, one of the four districts under the Municipality's jurisdiction. The total population of CMHC is 2,000, spread out among 438 households. The study site is a residential area where most of the populations are wage workers and small-scale business entrepreneurs. The floods of 2005 affected the residents in this area for approximately 3-7 days, depending on the topography of the area. A major impact was damage to property (houses, electrical appliances, etc.). In addition, some households, especially the small-scale retailers, also suffered income losses as they could not do business during the floods. According to the CMHC leader, some households had since moved to other areas to escape the flooding problem.

The Municipality is in charge of disaster management in the area including taking precautionary measures and alleviating any adverse impacts. Generally when floods or other disasters occur, the role of the community leader is to report the impact to the Municipality in order to obtain assistance and relief.

2.2 Rural Study Site: Mae Kong Tai Village (MKT)

MKT is a village of Mae Ka sub-district located to the south of Chiang Mai City. It is a lowland area located along the Ping River and is more affected by annual flooding compared to other villages in the same sub-district. The total area of MKT is 2.5 km^2 with 186 households and a population of 486. The major economic activity is agriculture in which *longan* plantations are the main source of income. Farmers also plant rice, chili, soybean and various kinds of vegetables, which have shorter rotation periods and can generate income all through the year and help supplement the income from *longan*, which can be harvested only once a year.

MKT experiences floods every year, usually from August to September. It is low land, located downstream of the Ping River so the floodwaters from the city drain down to it. The 2005 floods affected the village seriously over a period of about one month. The agricultural areas suffered more damage than the houses because of the lower level of the farms. The Sub-district Administration Organization (SAO) of Mae Ka is responsible for flood management in this area. Flood management and assistance measures are basically similar to those provided by the Municipality of Chiang Mai City.

2.3 The 2005 Floods in Chiang Mai Province

2.3.1 Topography of Chiang Mai Province

We describe the topographical characteristics of Chiang Mai Province first in order to explain why Chiang Mai Province is prone to floods. The province is located in the north of Thailand at 310 meters (1,027 feet) above sea level covering an area of 20,107 square kilometers (2,010,700 hectares). Chiang Mai Province is located in the Ping watershed and the city of Chiang Mai is literally surrounded by mountains.

The Ping watershed comprises four main rivers: 1) the Upper Ping River; 2) the Mae Ngad River, across which the Royal Irrigation Department constructed the Mae Ngad Dam in 1985 to alleviate floods; 3) the Mae Tang River; and 4) the Mae Rim River (Figure 5). The Upper Ping and Mae Ngad converge to form the Ping River into which the other two rivers flow. The Ping River flows through the center of Chiang Mai Province and is its lifeline, being the largest and most important river in the northern region. The floods in Chiang Mai Province are generally caused by tropical cyclones, storms/depressions and intense rainfall due to the southwest and northeast monsoons (Garden 2007). When it rains in the upstream area, the volume of water in the Ping naturally increases. If the rate of the river exceeds 460 cubic meters per second at hydrological monitoring station P.1 (Nawarat Bridge in Chiang Mai City), the city will be flooded. During the 2005 floods, the rate of the Ping rose to 1,300 cubic meters per second, more than three times the river's carrying capacity.

2.3.2 Causes of the 2005 Floods

The Royal Irrigation Department (RID) reported that there were three main factors that caused the big floods of 2005 in Chiang Mai Province. Heavy rain at the Upper Ping area was the most important factor, exacerbated by the deforestation in northern Thailand to make way for tangerine plantations (Garden 2007). Secondly, encroachment of the Ping River by local residents as well as public agencies by way of housing, restaurants and government offices was another key factor. The encroachment made the river very narrow in some places, creating bottlenecks. The third factor was the construction of elevated roads and landfills for housing estates which disrupted the natural drainage system (Manuta et al. 2006). Chiang Mai City was flooded five times between August and November 2005. These were the most severe floods in the province in four decades.

The first episode of floods in 2005 began when it rained intensely in the upstream areas of the Upper Ping and Mae Tang rivers on the eve of the Queen's birthday, a national holiday on the 12th of August. After almost 24 hours of continuous rain, the Ping River began to overflow in Chiang Mai City. The Hydrology and Water Management Center (HWMC) of the RID was in charge of the early warning system and disseminated warnings to the Chiang Mai Municipality and other local governments which in turn sent out alerts to the public. However, no one believed the warnings of the first flood (Garden 2007) or rather, they did not believe that the flood would be as severe as it turned out to be.

The second flood began on 9th September with heavy rain. Warnings were sent out again. This time, people believed the warnings and prepared for the flood, so the damage was less. The third episode was different. Unlike the previous floods, the water did not overflow the banks of the Ping River. Instead it rushed down the mountain sides to the west of the city, overwhelming drains and flowing down roads and even across bridges. This is why the RID's water monitoring station could not measure the water level before the water reached the city. In the fourth flood, Chiang Mai City was warned well in advance and prepared better for the floods. The commercial business area was protected, but conflicts erupted among households downstream. People were tearing down sandbag banks while others struggled to keep them intact (Garden 2007).

2.3.3 Damage Caused by the 2005 Floods

2.3.3.1 CMHC

(a) Damage to housing and infrastructure

The 2005 floods caused substantial damage to housing and infrastructure. According to official estimates, 2,176 houses were either damaged or destroyed. In addition, the floods wrecked 179 roads and 87 bridges in the whole province (Garden 2007). According to the report from the Chiang Mai Office of Disaster Prevention and Mitigation (DDPM), in the case of CMHC, total damage to housing and property due to the 2005 floods cost approximately 10 million THB (about USD 250,000[2]). The number of houses damaged was 488, affecting 1,433 persons (see Table 1).

Table 1. Damage to housing in CMHC due to the 2005 floods

Type of damage	Number of households affected	Value (THB)
Damage to some parts of the house	378	3,546,900 (USD 88,078)
Kitchenware	279	1,365,500 (USD 33,909)
Bedding (mattresses, etc.)	374	1,125,100 (USD 27,939)
Utensils for work/business	96	811,200 (USD 20,144)
Other property	254	3,405,136 (USD 84,558)
Total	488	10,253,836 (USD 254,627)

Source: Department of Disaster Prevention and Mitigation, Chiang Mai Office (2005)
Note: One household may have had more than one type of damage.

(b) Health impacts

The floods also affected both the physical and mental health of the people. The Public Health Office in Chiang Mai reported that for the whole flooded area in Chiang Mai, nearly 8,000 people were treated for ailments linked to the floods. The most common diseases were skin infections and athlete's foot which accounted for 50% and 20% of all the cases, respectively.

2 USD 1= THB 40.27 (average exchange rate of 2005). Source: Bank of Thailand

2.3.3.2 MKT

For MKT, the damage to housing and infrastructure was not as bad as in the urban area, but the impacts on agriculture were adverse. According to the SAO of Mae Ka, there was no recorded damage to housing and only one bridge was reported damaged. However, the recurrent floods caused great damage to agricultural fields, especially to vegetable farms. Based on the data from the Department of Agricultural Extension, the total farmland that was damaged by the 2005 floods was approximately 40 hectares which accounted for 16% of the total land area. It should be noted that this figure may be underestimated. Our focused group discussions revealed that almost all the farmland in MKT had been damaged by the floods (which would be more than 40 hectares). This reflects that many households did not claim damages from the relevant government agencies.

3.0 INSTITUTIONAL ADAPTATION TO THE 2005 FLOODS

3.1 Key Institutions in the Study Areas

In order to understand the adaptive capacity of local government units in relation to floods, it was necessary to list all the agencies that were involved in the 2005 floods. We first looked at the adaptive capacity of relevant organizations which was represented by a set of indicators that was expected to influence the adaptation behavior of local government agencies and community organizations. Overall, the role and responsibilities of the respective agencies could be categorized into two main areas: 1) flood control and mitigation and 2) relief and compensation.

Among the agencies, there were four that played a key role in responding to the 2005 floods. The first two agencies were the Hydrology and Water Management Center (HWMC) for the Upper Northern Region and the Department of Disaster Prevention and Mitigation (DDPM), both national agencies with direct responsibility for flood and disaster control and mitigation. The HWMC is under the Royal Irrigation Department (RID) which works on water management namely through irrigation and flood control. The DDPM is under the Ministry of Interior which coordinates disaster prevention and mitigation measures among the different agencies and provides relief to victims during disasters.

The other two key agencies were the administrative bodies at the local level in our study sites, the Chiang Mai City Municipality (Municipality) and the Sub-district Administration Organization (SAO) of Mae Ka. Both organizations have the responsibility to mitigate floods in their areas of jurisdiction and also provide relief to residents. Besides these key agencies, there were a number of others that played a part in flood management, especially in the provision of relief and compensation to communities affected by the floods. The number of staff in the various flood-related agencies is given in Appendix 1.

3.2 Provision of Relief/Compensation during the 2005 Floods

Table 2 summarizes the forms of local government assistance provided in the two study areas in respect of the 2005 floods. There were several organizations that provided assistance to affected residents in the Chiang Mai municipality area. In the case of CMHC, the Municipality was the main organization to provide aid to its residents during and after the 2005 floods since it had large financial resources at its disposal. During the floods, the Municipality, the Chiang Mai Provincial Administration Organization as well as the Chiang Mai Provincial Office of Disaster Prevention and Mitigation delivered necessity bags[3], food (lunch boxes) and drinking water to the affected residents. Also, the Municipality distributed sandbags and sand and the Public Health Office provided medicine and medical treatment for flood victims.

Table 2. Summary of governmental assistance given in the study sites in 2005

Organization	Form of assistance	Expenditure (USD)
Chiang Mai City Municipality	1. sandbags 2. necessity bags 3. food and drinking water 4. water pumping machines	No information available
Chiang Mai Provincial Administration Organization	1. sandbags 2. necessity bags 3. food and drinking water	239,918
Chiang Mai Provincial Public Health Office	1. medicine and medical supplies 2. medical treatment 3. chlorine (for water purification) 4. necessity bags 5. drinking water	14,793 (only for medicine and other medical supplies)
Chiang Mai Provincial Office of Disaster Prevention and Mitigation	1. necessity bags 2. materials for house repair	No information available
Sub-district Administration Organization of Mae Ka	1. sandbags 2. necessity bags 3. food and drinking water 4. medical supplies	No information available
District Office of Agricultural Extension	1. vegetable seeds 2. compensation for agricultural losses	2,071 (as compensation)

Sources:
(1) Interviews with Chiang Mai City Municipality staff on March 26, 2009
(2) Budget and financial report for 2005, Chiang Mai Provincial Administration Organization
(3) Report on assistance given during the 2005 floods, Chiang Mai Provincial Public Health Office
(4) Flood Prevention and Mitigation Plan for Chiang Mai City, Regional Irrigation Office 1, Chiang Mai Province.

3 A necessity bag contained basic necessities for a flood victim such as soap, a toothbrush, toothpaste, candles, a lighter, slippers, a T-shirt, etc.

It was more or less the same scenario in terms of relief in the rural areas. During the floods, food, drinking water and other basic necessities were delivered to the affected villagers. To help villagers recover from agricultural loss after the flood, the District Office of Agricultural Extension distributed vegetable seeds and *longan* seedlings to affected farmers. In addition, they could also claim for compensation for agricultural losses. However, the compensation rate was inadequate to truly help the affected farmers since the calculation was based on the costs of production not on the value of actual losses in agricultural production.

3.3 Adaptation of Government and Community Organizations to the 2005 Floods

This section will discuss the adaptive responses of the various government units and community organizations in response to the 2005 floods. The adaptation strategies are divided into three categories according to level: 1) national government; 2) local government; and 3) communities. For the national and local government levels, the information was obtained from key informant interviews and secondary sources. Meanwhile, the information regarding adaptation behavior of the communities was obtained through focus group discussions and interviews with community heads.

3.3.1 National Government Level

The organization at the national government level that plays a key role in adaptation to floods in Chiang Mai Province is the Hydrology and Water Management Center (HWMC) for the Upper Northern Region, under the Royal Irrigation Department (RID). There were two main strategies that the HWMC undertook to deal with the 2005 floods in Chiang Mai Province.

a) Water resource management in the upstream area

As mentioned earlier in Section 2, the source of the floodwaters in 2005 came mainly from four upstream rivers which flowed into the Ping River. In 1985, the Mae Ngad Dam was constructed by the RID which claimed that the dam had a maximum holding capacity of approximately 30% of the entire volume of water that would flow into the city. The HWMC is in charge of managing the Mae Ngad Dam in order to mitigate the impacts of floods in the city. However, since this dam is also used for irrigation purposes, the authorities have to find a balance between reserving enough water for irrigation and keeping the level low enough to allow for the extra volume during the rainy season so as to avoid flooding.

The problem is that there is still no technology available for forecasting rain well enough in advance to enable the authorities to adjust the level of water in the dam in time to avoid floods. So they have to rely on their own judgment and thus, there is always the risk of miscalculation.

b) Flood warnings

Another important role of the HWMC is the establishment of the flood warning system. The flood warning system comprises several components and activities as described below.

• *Flood risk map*

The HWMC first created a flood map of Chiang Mai City in 1991. Figure 3 is the flood map that displays the severity of floods, illustrated by different colors, with respect to the water level of the Ping River. For instance, the bright orange area (area number 1) shows that there will be floods if the water level at the hydrological monitoring station P.1 exceeds 3.7 meters. This map indicates the level of risk of flooding in the different areas, where lower numbers indicate higher risks. This flood map has been used by the Municipality to implement flood preparation/protection measures as well as to decide where to provide assistance first. It has also been disseminated to residents to raise their awareness about their exposure to floods.

• *Early warning system*

With the current technology available, the HWMC can predict a flood before it hits the city about seven hours before time. When the hydrological monitoring stations show that the river level has exceeded the critical limit, the HWMC will contact the Municipality and other relevant government units to inform the residents to prepare for the flood.

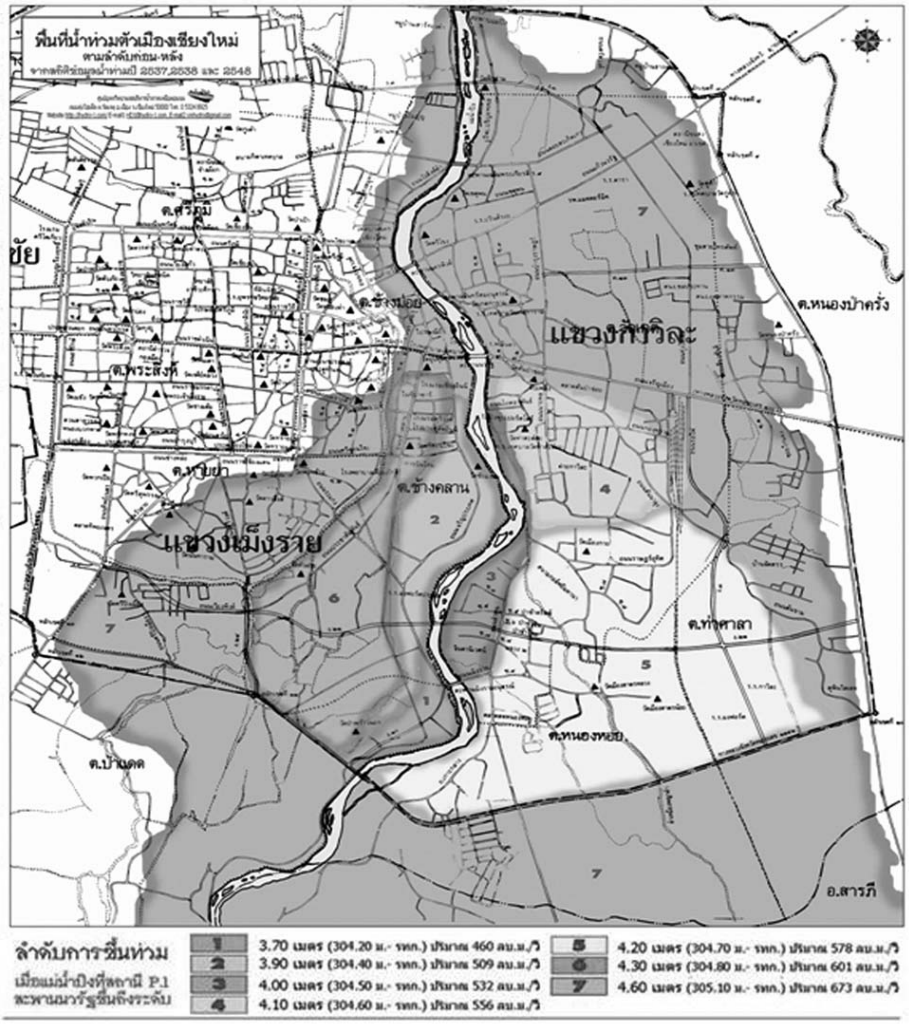

Figure 3. Flood map of Chiang Mai City
Source: Royal Irrigation Department (2008)

• *Flood information dissemination*

The real-time water level data is measured at the hydrological monitoring stations. Also other information related to impending floods is regularly uploaded onto the website (www.hydro-1.net) for public access. In addition, during the flood season, a call center is set up for inquiries about the flood situation. Flood warning information is also disseminated in the form of brochures in Thai and English and via flood information boards located near the Ping River. In addition, the HWMC regularly conducts training on basic knowledge of floods and early warning systems to various sectors of the public like students, government officers, and academics.

3.3.2 Local Government Level

3.3.2.1 Chiang Mai City Municipality

The adaptation measures of the Municipality can be divided into three categories: a) flood mitigation options, b) early warnings and c) assistance/relief to affected residents.

a) Flood mitigation measures

The main objective is how to ensure the floodwaters flow out of the city as quickly as possible and generally, four measures are undertaken.

i. Dredging the drainage system

   Dredging and cleaning up the drainage system is a task that the Municipality undertakes before the rainy season every year.

ii. Setting up mobile dikes

   Before a flood, the Municipality sets up mobile dikes to block the floodwaters from entering certain areas.

iii. Pumping out the floodwaters

   During floods, water pumping machines (provided by RID) are set up in several areas in order to drain the water from residential areas and divert it to rivers or canals.

iv. Expanding the Ping River waterway

   As mentioned earlier, it is widely acknowledged that the encroachment of the Ping River was one of the main factors that caused the floods in 2005. To deal with this problem, the Municipality began the Ping River expansion project after the 2005 floods. The project aimed to bring the Ping River back to the state it was in 1969 when the river was wider so that the water would flow through the city faster. This project will allow the river level to rise to a maximum of 4.2 meters. However, the scope of this project is only for the part of the Ping River which is under the jurisdiction of the Municipality, which is equal to a distance of six kilometers. This means that neighboring areas outside the Municipality's jurisdiction may suffer adverse impacts (negative externalities) from the project such as increased flooding.

b) Early warnings

Prior to the 2005 floods, the Municipality set up a flood early warning system which involved the various media channels such as the local cable network, community radios, and broadcasting cars as well as conducting meetings with all community leaders. The flood alarm for Chiang Mai City was triggered by water level readings at two hydrological monitoring stations, one located upstream from Chiang Mai Province (station P.67) and another (station P.1) at the Nawarat Bridge in the municipality area. In practice, if the level at the stations reaches the critical point, Chiang Mai has seven to eight hours before the Ping overflows its banks. During the 2005 floods, the HWMC was in charge of the early warning system and it contacted the Municipality and other local governments to sound the alarms.

3.3.2.2 Sub-district Administration Organization (SAO) of Mae Ka

The measures that the SAO undertook in the past and still undertakes to deal with floods are basically similar to those of the Municipality.

a) Flood mitigation strategies

i. Dredging the canals and drainage ways

   The SAO has undertaken this option regularly in the dry season. Apart from the flood mitigation purpose, this measure also helps channel the water to the farms more effectively.

ii. Sandbag dikes

   Before a flood occurs, the SAO will build temporary dikes using sandbags and eucalyptus logs to safeguard the area where the water is expected to overflow.

iii. Pumping out the floodwaters

   During floods, water pumping machines are installed to drain the floodwaters from residential areas and divert the water to rivers and canals.

b) Early warning dissemination

Before the 2005 floods hit, the SAO issued early warnings through local broadcasting speakers as well as via meetings with all the village headmen.

3.3.3 Community Level

At the community level, there was only one community/village committee in each of the study sites. These committees had an important role in response to the floods in 2005. The nature of community adaptation in both study sites followed a similar pattern in which the community committees contributed manpower to carry out adaptation strategies initiated by the local government agencies. The details of community adaptation for each study site are as follows.

3.3.3.1 CMHC

a) Contribution of labor force to build sandbag dikes

Before the floods, the community had helped to fill and pile up sandbags to block the floodwaters from entering the community area. The materials were provided by the Municipality.

b) Contribution of labor force to dredge the drains in the community

The community also helped to clean up the drainage system in the community during and after the floods since the Municipality had not enough manpower to do the task.

3.3.3.2 MKT

a) Contribution of labor force to build sandbag dikes

Before the flood, the community had helped to fill and pile up sandbags to block the floodwaters from entering the community area. The materials were provided by the SAO.

Collective action after the floods

It is widely believed that the irrigation weir, constructed by RID in 2005, was the main factor that caused severe floods that year. It is claimed that the height of this weir was too high and blocked much of the water from flowing downstream. After the floods, the community collectively filed a petition to the RID to lower the height of the weir and the RID conceded to their request.

3.3.4 Other Organizations

After the 2005 floods, the Faculty of Engineering in Chiang Mai University initiated the installation of flood poles to show the expected flood level based on the river level at station P.1. The residents of a flood risk area have to keep monitoring the river level as measured at station P.1. Once they know this, they can predict the flood level where the flood pole is located. Knowing this, they can prepare for floods more effectively. At the time of the study, there were 130 poles in all the flood zones in the flood map.

3.4 Adaptive Capacity of Government Units

We examined the institutional capacity of the four key players that took part in responding to the 2005 floods. The key informant interview method was employed to investigate the flood/disaster management capacity of each organization. We focused on four aspects: 1) institutions and governance; 2) risk assessment, monitoring and warning; 3) knowledge, education and information; and 4) climate change adaptation technology.

3.4.1 Institutions and Governance

For this aspect, we assessed the level of priority of adaptation to floods at the local level. We found that the Municipality had set a higher priority on adaptation to floods/disasters compared to the SAO in terms of the availability of disaster-related division staff, relevant programs and the well-trained or highly-skilled human resources. Flood responses of the Municipality and SAO tended to emphasize relief and assistance. There was only one flood mitigation dredging project in Chiang Mai City while no flood mitigation measures had been planned for the rural area.

For the HWMC and DDPM, adaptation to floods is their main responsibility. The HWMC, however, focused only on water monitoring and early warning systems. The main duties of the DDPM consist of formulating policy for disaster management; research on disaster prevention, maintaining early warning systems; building public awareness of and preparedness in disaster prevention; providing assistance to disaster victims and rehabilitating devastated areas; and coordinating assistance action among flood-related organizations (DDPM 2006). Although the DDPM is the main government agency for disaster mitigation, its staff reported that during 2005 floods in Chiang Mai, it merely acted as coordinator. It did not have its own budget for emergency flood response and needed to wait for provincial calamity funds which could be released only upon announcement of a disaster. However, the DDPM initiated a Community-Based Disaster Risk Management (CBDRM) project in 2004 (DDPM 2008) and there were a few pilot projects in 2005, but these did not cover our study areas.

3.4.2 Risk Assessment, Monitoring and Warnings

The indicator regarding risk assessment and monitoring was assessed by the extent of progress in monitoring flood/disaster risks and providing information to local communities. Both study sites possessed a mechanism that allowed the participation of vulnerable groups in the flood/disaster response process through meetings with all the headmen as representatives of the communities. The headmen used these meetings to report the extent of damage and the needs of the communities to the local government agencies.

Both the Municipality and SAO consider topographical factors as an indicator of vulnerability; higher land means less vulnerability. Flood-risk information and early warning dissemination were in place in both areas, although the rural area still lacked flood maps and flood monitoring systems due to the lack of financial and human resources. The HWMC is responsible for the provision of early warning information, including water and rainfall levels. Both the DDPM and Municipality had implemented a 24-hour monitoring system to record water levels on the HWMC's website during the floods.

3.4.3 Knowledge, Education and Information

The dimension of knowledge, education and information measures the effectiveness of the respective government agencies in disseminating information to and educating key stakeholders to ensure that they are well-informed about flood/disaster risks and how to deal with them. Although there was a reasonable level of flood warnings issued and monitoring carried out, the local government units in both the urban and rural areas tended to pay less attention to educating the general public on how to protect themselves and their property from floods or other disasters. Even though the Municipality had implemented community training programs on flood preparedness, this training was provided only to the community committees. However, the DDPM has been working on several activities to raise public awareness on disaster preparedness such as evacuation drills and training on disaster preparedness to representatives in each village.

3.4.4 Climate Change Adaptation Technology

This final facet refers to the availability of technology and infrastructure facilities to adapt to floods or climate-induced disasters in the future. Media and other facilities to support flood warning systems were available in both the urban and rural areas with flood-related information supplied by the HWMC. The necessary infrastructure was thus in place for flood protection in both study site.

3.5 Adaptive Capacity of Community Organizations

Next, we measured the institutional capacity of relevant community organizations in our study sites to adapt to floods. The Community Committee of CMHC and the Village Committee of MKT were the key organizations that were involved in adaptation to the 2005 floods. We considered five aspects of the institutional capacity of community organizations: 1) economic resources; 2) institutions and networking; 3) knowledge and skills; 4) technology; and 5) infrastructure.

For the economic resources indicator, neither of the committees in the study sites had a regular fund to manage their organizations. Generally, the committees mobilized funds on an ad-hoc basis, i.e. when they planned to carry out a certain activity. The sources of funds were usually the administrative bodies (Municipality or SAO) or money from various donors, especially local politicians. Financial support could also be obtained from the national government, such as via the SML (Small-Medium-Large) Fund, but the money could only be used for economic and social development reasons, not for community flood/disaster preparedness.

The institutions and networks indicator revealed that the organizations regularly provided a forum for members to discuss the problems or circumstances in the respective communities. There appeared to be a close linkage between the community/village committee and the local government agencies, especially in the rural area where the head of the village committee was also a staff member of the local administrative body.

The knowledge and skills indicator reflected some limitations in flood/disaster preparedness of both organizations. There were also constraints in terms of the technology and infrastructure aspects, especially the lack of transportation facilities and evacuation centers to deal with severe climate events.

3.6 Institutional Adaptation Gaps

Thus far, we have examined the adaptation measures/capacity of relevant organizations. Now we turn to find the gaps in adaptation by looking at “proposed adaptation” or “adaptation possibilities”. As mentioned earlier, adaptation possibilities are defined as options that government agencies wanted to undertake but did not or could not undertake due to certain barriers. A set of adaptation possibilities can be classified according to level as follows: national government level, local government level and community level.

3.6.1 National Government Level (Royal Irrigation Department)

Several measures have been proposed by the RID which can be categorized as short-term, medium-term and long-term options (Table 3). It is important to note that all these measures complement one other with each option having its own function. Nevertheless, each measure has its own pros, cons, and barriers which are described below.

Table 3. Proposed measures to mitigate floods in Chiang Mai City

Measures	Type of adaptation	Project period	Estimated cost (million THB)
1. Forest rehabilitation	Others	Short-term	112.4 (USD 2.8 million)
2. Early warning system improvement	Technology	Short-term	109 (USD 2.7 million)
3. Reducing the water flow in the Ping River and/or increasing the speed of water flow in it	Structural	Short-term	368 (USD 9.1 million)
- Dredging the river			
- Constructing more retention ponds			
- Building more reservoirs		Long-term	12,678 (USD 314.8 million)
- Building diversion tunnels			
4. Drainage system improvement	Structural	Short-term	1,446 (USD 35.9 million)
- Building new water gates			
- Diverting water flow away from the Ping			
- Dredging the river to lower the river bed		Long-term	280 (USD 7 million)
5. Building river revetments along the Ping River	Structural	Short-term	1,568 (USD 38.9 million)
6. Reducing/preventing river encroachment by negotiations between the encroachers and authorities	Others	Short-term	Regular budget of MD and DOL
Total budget	**16,561 (USD 411.2 million)**		

Source: RID (2008)
Notes: (1) MD = Marine Department; DOL = Department of Lands
(2) US$ 1 = THB 40.27

a) Forest rehabilitation at the head of the watershed

This involves reforestation at the head of the watershed area and weir construction to slow down the flow of water into the city. The Department of National Parks, Wildlife and Plant Conservation (DNP) is in charge of this project. From interviews with DNP staff, we found out that the project had been implemented only in some parts of the targeted area because of budget limitations.

b) Early warning system improvement

This includes: (i) increasing the number of rainfall measurement stations and installing a telemeter system which can provide accurate rainfall statistics in the upper Ping River watershed and along the Ping River; and (ii) improving the communication system of the Meteorological Department in reaching out to local government agencies and households. According to an interview with the Director of the HWMC[4], this measure has not been implemented yet because of budget limitations.

c) Reducing the water flow in the Ping River

This includes: (i) constructing more retention ponds, (ii) building more reservoirs, and (iii) building diversion tunnels. These measures can reduce the volume of water that flows through the city of Chiang Mai. However, people in the Upper Ping River watershed, which is the chosen area for the construction of retention ponds, are against this project since their houses and farms might get flooded and they do not want to relocate to other areas. In addition, the affected people will not get any benefit from the project. The option to use agricultural land for the storage of floodwaters would require "proper compensation schemes" to be in place first (Lebel and Sinh 2007).

d) Drainage system improvement

This involves: (i) replacement of the traditional weirs to modern dams with water gates, (ii) diverting the water flow, and (iii) dredging the river to lower the river bed. The option of changing traditional weirs into modern dams with water gates is highly controversial. Several groups of farmers have opposed the replacement of their traditional weirs because they doubt that the dams will function well and there are concerns about the community losing its power to manage the water system if the modern dams are built. In addition, academic groups are concerned about the issue of state intrusion into community-managed water diversion systems and the cultural legacy of the northern people (Garden 2007).

Disaster risk reduction often means risk redistribution. Diverting water flow to the neighboring areas of the city is another proposed measure to protect Chiang Mai City. This was what was done before to protect the central business district in Bangkok resulting in flooding of the surrounding suburbs and districts (Lebel and Sinh 2007).

Even though dredging the river to lower the river bed can help the water flow faster, it can negatively impact the ecosystem of the river, for example, it can affect the movement of sediments in the river and contribute to channel instability. Moreover, flora and fauna habitats along the river banks can be destroyed; and if dredging is carried out when there are low water levels in the dry season, it will cause the groundwater table to be lowered (Jompakdee 2003). Furthermore, dredging of the river would be an effective strategy only if it is done every year, but the related government agencies often face budget constraints in undertaking this. Some quarters feel that this strategy is implemented more for psychological effect since people feel better when they think that the government is doing something, even if the action is not an appropriate strategy for long-term flood mitigation.

[4] Personal communication with Mr. Thada Sukkapunphan, Director of HWMC, on April 27, 2009.

e) Building bank revetments along the Ping River

Bank revetments are usually built as concrete structures to prevent bank erosion and flooding. However, building revetments could damage and degrade the landscape of the Ping River and destroy the in-stream habitats of natural flora and fauna (Jompakdee 2003). There is an example of an unsuccessful concrete bank revetment built along the river in Sukothai Province. The officials had used the highest water level reading of 1.8 meters to design the height of the river revetment, but they did not realize that the revetment made the width of the river narrower so much so the water level rose to higher than 1.8 meters. Therefore, the revetment cannot prevent flooding and the government has to increase the height of the revetment again. Some local academics, civil society organizations, and NGOs do not think that this option would be an appropriate strategy. They argue that no one knows what the highest water level will be and that the government is relying on past statistics, but these are no guarantee of future maximum water levels.

f) Reducing/Preventing river encroachment by negotiating with the encroachers

The Chiang Mai Municipality has tried to solve the problem of encroachment of the Ping River. However, some encroachers from both the private and public sectors have not cooperated with the Municipality. The plan is to use negotiation first, and if this does not work, then to resort to legal action. Due to budget limitations, the Municipality has succeeded in getting the encroachers to retreat inland over six kilometers of the Ping (based on the length of the river under the Municipality's jurisdiction). However, the recommendation by experts is that this should be done for 20 kilometers[5].

3.6.2 Local Government Level

a) Chiang Mai City Municipality

Our study revealed that the adaptation possibilities for floods were beyond the Municipality's authority to implement. The measures proposed by the Municipality were basically similar to those proposed by the RID. They are:

i. Building more reservoirs to hold rain water in order to reduce the water flow into the city

ii. Replacing traditional weirs with modern dams with water gates

iii. Asking for farmers' cooperation to plant more trees in headwater areas to slow down the rate of water flow to downstream areas

b) Sub-district Administration Organization of Mae Ka

Diverting water flow is the adaptation option that the SAO officials said they would like to implement. However, no headmen of nearby SAOs agreed with this proposal as they were afraid that it would result in transferring floodwaters to their areas.

3.6.3 Community Level

The community leaders from both study areas also realized that their proposed adaptation options were beyond their authority to implement. The community leader of CMHC felt that the appropriate measure to undertake would be to build bank revetments along the Ping River whereas the leader of MKT wanted to divert the water flow to other areas. Table 4 provides a summary of the pro, cons and barriers related to the adaptation possibilities of the key institutions at national, local and community levels.

[5] Reducing/preventing river encroachment was part and parcel of the project to expand the Ping River.

Table 4. Pros, cons, and barriers related to flood adaptation possibilities for institutions

Measures	Pros	Cons	Barriers
National Government Level			
Forest rehabilitation	Helps to retain water and reduce water flow into the city	-	Lack of funds
Early warning system improvement	Greater accuracy in flood forecasting	-	Lack of funds
Constructing more retention pondsin	Reduces water flow into the city	Residents in/near the project site have to relocate to other areas and nearly all retention pond areas will be flooded	Residents in/near the project site are against this project as they will be negatively affected
Building more reservoirs		Residents in/near the project site have to relocate to other areas	Residents in headwater areas in the upper Ping watershed are against this project as they will be negatively affected
Building diversion tunnels			
Replacing traditional weirs with modern dams with water gates	Helps water to flow faster, so floods will be less severe	There is no guarantee that water distribution will be the same as using the traditional weirs	Local people, academics and NGOs do not want the RID to destroy the traditional weirs
Diverting the water away from the city		Surrounding suburbs of the city will be flooded	-
Dredging the river to lower the bed		- It will affect the sediment movement of the river and contributes to channel instability - It will destroy flora and fauna habitats along the banks - If dredging is accompanied by low water levels in the dry season, this can cause the groundwater table level to drop	Insufficient funds for yearly river dredging
Building bank revetments along the Ping River	Prevents river overflow and bank erosion	- Landscape of the river will be damaged and degraded - In-stream habitats of natural flora and fauna may be destroyed	Local people, academics and NGOs are against this and do not believe this method can alleviate floods in the city
Reducing/Preventing river encroachment by negotiating with the encroachers	Helps water flow faster	-	Encroachers' refusal to cooperate
Local Government Level			
Building more reservoirs to contain rainwater	Reduces water flow into the city	Residents in/near the project site have to relocate to other areas	No authority to implement
Replacing the traditional weir to modern dams with water gates	Helps water flow faster	There is no guarantee that water distribution will be the same as using the traditional weirs	No authority to implement
Reforestation in headwater areas	Helps retain water and reduce water flow into the city	-	No authority to implement
Diversion of floodwaters to other areas	Helps water to flow faster, so floods will be less severe	Transfers flood risks to other areas	Lack of cooperation from nearby local government units
Community Level			
Building bank revetments along the Ping River	Prevents river overflow and bank erosion	- Landscape of the river will be damaged and degraded - In-stream habitats of natural flora and fauna may be destroyed	No authority to implement
Diversion of floodwaters to other areas	Help water to flow faster, so floods will be less severe	Transfers flood risks to other areas	No authority to implement

Sources: RID (2008), Jompakdee (2003) and interviews with key informants; Mr. Thada Sukhapunphan (Director of HWMC), Municipality staff, the Head of SAO, and headmen of CMHC and MKT

4.0 HOUSEHOLD ADAPTATION TO THE 2005 FLOODS

The household survey questionnaire consisted of four sections. The first section included questions about household demographic and socio-economic characteristics as well as questions aimed at obtaining information on five adaptive capacity indicators: infrastructure, economics, technology, social capital, and skill and knowledge. The second section dealt with the specific extreme flood events in 2005 and their impacts. Here, we examined the extent and nature of the impacts of the floods on livelihood including flood frequency, flood depth, damage costs, health-related impacts, and duration of the recovery period. The third section investigated what the households individually and collectively did to adapt to the 2005 floods, the assistance received from external sources, and the needs of the households in dealing with the floods. This section also explored the respondents' perceptions regarding the future risks of floods. The last and most important section revealed the adaptation gaps which were assessed by examining what the respondents wanted to undertake but did not or could not at the time of the floods. The findings of the household survey are presented in the following sections.

4.1 Socio-economic Characteristics of the Respondents

A total of 308 households; 200 and 108 households in CMHC and MKT respectively, were interviewed face-to-face. Table 5 summarizes the general demographic and socio-economic characteristics of the 308 households in our sample. In CMHC, most of the respondents were women (73.5 %), who were the heads of their households (59.6 %). Most people interviewed in MKT had been born and raised in the village while almost no CMHC respondents had been born in the community.

Table 5. Demographic and socio-economic profile of the respondents

Characteristics	Chiang Mai Housing Community (urban area)		Mae Kong Tai (rural area)	
	Persons/ households	%	Persons/ households	%
Gender				
- Male	53	26.5	53	49.1
- Female	147	73.5	55	50.9
Total	200	100.0	108	100.0
Status				
- Household head	114	57.0	60	55.6
- Spouse	58	29.0	32	29.6
- Son/daughter/grandchild	12	6.0	14	13.0
- Parents	11	5.5	1	0.9
- Siblings/relatives	5	2.5	1	0.9
Total	200	100.0	108	100.0
Food security				
- Buys all food	193	96.5	15	13.9
- Buys > 50%	7	3.5	56	51.9
- Buys 50%	-	-	17	15.7
- Buys < 50%	-	-	20	18.5
Total	200	100.0	108	100.0
Availability of loans				
- Can take a loan if needed	155	77.5	90	83.3
- No credit to take a loan	32	16.0	14	13.0
- Not sure	13	6.5	4	3.7
Total	200	100.0	108	100.0

Source: Household survey (2009)

As expected, the households in the rural area tended to have a higher level of food security in which the ratio of households that could supply their own food needs was high (86.1%) compared to the urban study area in which almost all the households had to buy all their food. Most of the respondents from both sites could avail themselves of loans from formal and informal sources (77.5% for CMHC and 83.3% for MKT).

The average age of the respondents was 51 and 58 years for CMHC and MKT, respectively. For both areas, the average number of household members was 3.3 to 3.5 persons with an average of about two working members. Almost all of the interviewed respondents had attained formal education, in which the average educational attainment of CMHC and MKT was lower secondary school and primary school levels, respectively.

As shown in Table 6, the sources of household income in CMHC were employment in government and business sectors, wages[6], and self-employment, while the income sources in MKT were agriculture, wages, and self-employment. More than half the households in CMHC had only one source of income (56.5%) while the majority of households in MKT had more than one (73.1%). Households that had more income sources naturally had more income. The average monthly income of households in CMHC was THB 22,667 (USD 563)[7], higher than the average household income for the whole country, which is THB 14,963 (USD 372) (National Statistical Office 2005). Meanwhile, the average monthly household income in MKT was THB 8,507 (USD 211), lower than the average national income for Thai farmers, which is THB 9,937 (USD 247) (National Statistical Office 2005). However, the income data does not incorporate income like the value of vegetables that rural households grow and consume in their households, and hence the income data may underestimate the actual income of our rural respondents.

Table 6. Average household income classified by number of income sources

No. of income sources	No. of respondents		Average HH income in 2005 (THB/month)
	persons	%	
Chiang Mai Housing Community (urban area)			
- One source of income	113	56.5	19,662 (USD 488)
- Two sources of income	71	35.5	24,738 (USD 614)
- Three sources of income	13	6.5	37,101 (USD 921)
- Four sources of income	3	1.5	24,300 (USD 603)
Total	200	100.0	22,667 (USD 563)
Mae Kong Tai (rural area)			
- One source of income	28	26.2	4,376 (USD 109)
- Two sources of income	47	43.9	8,004 (USD 119)
- Three sources of income	27	25.2	12,035 (USD 299)
- Four sources of income	5	4.7	17,325 (USD 430)
Total	107[1]	100.0	8,507 (USD 211)

Source: Household survey (2009)
Note: [1] The total number of respondents in MKT was 108 but one household was dropped from the calculation. The household in question had only one source of income; from agriculture. It lost its total crop production in 2005 due to the floods.

6 Wages earned from manual labor like construction.
7 Annual exchange rate in 2008: USD 1 = THB 40.27 (www.bot.or.th, October 5, 2009)

4.2 Adaptive Capacity Indicators

4.2.1 Infrastructure Indicators

Table 7 presents information related to the infrastructure indicators in our study sites. Most of the respondents in CMHC (80%) and all the respondents in MKT (100%) owned their houses. All the houses in CMHC and almost all the houses in MKT (94.4%) were permanent structures, with some semi-permanent houses. Nearly four-fifths of the houses in CMHC (77.5%) were one-storey buildings, which mean that the residents had to leave when their houses were flooded. This vulnerability is exacerbated by the fact that the drains are commonly situated in front of the houses and are the main channel for floodwaters flowing. Most houses in MKT (59.3%) were elevated while some were two-storied (27.8%) so people could move their belongings upstairs if they had enough time before the floods came.

Generally, all the respondents in both study sites had access to electricity. During the floods, however, some houses in CMHC (28.5%) and MKT (18.5%) faced blackouts for short periods. Buying bottled water for drinking was popular in CMHC even in normal (non-flood) situations (74%). The source of drinking water in MKT was mostly piped water (50.9%). Nevertheless, the pattern of drinking water consumption of the respondents during the floods was similar to that under normal circumstances except that some households received water from the local government during the floods.

Table 7. Infrastructure Indicators

Characteristics	Chiang Mai Housing Community (urban area)		Mae Kong Tai (rural area)	
	persons	%	persons	%
Ownership of houses				
- Owner	160	80.0	108	100.0
- Renting	40	20.0	-	-
Total	200	100.0	108	100.0
Types of residential houses				
Permanent	200	100.0	102	94.4
Semi-permanent	-	-	4	3.7
Not permanent	-	-	2	1.9
Total	200	100.0	108	100.0
Number of stories				
One	155	77.5	14	13.0
Elevated house	1	0.5	64	59.3
Two	40	20.0	30	27.8
Three	4	2.0	-	-
Total	200	100.0	108	100.0
Utilities				
Normal situation Availability of electricity				
- Yes	200	100.0	108	100.0
- No	-	-	-	-
Total	200	100.0	108	100.0
Availability of drinking water				
- piped water	43	21.5	55	50.9
- well/tube-well	-	-	3	2.8
- buying bottled water	148	74.0	36	33.3
- piped water and buying bottled water	9	4.5	14	13.0
Total	200	100.0	108	100.0
Flood period Availability of electricity				
- Yes	143	71.5	88	81.5
- Blackout during flood	57[1]	28.5	20[2]	18.5
Total	200	100.0	108	100.0
Available sources of drinking water				
- piped water	34	17.0	23	21.3
- well/tube-well	-	-	4	3.7
- buying bottled water	118	59.0	19	17.6
- distributed by local government	11	5.5	35	32.4
- piped water and distributed by local government	-	-	6	5.6
- buying bottled water and - distributed by local government	27	13.5	12	11.1
- piped water and buying bottled water	10	5.0	9	8.3
Total	200	100.0	108	100.0

Source: Household survey (2009)

Notes: [1] The average duration of a black-out during the floods in CMHC was approximately 17 hours.

[2] The average duration of a black-out during the floods in MKT was approximately 3 hours.

4.2.2 Technology Indicators

When asked whether they would evacuate to shelters if a severe flood occurred, most respondents in CMHC (60.5%) and MKT (77.8%) said that they would not, reasons being that they considered their houses safe enough and/or there was no shelter to go to. Households received information from various sources, with television, radio and broadcasts from the local government being the most popular in both sites. In MKT, almost all the respondents had their own motorbikes (92.6%) while some had their own cars (36.1%), boats (43.5%) and bicycles (41.7%). Most of the respondents in CMHC also had their own motorbikes (88.5%), cars (59.5%) and bicycles (40.5%) (Table 8).

Table 8.Technology Indicators

Characteristics	Chiang Mai Housing Community (urban area)		Mae Kong Tai (rural area)	
	persons	%	persons	%
Intention to evacuate to shelter				
- Do not want to go to shelter	121	60.5	84	77.8
- Want to go to shelter	79	39.5	23	21.3
- Not sure	-	-	1	0.9
Total	200	100.0	108	100.0
Sources of information*				
- Television	192	96.0	98	90.7
- Radio	141	70.5	79	73.1
- Internet	32	16.0	5	4.6
- Newspaper	104	52.0	40	37.0
- Neighbor	100	50.0	39	36.1
- Broadcast from headman/ SAO/Municipality	167	83.5	87	80.6
- Telephone**	164	82.0	72	66.7
Ownership of vehicles**				
- Car	119	59.5	39	36.1
- Motorbike	177	88.5	100	92.6
- Boat	-	-	47	43.5
- Bicycle	81	40.5	45	41.7

Source: Household survey (2009)
Notes: * Households which received information from more than one source.
** The average no. of telephones in CMHC and MKT was 2.51 and 1.94 per household, respectively.
*** Households which owned more than one type of vehicle.

4.2.3 Social Capital Indicators

When asked whether the respondents had ever turned for help from others due to the floods, more than half the respondents in CMHC (61.5%) and MKT (66.7%) said they had not. The majority of the households in both CMHC (43%) and MKT (82.4%) attended community meetings once a month. However, the flood issue did not seem to be an important topic for discussion. Regarding the membership of local organizations (another aspect of social capital), about 70% of the respondents in CMHC did not belong to any local organization while more than half the respondents in MKT did. Table 9 shows the results for the social capital indicators.

Table 9. Social Capital Indicators

Characteristics	CMHC		MKT	
	persons	%	persons	%
Requested for help				
- No (Could not ask anyone for help)	123	61.5	72	66.7
- Yes	77	38.5	36	33.3
Total	200	100.0	108	100.0
Attended community meetings				
- *Regular meeting*				
- None	8	4.0	-	-
- Twice a month	4	2.0	4	3.7
- Once a month	86	43.0	89	82.4
- Once every 3months	32	16.0	-	-
- Once or twice a year	39	19.5	15	13.9
- Don't know	31	15.5	-	-
Total	200	100.0	108	100.0
- *Flood discussion*				
- Never	41	20.5	4	3.7
- Rarely	91	45.5	60	55.6
- Sometimes	47	23.5	35	32.4
- Often	21	10.5	9	8.3
Total	200	100.0	108	100.0
Membership in community organization				
- No	142	71.0	52	48.1
- Yes	58	29.0	56	51.9
Total	200	100.0	108	100.0

Source: Household survey (2009)

4.2.4 Knowledge Indicators

When asked if the respondents had ever attended a disaster/flood training program or if they had ever received information on flood preparedness, less than one-fifth of all the respondents in CMHC (13.5%) and MKT (18.5%) responded affirmatively (Table 10). Nonetheless, 85% and 68% of the respondents in CMHC and MKT, respectively, believed that such training should be provided. In addition to formal training and information, about half the households in CMHC (52%) and three-quarters of those in MKT (75.9%) had applied indigenous knowledge on flood mitigation but used this only as a supplement to early warnings from the government. Most of the respondents in CMHC (80.5%) and MKT (97.2%) had received early warnings of the floods and had understood them. Since MKT was located at downstream of the Ping River, it is usually flooded about one to two days after the city is hit. Therefore, households in MKT have more time to prepare for floods compared to households in the city like in CMHC.

Table 10. Knowledge Indicators

Characteristics	CMHC		MKT	
	persons	%	persons	%
Received disaster training attendance/disaster preparedness information				
- Yes	27	13.5	20	18.5
- No	173	86.5	88	81.5
Total	200	100.0	108	100.0
Agreement with the need for disaster preparedness training				
- Yes	170	85.0	73	68.0
- No	30	15.0	35	32.0
Total	200	100.0	108	100.0
Applied indigenous knowledge on flood mitigation				
- Yes	104	52.0	82	75.9
- No	96	48.0	26	24.1
Total	200	100.0	108	100.0
Received flood early warnings				
- Yes	161	80.5	3	97.2
- No	39	19.5	105	2.8
Total	200	100.0	108	100.0

Source: Household survey (2009)

4.3 Impacts of the 2005 Floods

4.3.1 Characteristics and Perception of the Floods

First, we investigated the exposure to floods in 2005. We asked the respondents to indicate the flood levels both inside and outside their houses and the enumerators used a tape measure to determine the height of the flood. In MKT, there was a large gap of about 70 cm between the average flood level in the house and the level in the yard because most of the houses had elevated ground floors. The farms were highly affected with an average flood level of more than two meters due to being located in low land. It should be noted only the flood levels for farming areas was taken into account for the study in MKT. In CMHC, the flood levels were not as high as in the rural area, with average flood levels of 31.8 cm and 66.1 cm inside and outside the house, respectively. In addition to higher flood levels, MKT respondents also faced a longer period of floods of almost three weeks compared to a flood period of only about four days in the urban area.

Besides the height and duration of the floods, we also found a difference in the timing of the floods between the two study sites. Table 11 shows that the floods in MKT recur every year, unlike in CMHC where floods are rare. There is a high variation in the frequency of floods in the urban area because of the difference in topography (the ground levels in different areas in CMHC are different) and the proximity of the houses to drains (those closer to drains are more likely to be flooded). The respondents' perception of the impacts of the 2005 floods is also shown in the same table. The majority of interviewed households in CMHC thought that the damage from the 2005 floods was severe whereas those in MKT thought that the events were not so as severe. In addition, we also explored the issue of fatalistic attitudes about the floods. We found that the extent of the belief that floods were decided by fate and that people had no control over them was higher in the rural area than in the urban area. The percentage of those who agreed and strongly agreed to this statement was about 40% and 60% in CMHC and MKT, respectively.

Table 11. Flood frequency, flood areas, and perceptions of floods

Characteristics	CMHC		MKT	
	Persons	%	persons	%
Frequency of floods				
- Every year	8	4.0	107	99.1
- Every two years	2	1.0	1	0.9
- Every five years	49	24.5	-	-
- Every ten years	78	39.0	-	-
- More than every ten years	63	31.5	-	-
Total	200	100.0	108	100.0
Flooded area				
- Residential area	200	100.0	12	11.1
- Agricultural area	-	-	2	1.9
- Both residential and agricultural areas	-	-	94	87.0
Total	200	100.0	108	100.0
Perception of the 2005 flood impacts				
- Severe damage/loss	133	66.5	59	54.6
- Little damage/loss	57	28.5	46	42.6
- No damage/loss at all	10	5.0	3	2.8
Total	200	100.0	108	100.0
Fatalism about floods				
- Strongly agree	12	6.0	9	8.3
- Agree	69	34.5	55	50.9
- Disagree	82	41.0	38	35.2
- Strongly disagree	37	18.5	6	5.6
Total	200	100.0	108	100.0

Source: Household survey (2009)

4.3.2 Damage Costs

Regarding the costs of damage caused by the 2005 floods (shown in Table 12), the highest cost in CMHC was in terms of loss of household commercial activities, averaging THB 51,128 (USD 1,270) per household. The second highest cost was from damage to household appliances/items, including furniture and electrical appliances, with an average cost of THB 11,660 (USD 290) per household. It was the same case in MKT where the highest loss was in terms of household commercial activities at an average cost of THB 50,000 (USD 1,242) per household, and the second highest loss was from crop damage costing an average of THB 18,971 (USD 471) per household.

Table 12. Costs of damage caused by the 2005 floods

Characteristics	No. of respondents	Min	Max	Mean (USD)
Chiang Mai Housing Community (urban area)				
1.1 Property damage (THB)				
- Houses	106	200	100,000	11,140 (USD 277)
- Appliances	121	300	200,000	11,660 (USD 290)
- Vehicles	23	300	43,000	5,596 (USD 139)
- Utilities (water supply and electricity)	3	500	2,000	1,167 (USD 29)
1.2 Loss of household production (THB)				
- Crops	-	-	-	-
- Livestock	-	-	-	-
- HH commercial activities	18	1400	400,000	51,128 (USD 1,270)
1.3 Forgone income(THB)				
- Wages	51	300	20,000	3,264 (USD 81)
- Business	54	500	70,000	8,944 (USD 222)
1.4 Loss of lives/sickness/injury (THB)				
- Dead or missing	-	-	-	-
- Injury	2	4,000	4,000	4,000 (USD 99)
- Illness*	18	15	3,000	451 (USD 11)
Mae Kong Tai (rural area)				
2.1 Property damage (THB)				
- Houses	14	330	15,000	3,952 (USD 98)
- Appliances	7	200	5,000	2,586 (USD 64)
- Vehicles	2	1,200	1,500	1,350 (USD 34)
- Utilities (water supply and electricity)	2	400	450	425 (USD 11)
2.2 Loss of household production(THB)				
- Crops	83	300	100,000	18,971 (USD 471)
- Livestock	14	200	20,000	2,493 (USD 62)
- HH commercial activities	1	50,000	50,000	50,000 (USD 1,242)

Table 12. Continued				
2.3 Forgone income (THB)				
- Wages	33	360	30,000	5,571 (USD 138)
- Business	5	1,000	10,000	5,160 (USD 128)
2.4 Loss of lives/sickness/injury (THB)				
- Dead or missing	-	-	-	-
- Injury	-	-	-	-
- Illness**	10	30	1,500	335 (USD 8)

Source: Household survey (2009)

Notes: * 87% of the respondents in CMHC had suffered no illness. 13% of the respondents had had athleteís foot (12.0%), dizziness (0.5%), and diarrhea (0.5%).
** 80.6%of the respondents in MKT had suffered no illness. 19.4% of the respondents had had†athleteís foot (17.6%), dizziness (0.9%), and diarrhea (0.9%).
(1) 26 households or 13% of the households in CMHC reported no damage costs (no serious damage to their property).
(2) 10 households or 9% of the households in MKT reported no damage costs (no serious damage to their property).
(3) Exchange rate: USD 1= THB 40.27

The majority of the households in CMHC reported property damage while almost all the respondents in MKT cited crop damage. Generally, cleaning a house after floods takes less time than farmland preparation for the next crop. This is the reason why the recovery period of households in MKT (40 days) was much longer than in CMHC (16 days).

Table 13 shows that, in absolute terms, the average flood damage costs of households above the poverty line are higher than the costs borne by those below the poverty line for both sites. Moreover, for wealthier households in the urban area, the share of flood damage was about one-tenth of their annual income, substantially lower than the damage share of poorer households, which accounted for more than half of their income. However, the damage cost share in the rural area was higher, almost 60% of annual household income. This result reflects that there is a positive linkage between socio-economic vulnerability and flood damage.

Table 13. Flood damage costs in relation to income

Poverty threshold	No. of respondents	Average flood damage costs (THB)	% share of flood damage costs over income
Chiang Mai Housing Community (urban area)			
Below poverty line[1]	7	19,400 (USD 482)	54.2
Above poverty line	193	21,087 (USD 524)	9.7
Total	200	21,028 (USD 522)	11.2
Mae Kong Tai (rural area)			
Below poverty line[2]	35	13,208 (USD 328)	59.0
Above poverty line	72	20,199 (USD 502)	16.3
Total	107[3]	17,912 (USD 445)	30.2

Source: Household survey (2009)
Notes: [1] The poverty line in CMHC was approximately THB 4,046 per household per month. (Source: www.nesdb.go.th/Default.aspx?tabid=322, downloaded 17 December 2009)
[2] The poverty line in MKT was approximately THB 3,815 per household per month. (Source: www.nesdb.go.th/Default.aspx?tabid=322, downloaded 17 December 2009)
[3] One household in MKT was not counted (it had lost its only one source of income-from agriculture-in the 2005 floods).

4.3.3 Benefits from the 2005 Floods

There are some benefits from the 2005 floods. About 60% of all the respondents in MKT stated that they could catch more fish for food during the floods. Also, surprisingly, some respondents in CMHC mentioned that they benefited from the floods in terms of better business than usual, for e.g. they could sell more goods in the community since residents could not go outside the area.

4.4 Household Adaptation Strategies for the 2005 Floods

4.4.1 Past Adaptation

The surveyed households undertook various options to adapt to the floods in 2005 which can be grouped into four categories: behavioral adaptation, structural adaptation, technological adaptation, and financial adaptation. It should be noted that all the households had applied more than one strategy. Most adaptation strategies were autonomous, except for sandbag dikes as the sandbags were provided by the Municipality, so this should be called planned adaptation. It was also found that households had individually adapted to the problem at hand. However, they also acted as a group, led by local government officers, to build dikes or to dredge the Ping River, which may considered as acts of collective adaptation. The details of adaptation behavior in each study site are described below.

Table 14 lists the adaptation strategies undertaken in response to the 2005 floods in CMHC. Moving belongings to higher ground was the most common option (87.5%). One respondent (0.5%) stored food before the floods. Structural adaptation, like making dikes using sandbags or concrete blocks, was widely applied in the urban study area. Most of the households made sandbag dikes (70%). The Municipality had provided sand and plastic bags and the households had to fill the bags and carry the sandbags back home on their own. However, the sand and bags provided were not enough, and some households had to buy these themselves. Eight respondents (4%) had added a second floor to their houses, which was the most expensive option. More than half the respondents (76.5%) monitored weather updates (on TV, radio, information bulletins, etc.) while three respondents (1.5%) bought disaster insurance after the flood. The latter thought that this insurance covered damage from floods. When we checked with the insurance company, however, we found that this disaster insurance only covered damage caused by water, such as damage caused by rain, but not by floods. We also investigated why households chose the above adaptation methods and found that the main reason was that everybody was doing them.

Table 15 presents the past adaptation of households in the rural area of MKT in response to the 2005 floods. Similar to the urban case, moving personal belongings to higher places was the option every household applied to cope with the flood. However, unlike the people in the urban area, only 10 households (9.3%) used sandbags as the people thought that sandbags were useless in protecting their farms from floods. Even though MKT experiences recurrent floods every year, some households still plant vegetable crops during early flood season. However, one respondent (0.9%) reported that he changed his crop calendar by delaying vegetable planting to avoid the 2005 floods. Actually, households reported that it was difficult to harvest early or change their cropping calendar; the vegetables needed more time to mature before the flood period. Only one respondent (0.9%) had renovated his house before the 2005 floods by adding a second floor. More than half the respondents (70.4%) keep abreast of weather updates for the 2005 floods. Furthermore, no one in MKT had bought disaster insurance. When asked why they chose the adaptation methods they did, the households cited the same reasons as those in CMHC.

Table 14. Household adaptation to the 2005 floods in CMHC

Adaptation strategies	Reasons to adapt						Total who adapted	No adaptation
	Cheap option	Recommended by neighbor/ expert	Recommended by the govt.	Everyone is doing it	Our ancestors did it	Other reasons		
Behavioral adaptation								
- Moving belongings to higher places	24 (13.7%)	2 (1.1%)	10 (5.7%)	132 (75.4%)	-	7 (4.0%)	175 (87.5%)	25 (12.5%)
- Parking car in a safer place (e.g. road)	10 (8.5%)	3 (2.5%)	2 (1.7%)	94 (79.7%)	-	9 (7.6%)	118 (59.0%)	82 (41.0%)
- Evacuation	4 (13.8%)	1 (3.4%)	2 (6.9%)	18 (62.1%)	-	4 (13.8%)	29 (14.5%)	171 (85.5%)
- Installing pumping machines	-	2 (66.7%)	-	1 (33.3%)	-	-	3 (1.5%)	197 (98.5%)
- Storing food	-	-	-	1 (100.0%)	-	-	1 (0.5%)	199 (99.5%)
Structural adaptation								
- Building sandbag dikes	17 (12.2%)	5 (3.6%)	32 (23.0%)	82 (59.0%)	-	3 (2.2%)	139 (69.5%)	61 (30.5%)
- Building concrete block dikes	7 (8.5%)	7 (8.5%)	2 (2.4%)	62 (75.6%)	-	4 (4.9%)	82 (41.0%)	118 (59.0%)
- Building scaffolds to protect property	1 (7.7%)	1 (7.7%)	-	9 (69.2%)	1 (7.7%)	1 (7.7%)	13 (6.5%)	187 (93.5%)
- Adding a second floor	-	-	-	6 (75.0%)	-	2 (25.0%)	8 (4.0%)	192 (96.0%)
Technological adaptation								
- Monitoring weather updates	16 (10.5%)	3 (2.0%)	15 (9.8%)	112 (73.2%)	1 (0.7%)	6 (3.9%)	153 (76.5%)	47 (23.5%)
Financial adaptation								
- Buying disaster insurance	-	2 (66.7%)	-	1 (33.3%)	-	-	3 (1.5%)	197 (98.5%)

Source: Household survey (2009).
Note: The total number of respondents in CMHC was 200. All the households applied more than one option.

Table 15. Household adaptation to the 2005 floods in MKT

Adaptation strategies	Reasons to adapt						Total who adapted	No adaptation
	Cheap option	Recommended by neighbor/ expert	Recommended by the Gov.	Everyone is doing it	Our ancestors did it	Other reasons		
- Moving belongings to higher places	6 (5.8%)	-	-	93 (89.4%)	1 (1.0%)	4 (3.8%)	104 (96.3%)	4 (3.7%)
- Parking car in a safer place (e.g. road)	5 (5.7%)	1 (1.1%)	-	77 (88.5%)	1 (1.1%)	3 (3.4%)	87 (80.6%)	21 (19.4%)
- Evacuation	-	-	-	2 (100.0%)	-	-	2 (1.9%)	106 (98.1%)
- Harvesting before floods	-	-	-	15 (93.8%)	1 (6.3%)	-	16 (14.8%)	92 (85.2%)
- Changing crop calendars	1 (100.0%)	-	-	-	-	-	1 (0.9%)	107 (99.1%)
- Building sandbag dikes	1 (10.0%)	1 (10.0%)	1 (10.0%)	7 (70.0%)	-	-	10 (9.3%)	98 (90.7%)
- Building concrete block dikes	-	-	-	1 (100.0%)	-	-	1 (0.9%)	107 (99.1%)
- Building scaffolds to protect property	2 (4.4%)	-	1 (2.2%)	40 (88.9%)	-	2 (4.4%)	45 (41.7%)	63 (58.3%)
- Adding a second floor	-	-	-	-	-	1 (100.0%)	1 (0.9%)	107 (99.1%)
- Monitoring weather updates	7 (9.2%)	4 (5.3%)	4 (5.3%)	60 (78.9%)	-	1 (1.3%)	76 (70.4%)	32 (29.6%)
- Buying disaster insurance	-	-	-	-	-	-	-	-

Source: Household survey (2009).
Note: The total number of respondents in MKT was 108. All the households applied more than one option.

4.4.2 The Costs of Past Adaptation

Regarding the financial costs of adaptation, the most expensive method of adaptation to the 2005 floods was building a second floor. However, it should be noted that adding a second floor may not be entirely attributed to adaptation to floods because this option has other benefits as well, for example, making more rooms in the house. Several adaptation strategies did not generate financial costs, like parking one's car in a safer place and monitoring weather updates. Some households in CMHC moved to other places, e.g. relatives' houses, hotels, etc. during the floods, the average cost being about THB 1,333 per household. The average annual adaptation cost in CMHC for all strategies was approximately THB 32,997 (USD 819) per household, which accounted for approximately 8.8% of the average monthly household income (Table 16). Meanwhile, the average annual adaptation cost in MKT was THB 14,425 (USD 358) per household, which accounted for 93% of the average monthly household income.

Nevertheless, we were cognizant that since the adaptation costs of second-floor addition was very expensive and it consisted of benefits other than adaptation, including the adaptation cost of this strategy could lead to a biased average value. Therefore, the average annual adaptation cost in CMHC, without the second-floor addition option, was THB 943 (USD 23) per household or 0.4% of the average monthly household income. For MKT, the average annual adaptation cost (without second-floor addition strategy) was THB 720 (USD 18) per household or 1.5% of the average monthly household income. In short, current adaptation practices cost only about 1% of the monthly household income.

Table 16. Adaptation cost as a share of annual household income

Adaptation	No. of respondents	Min (THB)	Max (THB)	Mean (THB)	Adaptation cost as a share of annual HH income (%)
Chiang Mai Housing Community (urban area)					
All adaptation strategies	94	50	1,500,400	32,997 (USD 819)	8.8
Without second-floor addition	92	50	7,500	943 (USD 23)	0.4
Mae Kong Tai (rural area)					
All adaptation strategies	16	20	220,000	14,425 (USD 358)	14.5
Without second-floor addition	15	20	5,000	720 (USD 18)	1.5

Source: Household survey (2009)

4.4.3 Collective Adaptation

There were a few collective adaptation strategies in both sites which were led by the local government, not the households. In both areas, the local government initiated the making of sandbag dikes and provided the material, with households collectively contributing the labor. Table 17 shows that some households in CMHC (4.5%) and MKT (16.7%) pooled their efforts to fill sandbags or build river dikes. Most of the households in MKT (81.5%) got together to operate a pumping machine during the flood. Some households in CMHC (9.5%) took collective action to clean up the drains in the community while some households (6.5%) in MKT dredged a canal. Another collective action in MKT after the 2005 floods was filing a joint petition to the RID to decrease the level of water in the Nong Saleak weir as they claimed that this weir was blocking the floodwaters from flowing down the Ping River, causing the floods in MKT to be worse than usual.

Table 17. Collective adaptation to the 2005 floods in CMHC and MKT

Adaptation strategies	Timing of adaptation					Total who adapted	No adaptation	Total no. of HHs	Supporting organization
	Before	During	After	Before + During	During + After				
Chiang Mai Housing Community (urban area)									
- Building sandbag dikes	5 (55.6%)	3 (33.3%)	-	1 (11.1%)	-	9 (4.5%)	191 (95.5%)	200 (100.0%)	Municipality and Community Committee
- Dredging drains	9 (47.4%)	2 (10.5%)	6 (31.6%)	1 (5.3%)	1 (5.3%)	19 (9.5%)	181 (90.5%)	200 (100.0%)	Municipality
Mae Kong Tai (rural area)									
- Building sandbag dikes	9 (50.0%)	7 (38.9%)	2 (11.1%)	-	-	18 (16.7%)	90 (88.3%)	108 (100.0%)	Village Committee and Village Headman
- Using pumping machines to drain water	29 (33.0%)	54 (61.4%)	3 (3.4%)	2 (2.3%)	-	88 (81.5%)	20 (18.5%)	108 (100.0%)	RID, Village Committee, and VILLAGE HEADMAN
- Requesting the RID to decrease the level of weir	-	-	19 (100.0%)	-	-	19 (17.6%)	89 (82.4%)	108 (100.0%)	Mae Ka SAO and VILLAGE HEADMAN
- Dredging the canal	5 (71.4%)	-	2 (28.6%)	-	-	7 (6.5%)	101 (93.5%)	108 (100.0%)	Mae Ka SAO and Village Headman

Source: Household survey (2009)
Notes: (1) RID = Royal Irrigation Department
(2) Households (HHs) could cite more than one strategy used.

4.4.4 Perceptions of Future Flood Risks

Almost one-third of the respondents (28.5%) in CMHC said they thought that the impacts of floods would be more severe in the future. Interestingly, two respondents reported that the reason for this belief was because the houses surrounding theirs were on higher ground and the flood impact on their houses would be worse (which may be considered as an *externality of adaptation*). The reason that some households in CMHC believed that the impacts of future floods will be less severe (23%) was the implementation of the Municipality's project to expand the waterway of the Ping River. These households believe that this project will alleviate flood impacts. This can be called *the effect of public flood protection*. If households rely on the efficacy of public flood protection, however, they may take less precautionary action of their own (Grothmann and Reusswig 2006).

In the MKT, nearly half the households (44.4%) believed that the impacts of floods will be less severe in the future due to the fact that the RID weir water level had been reduced; according to the villagers, there had been no flood problems since the height of the weir has been reduced. In addition, some households both in CMHC (11%) and MKT (13.9%) believed that they would not be affected from floods in the future. It is also important to note that about one-third of all the respondents in both study sites were not sure about flood risks in the future.

4.5 Adaptation Gaps

4.5.1 Adaptation Possibilities Proposed by the Households

We have seen that the nature of the impacts of the 2005 floods in the two study sites were different, in which property damage was paramount in CMHC while for MK, it was crop damage. When asked what kind of adaptation strategies the households would like to have undertaken but did not or could not in 2005, we found that the adaptation possibilities they desired were contingent on the impacts suffered. We also found that the adaptation possibilities were not necessarily only new *types* of strategies, but also past adaptation options differing in terms of *level and timing*.

About a quarter of the households in CMHC (28%) and MKT (26%) answered that they did not want to do anything other than what they had done before. They said that they were not capable of doing anything better than what they had done and it should be the government's responsibility to help them out. One possible reason that these households did not want to do anything more could be because of the 'populism policy' in Thailand where politicians have tried to gain the favor of voters by handing out benefits like subsidies for fuel, which may not be what is best for the sustainable development of the country. Such a policy has made the Thai people dependent on the government so much so they are less inclined to take action to help themselves.

Since the greatest impact in CMHC was property damage, most of the adaptation possibilities suggested centered on protecting houses/property from flood. Some households which had made dikes that proved not strong/high enough wanted more sandbags (29.5%) and concrete blocks (18%). A few households whose members were not at home when the floods occurred in 2005 wanted to build sandbag dikes (1%) and concrete-block dikes (2.5%). The major barrier to adaptation knew too late when the floods would occur to take sufficient and timely action. As many houses in CMHC were one-storied, some households (19.5%) wanted to add a second floor to their houses. The reasons cited for not applying this option was lack of money and lack of timely information confirming the occurrence of the floods (the warnings came just several hours before the floods). Other households (3.5%) wanted to relocate to other areas but did not have enough money to do so. Moreover, some households just wanted to be able to move their belongings to a safer place earlier, which is a new adaptation possibility in terms of timing (Table 18).

For MKT, the floods had badly affected the farms/crops and therefore, the livelihoods of the people. The farming households in MKT believe that they cannot do anything to protect their farms from floods.[8] Many households (42.6%) would like to have harvested earlier, but cited the obstacle that they did not know exactly when the floods would occur. Some households (12%) wanted to find other sources of income during the flood period but had no idea how to do this while others wanted to add a second floor (17.6%) or raise the ground floor of their houses (10.2%), but did not have enough money to do so (Table 19).

[8] Since the area is subject to recurrent floods, however, farmers have learnt to live with the floods by adjusting their crop calendars (in terms of vegetable growing) to avoid the flood period. As they are quite low-income households, some take the risk to plant their vegetables in the early stages of the rainy season so that if the flood comes late, at least they will have earned some income.

Table 18. Adaptation possibilities and barriers in CMHC

Adaptation Possibilities		Want to Adapt									Do Not Want to Adapt
		Adaptation Barriers									
		Lack of money	Need to act as a group	Responsibility of the govt.	Did not know when the event would occur	Did not think the flood would occur	Did not know where to go	Cannot go outside house	Rented house	Total	
Type	Building sandbag dikes	-	-	-	2	-	-	-	-	2 (1.0%)	198 (99.0%)
	Building concrete block dikes	-	-	-	5	-	-	-	-	5 (2.5%)	195 (97.5%)
	Adding a second floor	37	-	-	2	-	-	-	-	39 (19.5%)	161 (80.5%)
	Evacuating	3	-	-	-	-	3	5	-	11 (5.5%)	189 (94.5%)
	Relocation	7	-	-	-	-	-	-	-	7 (3.5%)	193 (96.5%)
	Raising the ground floor of the house	7	-	-	2	-	-	-	1	10 (5.0%)	190 (95.0%)
Level	Using more sandbags	9	8	16	19	7	-	-	-	59 (29.5%)	141 (70.5%)
	Using more concrete blocks	11	-	1	22	-	-	-	2	36 (18.0%)	164 (82.0%)
Timing	Moving belongings earlier	-	-	-	12	-	-	-	-	12 (6.0%)	188 (94.0%)

Source: Household survey (2009)
Note: The total number of respondents in CMHC was 200. Households could choose more than one adaptation possibility.

Table 19. Adaptation possibilities and barriers in MKT

Adaptation Possibilities		Want to Adapt								Do Not Want to Adapt
		Adaptation Barriers								
		Lack of money	Need to act as a group	Responsibility of the govt.	Did not know when the event would occur	Too early to harvest	Did not know where to go	Did not know how to do it	Total	
Type	Finding other sources of income during floods	-	-	-	-	-	-	13	13 (12.0%)	95 (88.0%)
	Adding second floor	19	-	-	-	-	-	-	19 (17.6%)	89 (82.4%)
	Relocation	-	-	-	-	-	4	-	4 (3.7%)	104 (96.3%)
	Raising ground floor of the house	10	-	1	-	-	-	5	11 (10.2%)	97 (89.8%)
Timing	Harvesting crops earlier	2	10	1	25	8	-	-	46 (42.6%)	62 (57.4%)
	Moving belongings earlier	-	-	-	4	-	-	-	4 (3.7%)	104 (96.3%)

Source: Household survey (2009)
Note: The total number of respondents in MKT was 108. Households could choose more than one adaptation possibility.

4.5.2 Set of Adaptation Possibilities Recommended by the Experts

Besides the set of adaptation possibilities proposed by the households, we also asked an expert[9] to recommend adaptation options to deal with floods at the household level. The recommended options were: (1) buying flood/crop insurance, (2) finding temporary work during the flood period, and (3) relocating. The first option of buying disaster insurance is not applicable at the moment as Chiang Mai is a high flood risk area[10], so insurance companies do not currently provide flood insurance for this area. Also, crop insurance against flooding does not exist in Thailand yet. Table 20 summarizes the type of adaptation possibilities recommended by the expert with the pros, cons and barriers for each option. Many of these are similar to the feedback received from the households.

Table 20. Household adaptation possibilities as recommended by the expert

Adaptation possibilities	Type of adaptation	Pros	Cons	Barriers
Buying flood/ crop insurance	Financial	Households will spread out the risk of damage from floods/disasters	-	Insurance companies do not offer this for the Chiang Mai area
Finding temporary work during the flood period	Behavioral	Will provide a secondary source of income	-	Households do not know how to find other income sources
Relocating	Behavioral	Households will avoid the floods	Costly option	Lack of money

We asked the households whether or not they wanted to adopt the options proposed by the expert and the reasons for their choice. Their responses are discussed below.

4.5.2.1 Flood/Crop Insurance

When asked whether they would like to buy flood insurance in CMHC or crop insurance in MKT, 57% of the households in CMHC and 39% of those in MKT said that they did not. The main reason given was that they felt it was not worth buying. Some households even said that they did not believe that this kind of insurance existed. For those who were not sure whether they wanted to buy the flood/crop insurance (14.5% in CMHC and 21.0% in MKT), it was because they needed more information on the premiums and returns.

[9] The expert was Mr. Suppakorn Chinvanno, a consultant from Southeast Asia START Regional Center (START stands for the Global Change System for Analysis, Research and Training). He has been involved in research on climate change adaptation in Thailand for many years.

[10] According to our telephone interviews with insurance agencies in Chiang Mai on April 30, 2009, they said that flood insurance was not applicable anymore for Chiang Mai due to the severe floods of 2005. As to whether they would consider offering it again in the future, they said that it depended on whether Chiang Mai was flooded again in the next few years or not.

4.5.2.2 Temporary Work during the Flood Period

The opinions of households in CMHC and MKT on temporary work during floods were quite different. More than half the respondents (57.5%) in CMHC did not want this because they could earn enough from their normal work. Since the average number of days of flooding in 2005 was only about four days, the households felt it was not necessary for them to find temporary jobs during this short period. Some said that they would be too worried and busy during the floods to do anything else while others did not think anyone would hire them since everybody would be affected by the floods.

However, almost 60% of the respondents in MKT wanted have temporary work during the flood period. The average number of flood days in MKT was approximately 19, much longer than in CMHC. This can explain why most households in MKT wanted temporary jobs during the flood period; to earn some income. Most of those that did not desire this option said that they could earn enough from their normal work. Meanwhile, others were not sure about this option because they did not believe that anyone would hire them during floods or were uncertain about whether they needed the extra money as they had their own sources of income.

4.5.2.3 Relocation

Most of the households in CMHC (68.5%) and MKT (96.3%) do not want to relocate to other areas because they were used to living in the area and their workplaces were not far from their homes. About a quarter of the households in CMHC (27.5%) would like to relocate to other areas which had no flood problems while a small percentage (4%) was not sure. Meanwhile, only four households (3.7%) in MKT said they would like to relocate so that they would not have to deal with floods anymore.

4.6 The Determinants of Flood Damage

4.6.1 Analysis

The examination of factors that determine the extent of damage is considered critical especially with respect to policy implications for disaster preparedness and climate change adaptation. Such information would be useful for local policy-makers in terms of whom or where the resources should be allocated to, to alleviate the damage from floods. We estimated the determinants of damage that households incurred from the 2005 floods using the following equation in a regression analysis.

$$Yi = \beta_1 + \beta_2 X_{2i} + \ldots + \beta_{17} X_{17i} + u_i$$

Where

Yi = Total damage costs from the floods (property, business, agricultural products, and health losses as well as forgone income from not being able to do one's job or go to work);
u_i = error term; and

X_{2i}-X_{17i} = Explanatory variables categorized according to six factors.

a) *Prior experience and vulnerability:* Covers flood frequency, participation in training on disaster preparedness or climate change adaptation, total house area (including farm in cases of households in rural areas), number of stories of house, and the level of flooding.

b) *Adaptation behavior:* Covers structural adaptation, evacuation to safer places, and the amount of time between receiving warnings and flood occurrence.

c) *Wealth:* Covers household income and the number of cars a household owns.

d) *Household characteristic:* Covers the number of schooling years and age of the respondents

e) *Interaction with society or social capital:* Covers participation in collective adaptation and the number of information channels that a household can access.

f) *Attitude and perception:* Covers whether a household is fatalistic about floods and its perception of the severity of flood impacts in the future.

4.6.2 Estimation Results

We employed two regression techniques; ordinary least square (OLS) and Tobit regression using the above equation with 308 observations in total. The results of both estimations, presented in Table 21, showed a similar pattern which reflected the robustness of our results. Regarding the prior experience of households in terms of how frequently they faced floods, there was no evidence that households with more experience with floods suffered less damage than those which rarely encountered floods. Attending disaster preparedness training also was not found to help reduce damage from floods. In this case, whether the training was inadequate or impractical would need further study. However, the relationship between house area and damage was statistically significant; households with a larger area were more likely to suffer more damage from floods due to, in this case, higher losses of agricultural products. Also houses with more stories tended to have less damage since the residents could move their things to higher levels. The flood level was found to be positively significant which means that households with higher flood levels would suffer more damage.

We also examined whether the adaptation options that households undertook were able to effectively reduce the damage from flooding. Their adaption options included structural adaptation (making sandbag or concrete block dikes) and evacuation to safer places. The amount of time between the receipt of early warnings and the occurrence of the floods was used as a proxy for the adaptation option of reacting to early warnings to gauge the impact of the timing of early warnings. Our results showed that the above adaptation options did not significantly lessen the damage costs. In fact, households that decided to evacuate to other places were more likely to suffer losses because they were not at home to protect their property.

Regarding the wealth factor, we found that household income was positively significant which means that households with higher incomes were likely to suffer more damage than less wealthy households. However, this does not mean that the government should give priority to assist the rich households since as we mentioned in the previous section that the burden of damage was higher on the poor than the rich. For household characteristics, the educational attainment of household members was not found to determine the amount of damage from floods. Nonetheless, it was found that households with older household heads tended to have larger losses than those with younger ones. This could be because older families would have acquired more property and consequently lost more in the floods. The significant, negative sign of the age-squared variable means that although the likelihood of damage increased with age, this would only apply until a certain age after which the reverse would be true.

Contrary to expectations, participating in collective adaptation did not significantly reduce losses. We also tested the importance of the accessibility to information channels, but could find no significant relationship between this factor and damage. Finally, we tested the extent of fatalism about floods and perceptions of the severity of future floods. We found that only the fatalism variable was positively significant which means that household that was fatalistic about floods (thinking that the impacts could not be controlled) tended to suffer more losses. Thus people's attitude to floods plays an important role in that households which do not think that floods are fated are more likely to do something to alleviate the impacts.

Table 21. OLS and Tobit regression results for the determinants of flood damage

Variable	OLS		Tobit	
	Coefficient	**P-value**	**Coefficient**	**P-value**
1) Prior experience and vulnerability				
Flood frequency	-17.524	0.961	-31.504	0.935
Training participation	-41.424	0.856	-18.999	0.938
Total area	0.041***	0.001	0.041***	0.002
No. of stories of house	-188.232*	0.076	-239.460**	0.037
Level of flood (cm) (Note 2)	2.575*	0.061	4.089 ***	0.006
2) Adaptation behavior				
Structural adaptation	-152.079	0.473	-91.708	0.686
Evacuation	56.247	0.837	184.412	0.522
Receiving early warning (amount of time of receiving early warning before the event occur)	-7.099*	0.085	-7.982*	0.071
3) Wealth				
Household income	0.001**	0.025	0.001**	0.036
Number of owned cars	196.536	0.132	188.567	0.178
4) Household characteristics				
Years of education	-2.278	0.922	-.323	0.990
Age	76.416**	0.050	111.953***	0.010
Age squared	-0.722**	0.042	-1.042***	0.008
5) Interaction with society/social capital				
Participation of collective adaptation	-205.101	0.433	-289.392	0.304
Number of information channels	16.523	0.789	33.850	0.613
6) Attitude/Perception				
Fatalistic about flood	274.311*	0.097	346.985**	0.049
Perception on future impact	-26.032	0.902	83.652	0.710
Number of observations	308		308	
Prob>F /Prob>chi^2	0.0000		0.0000	
Adjusted R^2	0.1246		0.0137 (pseudo R^2)	

Notes: (1) ***significant at 1%,** significant at 5%, and * significant at 10%
(2) Level of flood: For CMHC, we used the highest flood level in the house, but for MKT, we used the highest flood level in the agricultural area.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Chiang Mai Province has long experienced floods since 1956, namely due to its bowl-like shape which makes it prone to flooding. There is a trend of increasing frequency and intensity of flood occurrences with the most recent severe floods taking place in 2005 which affected both the inner city and rural areas of the province. The Royal Irrigation Department reported that there were three main factors which caused the 2005 floods in Chiang Mai Province. The most crucial factor was heavy rain at the Upper Ping River exacerbated by deforestation in northern Thailand to make way for tangerine plantations (Garden 2007). Encroachment into the Ping River by both private and public agencies was another factor. Lastly, elevated roads and landfills for housing estates in Chiang Mai City had disrupted the natural drainage system (Manuta et al. 2006).

This study aimed to determine the adaptive capacities of households and institutions in dealing with floods by examining the adaptation gaps between past adaptation and adaptation possibilities (appropriate adaptation) as well as adaptation barriers. An urban and a rural area were selected to be the study sites, namely the Chiang Mai Housing Community (CMHC) and the Mae Kong Tai (MKT) Village. It should be noted that MKT has faced floods every year, and thus the households in MKT have more experience in flood preparation than do the households in CMHC which have hardly faced any floods. A literature review, interviews with key informants, focus group discussions and a household survey were the methods of data gathering for this study.

5.1 Institutional Level

To understand adaptive capacity at the institutional level, we analyzed the institutional adaptive capacities of related-flood agencies at three levels, i.e. national government, local government and community level. Key agencies at the national level comprised the Hydrology and Water Management Center (HWMC) for the Upper Northern Region and Department of Disaster Prevention and Mitigation (DDPM). The HWMC's main responsibility lies in monitoring water levels and managing early warning systems. The DDPM acts as coordinator in providing relief and assistance in times of disaster. At the local government level, we analyzed the Chiang Mai City Municipality and Sub-district Administration Organization (SAO) of Mae Ka. Both agencies carried out flood mitigation activities and disseminated early warnings during the 2005 floods. At the community level, the community committees of our two study sites, Chiang Mai Housing Community and Mae Kong Tai Village, were examined. The committees in both areas were involved in flood mitigation activities initiated by the local government agencies, especially in terms of labor contribution.

The lessons learned and recommendations for improvement at the institutional level are as follows:

1) Flood mitigation plans that emphasize structural measures are quite common for Thailand. The reasons given for promoting such measures include claims that the construction of dams or retention ponds upstream will effectively reduce water flow into the city and that heightening river bank revetments will increase the carrying capacity of rivers. Even though experts have accepted that structural measure cannot be the sole method of flood mitigation (Lebel et al. 2008), most policy-makers still tend to pay less attention to alternative approaches in flood management like assigning floodplain zones along the Ping River or making provision for flood insurance. Three examples of the problem of structural measures to flood mitigation were given and the key lessons learned are discussed below.

a. The Nong Saleak Weir case had created a *"negative externality of adaptation"*. This example shows that flood-disaster related agencies should integrate flood disaster management into their development planning.

b. The second example of the Ping River expansion project covering a distance of only six kilometers into the city reveals that the authorities perceive flood mitigation as just shifting floodwaters out of the city (or their jurisdiction). In fact, experts had recommended that the project should cover at least 20 kilometers. Disaster risk reduction should not mean risk redistribution to surrounding areas which does not solve the problem but simply passes it on to others.

c. The last example is the proposed concrete bank revetment along the Ping River. Critics say that this is not a practical solution as no one knows what the highest water level will be in the future. The government should learn from its mistakes such as the failure of the river revetment built in Sukothai Province to prevent floods.

2) The main duties of the DDPM consist of formulating policy for disaster management; research on disaster prevention, maintaining early warning systems; building public awareness of and preparedness in disaster prevention; providing assistance to disaster victims and rehabilitating devastated areas, and coordinating assistance action among flood-related organizations. In practice, however, its mandates exceed its capacities. The DDPM acts more as a coordination agency, which is only one of its roles. It does not have an emergency budget for flood rehabilitation and assistance for flood victims and needs to wait for calamity funds after the affected area is declared as a disaster area by the Governor. The DDPM should be given the necessary resources and authority to take appropriate measures promptly especially in times of emergency without bureaucratic obstacles.

3) The flood early warning system in Chiang Mai Province is well developed, especially the flood map for the city of Chiang Mai. The HWMC for the Upper Northern Region, which is under the jurisdiction of the RID, plays an important role in this. The real-time water level data measured at the hydrological monitoring stations is used as the indicator for early flood warnings. The warnings have been quite accurate; however, it can predict a flood only approximately seven hours beforehand. According to the Director of the HWMC, increasing the number of rainfall measurement stations and telemeter systems can provide accurate rainfall statistics in the Upper Ping River watershed and along the Ping River, but the problem is limitation of budget. Nevertheless, this measure should be carried out to improve the early warning system.

4) Some mitigation approaches of the respective agencies do not take public participation into account in the early stages of a project. In the case of flood mitigation in Chiang Mai, the RID proposed changing traditional weirs into modern dams. It claimed that the new dams would help increase the speed of flood drainage and that the existing weirs slowed down the water flow in the Ping River. As mentioned earlier, this argument is extremely controversial. Local residents, academics, and NGOs are skeptical that the dams will function better than the traditional weirs and have campaigned against this project. Government agencies need to understand that the social aspects of a project are just as important as the technical aspects to ensure success.

5.2 Household Level

The main impacts of the 2005 floods in both study sites were different. In terms of the number of affected households, the main impact in CMHC was property damage, whereas the main flood damage in MKT was crop loss. The average damage costs in CMHC and MKT were THB 21,028 (USD 522) and THB 18,028 (USD 448) in 2005 constant prices, respectively. Also, the average flood level in the house at MKT was higher than in CMHC. The average flood level in the house at CMHC and MKT were 31.8 cm and 61 cm, respectively. Furthermore, the duration of flooding in MKT was longer than in CMHC. The average duration of flooding in CMHC and MKT were 3.7 and 19 days, respectively. Every adaptation strategy has its own value and does not exclude other strategies; in fact, the strategies collectively contribute to overall adaptation. This explains why all the households in the study sites applied more than one option. The average adaptation costs for all the adaptation strategies were approximately THB 32,997 and THB 14,425 in 2005 constant prices, for CMHC and MKT, respectively. There were a few collective adaptation actions in both sites; however, such actions were led by the local government agencies and community headmen, not by the households acting as a group by themselves. The adaptation gaps between past adaptation and adaptation possibilities represent the level of improvement in adaptive capacity that is needed. The lessons learned and recommendations at the household level can be divided into two parts: past adaptation and adaptation possibilities.

5.2.1 Past Adaptation

a. Most adaptation strategies adopted by the households in both sites were autonomous and individual in nature. However, there were some strategies that could be considered as planned adaptation, like making sandbag dikes, initiated by the Municipality which provided the raw materials.

b. In the first flood in 2005, the reason why some households in CMHC did nothing was because they did not believe the early warnings as floods were rare in CMHC. Therefore, education on flood information is needed to increase household awareness of floods namely, understanding that floods can occur any time, anywhere, and teaching people how to prepare for and respond to a flood event.

c. There is a linkage between socio-economic vulnerability and flood damage. The evidence in both sites showed that the poor suffered more from the floods than the wealthy. The share of flood damage costs against annual income was higher for households below the poverty line (54.2% in CMHC and 59% in MKT) than for those above the poverty line (9.7% in CMHC and 16.3% in MKT).

d. The 2005 floods did not create only negative impacts but also some positive ones. Three retail shops in CMHC reported that their business was better during the floods as it was difficult for the residents to leave the area so they shopped for necessities at neighborhood shops. About 60% of the respondents in MKT said that they could catch more fish during the flood period.

5.2.2 Adaptation Possibilities and Gaps

a. Adaptation possibilities or options that household did not undertake but would like to have carried out to deal with the floods were not merely different methods from past adaptation. Some households wanted to increase the level/degree or timing of the adaptation strategies they had undertaken. For example, some households wanted more sandbags/concrete blocks to build stronger and higher dikes. Meanwhile, most of the households in MKT (42.6%) wanted to harvest their crops earlier.

b. Barriers to adaptation possibilities comprised financial and non-financial constraints. An example of the latter was receiving warnings too late to harvest crops, as reported by the households in MKT. Also, some households were of the opinion that flood mitigation was the responsibility of the government, and this belief prevented them from taking precautionary action.

c. Some households in CMHC had the perception that floods in the future would be less severe than they had experienced (23%) mainly because the Municipal has finished the project on dredging and expanding the waterway of the Ping River in the city. This is called *effect of public flood protection.* It can be a dangerous perception as households may not take the necessary preventive measures due to a false sense of security in the effectiveness of public flood protection measures.

d. The expert recommended three adaption strategies for households to deal with floods: buying flood/crop insurance, finding temporary work during the flood period, and relocation. Most of the households thought that flood/crop insurance was not worth buying because the premium was too high and their losses might not be large. As for temporary work, 57% of the respondents in MKT favored this option while about the same percentage of the respondents in CMHC did not think it necessary as they could earn enough from their regular jobs. Most of the respondents both in MKT and CMHC were not interested in relocating because they were used to living in the area and did not know where to relocate to.

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