Final Report

Assessment of Trans-boundary Drought Causes, Impacts and Adaptations: The Case of the Mekong River Basin in Chiang Rai, Thailand

Submitted By:

Nguyen Luong Bach
Nion Sirimongkalerkal
Nuttiga Hempattarasuwan
Pakornpan Nakhampa

This research was made possible by support of Mae Fah Luang University
2011

Acknowledgement

We sincerely express our gratitude to Mae Fah Luang University for her financial support without which this study could not be completed successfully.

Strong support and kind cooperation from many local stakeholders for sharing their valuable knowledge, experience, and concerns are very much appreciated.

Executive Summary

The recent historical 2010 drought in the Mekong region, especially in trans-boundary areas, have raised various critical concerns from stakeholders at various levels and scales. Partial views on the causes of the drought include hydro-climate causes (related to extreme rainfall changes), man-made upstream dams, and upstream and local landuse changes (including widespread deforestation). In addition, both economic impacts of drought and adaptations to drought are not assessed in sufficient details.

This preliminary study is conducted mainly to investigate the drought issues (from causes and impacts to adaptations) facing the Mekong river basin in Northern Thailand, with a focus on the bordering areas of Chiang Saen, Chiang Khong and Wiang Kaen districts along the Mekong river in Chiang Rai province, as a case study for illustration. Available reliable data on both long-term and recent hydro-climate patterns are used to identify possible recent changes and correlations with a series of upstream dams to provide additional evidences on causes of the drought. Field surveys based on questionnaires designed are used to assess an overall social impact monitoring vulnerability, impacts and adaptations across study locations and local people groups. Focus group discussions are further conducted for specific assessment of such targets and locations.

Our main findings show that there are additional evidences to indicate that upstream dams are among various causes of the drought, especially under regional drought conditions. Upstream flows are indicated to have apparent correlations with downstream drought and flood events through existence of timing coincidence of more upstream hydropower dams and through almost direct dependence of downstream water levels on upstream discharges (as there are no major lateral flows between upstream and downstream in this case). In addition, evidences of climate changes in terms of regional drought conditions through extremely low precipitation and early ending of rainy season in the study are also found clearly. Besides these causes that have been analyzed in this study, there are still other causes that are generally recognized and understood, including regional landuse changes and

widespread deforestation, along with possible ice melting conditions, which need further investigations in details.

Local people vulnerability to changes of water resources as droughts and floods seem to be high because of (i) lack of second most important occupations by majority of the households, (ii) limitation of farming diversification, and (iii) decline of resource productivity apparent during the last five years, especially in the long drought duration.

Socio-economic impacts of the drought are seen clearly on river fishing, riverweed collection, riverbank gardening, and agricultural crops. These impacts vary, however, from village to village, according to extent of local dependence on water resources.

Adaptations to the drought are assessed to be limited, and also vary from site to site, except for compensation schemes by the government for crop damages that are common throughout the study sites. Majority of the local households have found very difficult to think of an alternative for adaptation, but there are still some possible options that have been adapted or proposed elsewhere in the study areas. Most preferred options focus on physical infrastructure to have more water supply, namely building water reservoirs and storages, digging wells and ponds, and extending water supply canals and pipes. Some non-physical options include development of inland fish farming as an alternative to river fishing, changing to some suitable crops that require less water (such as soybeans). These initial options, based on local people perspectives, can be used for further in-depth study, in addition to other adaptation options on more integrated fish-crop-animal farming systems.

Recommendations on continuous monitoring, more detailed adaptation plans, and some possible mitigation measures are also made. Continuous monitoring of river hydrology and climate change is required for better understanding possible changes for updating adaptations. Adaptation plans should be further developed in more details, especially for target groups and sites. More efforts should be made towards reaching some agreements for upstream dam operations to ensure minimum water flows downstream in the Mekong river, as well as minimum water level fluctuations to reduce downstream adverse impacts.

Abstract

The recent historical 2010 drought in the Mekong region have raised various critical concerns, especially on a possible cause from upstream dams. This study aims to investigate drought causes, impacts and adaptations in the Mekong river basin in Northern Thailand, by analyzing available reliable hydro-climate data and conducting field surveys and focus group discussions. Additional evidences are found out to indicate that upstream dams are correlated with the drought and flood event, thus the dams are a likely cause especially under regional drought conditions reflected in less precipitation and early end of rainy season. Local people vulnerability is high due to limitation of second occupations and farming diversification. Socio-economic impacts are found on river fishing, riverweed collection, riverbank gardening, and agricultural crops; but vary from site to site. The adaptations are currently limited, but some options are identified on water supply side, and shift to inland fish farming and drought-resistant crops. Recommendations on continuous monitoring, adaptation plan updates, and some mitigation measures are also provided.

Keywords: *Mekong water changes, Climate change, Trans-boundary droughts, Drought causes and impacts, Drought mitigation and adaptation*

Table of Contents

List of Tables

List of Figures

Chapter 1
Introduction

1.1. Background

There are a number of climatic and non-climatic drivers influencing droughts. The term 'drought impacts on the socio-economic' may arise from the interaction between natural conditions and human factors. Thailand faced severe drought on a large scale in 2010. The University of the Thai Chamber of Commerce (UTCC) and the Cooperative Auditing Department estimated that the direct impact from drought in Thailand leads to a loss of Bt 480.4 million for the agricultural sector in 2010. Indirect losses amounts to Bt 519.9 million for the farming sector, Bt 268.7 million for the industrial sector and Bt 46 million for the service sector. About 150,000 rai of farming areas is affected, compared to 120,000 rai in 2007. The North and the East of the country will be the hardest hit by the drought. In addition, 75.5 per cent of respondents affected by the drought had not yet received sufficient assistance from the government. The assistance includes allocation of water to relieve problems, money for compensating damaged areas, and helping to lower the costs of production (The Nation, 2010).

The extreme drought is widely declared in 2010 as a water crisis of the Mekong River by government officials in Thailand, Laos, Cambodia, Vietnam, Myanmar and China's Yunnan province. The serious drought that lasted for several months in 2010 caused significant loss of high economic costs and hardship. The Mekong region suffers its worst drought in decades, painfully demonstrating the importance of the river to the local people. It has been projected in increasing damage all over the Thailand, especially in Chiang Rai province of Northern Thailand.

Droughts in the Mekong River as elsewhere are typically caused by general causes such as a prolonged lack of rain, a decline of precipitation over time, climate change, and excessive water use. However, there may be other geographically-specific causes (in our case study) such as upstream dams, upstream and local deforestation, and high temperature that all together make river water levels more declining. The various possible causes and impacts are so controversial that have motivated us to conduct more specific research on assessment of drought causes, impacts and adaptations.

Various pressures from the GMS governments, NGOs and impacted local communities have led to the arrangement of the First Summit of the Mekong River Commission (MRC) in Hua Hin, Thailand on 5 April 2010, to gather regional Prime Ministers, political leaders, MRCs dialogue partners (the People's Republic of China and the Union of Myanmar), its Development Partners and a range of experts in the field of trans-boundary water resources management to discuss the emerging issue. The major outcomes from this are confined to the general identification of nine priority areas of action mentioned in the Declaration, with intensifying efforts agreed to effectively manage the risks from flood, drought and sea level rise including establishment of forecasting and warning systems across the whole Mekong basin (MRC, 2010a).

In media statements and reports in early April 2010, one of the specific concerns in the region is related to the dams; many in the lower basin suspect that Chinese dams are responsible for the decreasing water level. According to Permpongsacharoen (2010), with more dams to be built downstream, sandbars, rapids and deep pools could be adversely affected. However, the MRC insisted that the low water level was due to more than just Chinese dams; and increasing populations along the Mekong, urbanization, plantations, tourism and climate change were also likely causes (Bird, 2010).

The Mekong river plays an important role in the well-beings and economics of the people in China, Thailand, Laos, Cambodia, and Vietnam. Recently, the Mekong River basin in Thailand has become increasing vulnerable to drought. The MRC data reveals that the low water levels in the Mekong and its tributaries are the result of extreme natural conditions. Very low rainfall in dry season, following a particularly early end to the wet season in 2009, has led to river levels below those seen in at least 50 years. At Chiang Saen close to the Chinese border, the 2009 wet season ended about one and a half months early and rainfall in both September and October 2009 was more than 30 per cent less than average. The reduced Mekong water levels at the end of the wet season were typically at one-in-ten year lows. Coupled with very low rainfall afterwards, this means that levels at most extreme dry period on record. It is important to note that the conditions became more severe moving downstream from Chiang Saen to Vientiane (Bird, 2010).

As Mae Fah Luang University (MFU) is located in Chiang Rai, Thailand, our research team at MFU attempt to conduct this study in drought prone areas of Chiang Rai province in relation to the Mekong river where communities have been facing the impacts of drought. The purposes of the research are to provide better understanding of the issues from causes to impacts and adaptations. In addition to closely and continuously following media news and analyses, we have made a number of field visits and consulted with various local groups of stakeholders for fact finding purposes. As a combined result, we fully understand that trans-boundary issues are so complex and sensitive. However, we have tried our best to be as neutral as possible by basing on available and reliable data and evidence to come up with more convincing analysis for further in-depth studies.

Our study is organized to cover the common cycle from problem description, identification of possible causes, to assessment of impacts, followed by adaptations. Recommendations are then discussed along with highlighting further research needs.

1.2. Problem Overview

The drought in 2010 is seen clearly in Figure 1-1 with a historical (some 50 years) low water level of Mekong river in Chiang Saen, which is as low as around one meter during February and March, 2010. The flood that is intentionally and additionally included here to have better links with upstream dams is experienced in August 2008, with the water level in Chiang Saen as high as 10.63 meters (see Figure 1-2). While the impacts from these events are tangible and multi-dimensional, their causes remain controversial as to natural disasters or man-made factors, depending mainly on differently perceived points of view. As a consequence, responses and adaptations to the problem are also mixed, ranging from silence to moderate and extreme actions including protests by some local people groups.

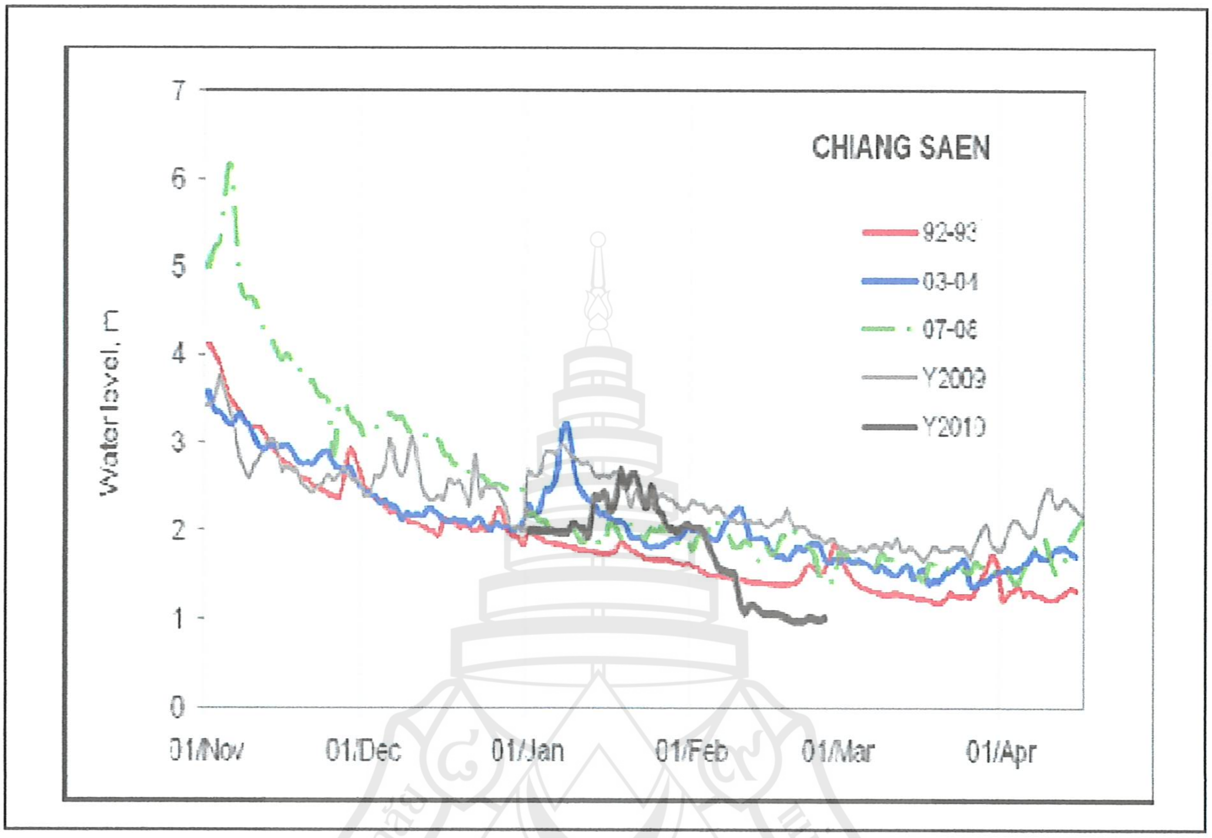


Figure 1-1: Low Water Level in 2010 Compared to Other Years

Source: MRC (2010b)

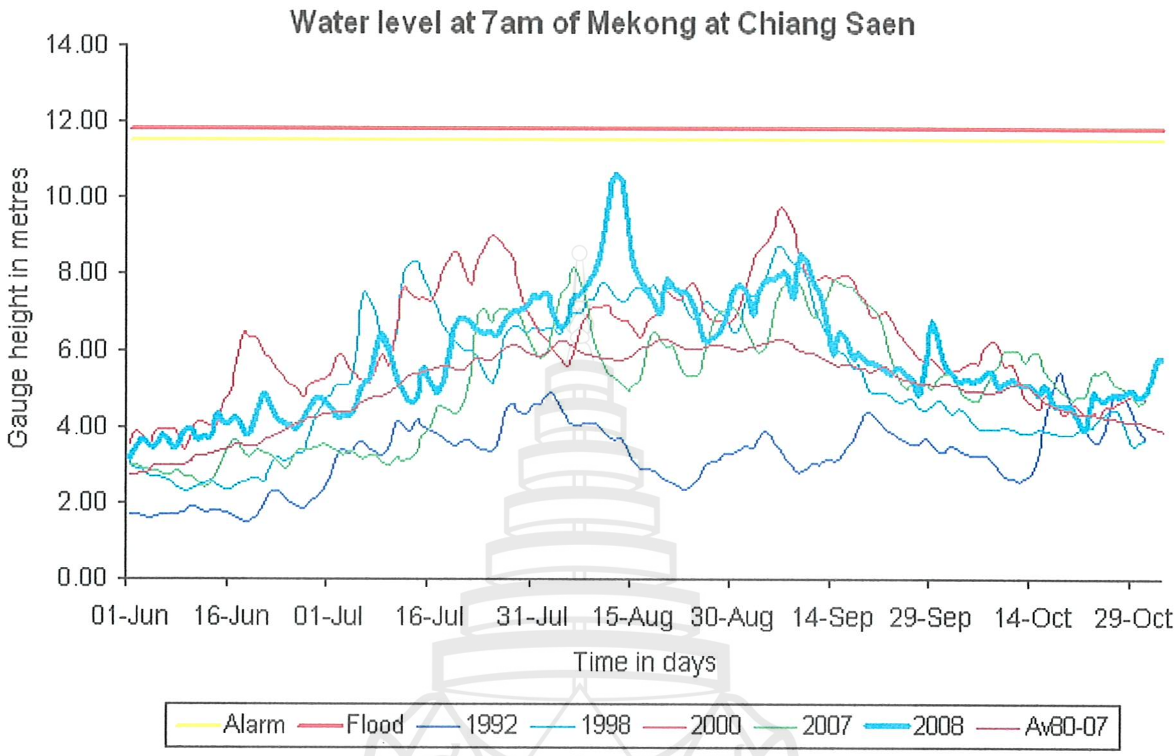


Figure 1-2: High Water Level in 2008 Compared to Other Years

Source: MRC [http://ffw.mrcmekong.org/historical_data/2008/his_data08.htm]

1.3 Objectives

The general aim of the project is to provide a better understanding of various factors related to drought causes, impacts and adaptations.

The specific objectives are to:

- Identify drought causes mainly from upstream dams and other hydro-climate factors, especially in the study areas.
- Assess drought impacts based on livelihood dependence of water resources that may vary from site to site and from a target population group to another group in relation to local livelihoods.
- Assess drought adaptations, including compensation by the government, and current and future adaptation options at both individual and community bases, especially from local perspectives.

- Recommend future research needs to mitigate the problems and well as to better adapt to reduce drought risks and vulnerability further in-depth follow-up.

1.4. Scope of Research

In this research, we focus more on trans-boundary causes of droughts (upstream dams in particular), and local impacts and adaptations. Due to time and budget constraints, we limit our scope on

- Hydro-meteorological data sources available mainly in Chiang Saen station (without reliance on upstream data that are impossible access to);
- Overall survey sites of all the three districts (Chiang Saen, Chiang Kong, and Wiang Kaen) in Chiang Rai province that are in the Mekong river basin; but just a couple of severely impacted villages for focus group discussions; and
- Economic impacts (not ecological impacts that may need a long-term study);
- Preliminary assessment of adaptation options for further in-depth study later.

1.5. Conceptual Framework

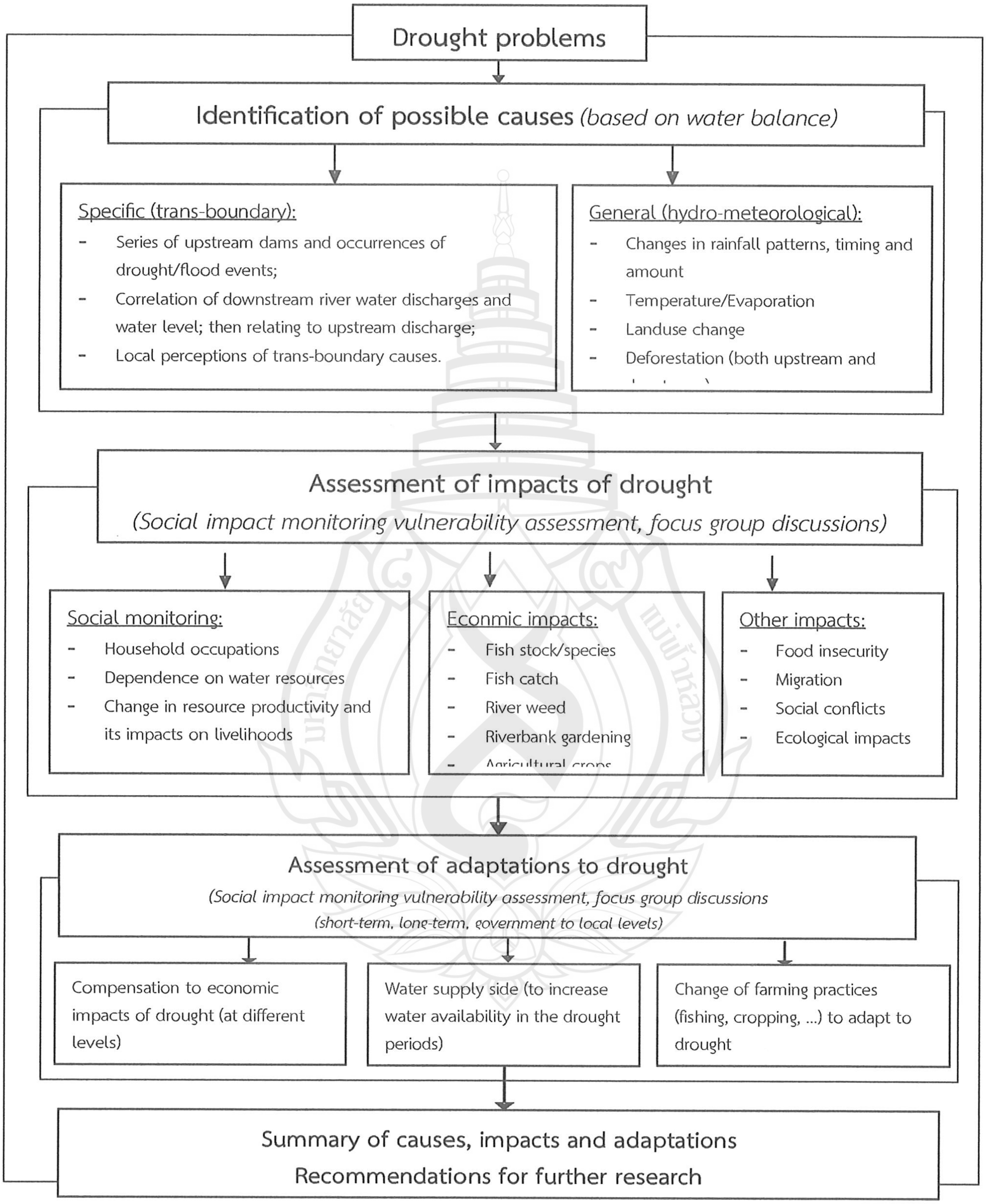


Figure 1-3: Conceptual Framework

Chapter 2
Theories and Literature Review

A literature review is provided in this chapter on drought concepts and related factors such as landuse change, dams, climate change, from various scales (global to regional and local). Concluding remarks are also discussed to identify gaps for our research.

2.1. Concepts of Drought

There are several conceptual definitions of droughts found in literature (e.g., Pacific Disaster Center, 2011). The most comprehensive and practical one can be traced back to Wilhite and Glantz (1985, as cited by Adamson and Bird, 2010, p.580). Drought occurs in various climatic zones, but its characteristics can differ from one region to another. Drought has many dimensions, so drought should be viewed beyond simply a physical phenomenon, to incorporate its social and environmental impacts (Adamson and Bird, 2010), and to reflect the result of interplay between a natural event and the demand placed on water supply by human-use systems, which should be considered relative to some long-term average condition of balance between precipitation and evapotranspiration (Wilhite, 2007).

Conventionally, four different types of drought have been classified as meteorological, hydrological, agricultural and socio-economic, as follows (Wilhite and Glantz, ibid.; UN/ISDR, 2007, p.5-6):

Meteorological drought: refers to precipitation deficiency over a specified period of time. The thresholds can be chosen, say, 30% of normal precipitation over a three-month period. They can vary from location to location, depending on needs or applications (UN/ISDR, 2007, p.5).

Agricultural drought: focuses on precipitation shortages in relation to agricultural impacts, through deficiency in soil moisture. Plant water demand depends on climatic conditions, stage of growth and other plant specific characteristics. Insufficient moisture may result in low agricultural yield.

Hydrological drought: refers to deficiencies in surface and ground water relative to average conditions at various time of the year. Although all droughts begin with precipitation deficit, hydrological droughts occur when this deficiency is reflected through the hydrologic system. Their occurrences and impacts usually lag behind meteorological and agricultural droughts. Precipitation deficit can result in an almost immediate depletion of soil moisture, but it may take several weeks before its impact on surface water storages. Other factors such as changes in land use and the dam construction also affect the hydrological characteristics of the basin, thus contributing to hydrological droughts.

Socio-economic drought: reflects relationships between the supply and demand of some commodity or economic goods with either or all of the above droughts. Its occurrence depends on the spatio-temporal processes of supply and demand to identify droughts. For example, if the water shortage occurs during paddy sprouts (rice seedlings) transplanting stage (Adamson and Bird, 2010, p.580), the event would be severe.

It is very interesting to note here that these types may not be independent of each other. Typically, among all other types of droughts, the meteorological drought is the prime mover. The temporal sequence first begins with an accumulated precipitation deficit (meteorological drought), which leads to a reduction in soil moisture content (agricultural drought) after some time delay between precipitation deficiencies and soil moisture deficiencies. Agricultural impacts also can vary from crop to crop. Precipitation and moisture deficit continue to accumulate for several months to some point where hydrological drought begins to manifest itself. Finally, drought is felt as a socio-economic drought when food price increases due to reduced farm output, power ration due to reduced electrical generating capacity, etc. (UN/ISDR, 2007, p.6; Adamson and Bird, 2010, p.582).

It should be noted here that drought is a slow but accumulative process compared to flooding in terms of both occurrence and impacts. Drought is a recurring natural phenomenon that can evolve into a disaster, depending on the severity and duration of the episode, and most importantly on the vulnerability and the capacity of the affected society to manage its impacts (Kampragou et al., 2011).

Owing to the rise in water demand and looming climate change, recent years have witnessed much focus on global drought scenarios. As a natural hazard, drought is best characterized by multiple hydro-meteorological parameters. An understanding of the relationships between these two sets of parameters is necessary to develop measures for mitigating the impacts of droughts (Mishra and Singh, 2010).

Increasing water withdrawals for urban, industrial, and agricultural use have profoundly altered the hydrology of many major rivers worldwide. Coupled with degradation of water quality, low flows have induced severe environmental degradation and water has been rendered unusable by downstream users (Molle et al. 2010).

Deforestation in a dry basin such as the Awash basin, Ethiopia, has increased total runoff but also accentuated excess and low flows (Taddese et al., 2003). The impact of particular types of land use on how much water (and sediments) is generated and on how this water is distributed during the year depends on many factors (soil type and slope, type of rainfall, etc.). The significant and complex link between land use and available river runoff should be recognized (Bossio et al., 2007).

In summary, it is worthwhile recognizing complexity of drought issues as pointed out by Peduzzi et al. (2009):

> *'Drought is a complex process to model as it is not clear when a drought starts both in spatial and temporal terms. The same deficit in precipitation may not induce similar impacts depending on types of soil, vegetation and agriculture as well as on differences in irrigation infrastructures. Moreover, casualties are not directly induced by physical drought but rather by food insecurity which is not purely a natural hazard as it includes human induced causes (such as conflicts, poor governance, etc.)'.*

2.2. Drought in the Mekong Basin

2.2.1. Public Concerns

Both government officials and civil society in the lower Mekong countries are very concerned about the potential for upstream developments to alter downstream river flows (Campbell, 2009). For example, results from workshops, as documented in Campbell (2007), at which participants, mainly government officials from the four lower Mekong countries, were asked to identify the most significant trans-boundary environmental issues, clearly shows that "Dams and reduced dry season flows" was the second most serious issue identified after "water quality." It was identified as a serious issue in all five workshops from which data were available. This concern has been reflected in the popular media with low flows during recent droughts often being blamed on dams in China. For example, during the drought in 2004 and earlier, articles implicating Chinese dams as a causative agent behind changes to Mekong River flows appeared in a range of regional papers and online media (Asia Times Online, 2002; Cambodianonline, 2004; Samabuddhi, 2004,) as well as in newspapers in Australia and Britain (Vidal, 2004), New Scientist (Pearce, 2004), and elsewhere. Subsequently, follow-up articles have appeared frequently in regional media (e.g., Bangkok Post, 2005, 2006).However, an analysis conducted by the MRC (MRC, 2004a) concluded that, while there was evidence of hydrological impacts of Manwan dam in China on flow variability at Chiang Saen in Thailand, there was no evidence that the existing Chinese dams played any role in contributing to the 2004 low flows. The low flows became more extreme downstream, and were evidently caused by reduced wet season rainfall throughout the basin (Campbell, 2009).

The most recent drought in 2010 has much more attention in the media (Bangkok Post 5/4/2010; 16/03/2010; Calgary Herald 8/2/2010), as well as in the expert community revolving around the MRC, the topic is bound to be addressed in a number of scientific publications in the coming years (MRC, 2010a). Below is a partial list of additional concerns from the media in March and April 2010 sorted by time, at various levels, and with different levels of response.

1. March 4: Drought will worsen as temperature rises to 43C. (Bangkok Post)
2. March 11: Drought in the Mekong Basin Hampers Southeast Asia Economy (Circle of blue: reporting the global water crisis)

3. March 12: Severe Drought Puts Spotlight on Chinese Dams (Science, Vol. 327 no. 5971 p. 1311: News of the week)
4. March 13: When the Mekong runs dry (Asia Times)
5. March 18: Frustration on the Mekong: Falling water levels reveal the hidden shoals of mistrust (The Wall Street journal)
6. March 24: Thai Officials Insist Chinese Dams Cause Mekong Drought (VOA Lao Service)
7. March 25: Southeast Asia Drought Triggers Debate Over Region's Water Resources (Voice of America News)
8. March 25: China reveals Mekong data in boost for drought response (Bangkok Post)
9. March 30: Drought Drops Mekong River to 50-Year Low, Affects Farmers and Trade (Voice of America News)
10. April 02: Thailand Facing Severe Drought along Mekong River (NTD TV)
11. April 03: Experts Say Cooperation Needed on Mekong River Resources (Voice of America News)
12. April 04: China Pressed for More Information on Mekong Dams (Voice of America News)
13. April 12: Record Drought Exposes Water Woes (IPS, Inter Press Service News Agency)
14. April 12: The Mekong and China: Dams and Trust (Vietnamnet)
15. April 15: Mounting Tensions over the Mekong River (Caixin online)
16. April 26: China debates whether human activity or nature is to blame for drought (Los Angeles Times)

However again, the main causes of water levels being experienced in the 2010 dry season in the Mekong mainstream are recognized by MRC (2010) not directly in relation to upstream dams, but mainly a combination of early end to the 2009 wet season, low monsoon rainfall and very low rainfall in the dry season which together have led to regional drought conditions. Based on the available information it appears that flows from tributary rivers in Lao PDR and northern Thailand are at levels that are amongst the lowest recorded in recent decades. This situation represents a regional hydrological drought affecting all countries in the Basin. The higher than natural levels in the Mekong River experienced at Chiang Saen in early to mid-January resulted from hydropower operations upstream. These levels then reduced to levels closer to those of the usual conditions in late January as reservoir storage levels upstream fell in response to the drought (MRC, 2010).

An opposite view is, however, raised by a local group in Mekong Community Media Project in a booklet edited by Lamun (2010), which clearly claims that dams cannot control flooding, and, in the context of the climate change crisis, dams cause rivers to dry.

2.2.2 Drought Factors

2.2.2.1. Landuse Change

Landuse change is recognized in a number of research papers and articles. Upstream, in the past decades, Lancang river has suffered cascade development of dams on the mainstream, which have caused pressure upon changes of land use, and the forest land in Manwan reservoir region declined with time (Zhao et al. 2010). The MRC (2005) proposed that land use changes in the catchment could be expected to reduce the storage of water resulting in less water flowing into the river during the dry season from December to April. Less catchment storage capacity would also tend to increase the proportion of runoff during the wet season, producing increased flood volumes (Adamson et al. 2009).

Forest degradation in the Mekong Basin has, according to Giril et al. (2001), been occurring at an unprecedented rate and scale, particularly from the 1960s onwards. Furthermore, logging pressure on the forests of Lao PDR, Cambodia, and Burma was intensified after 1989, when Thailand introduced a logging ban within natural forests, and consequently sought increased imports from its neighbors. Two potential hydrological impacts of deforestation might be distinguished: (i) Total water yield may be increased as annual evapotranspiration decreases, and (ii) Seasonal distribution of flows may be modified as flood runoff increases and dry-season flow decreases.

There is also some literature, according to He et al. (2009) indicating that environmental changes (e.g., climatic factors and land use) are the main cause of the hydro-meteorological variations in the Mekong River basin (Fu et al., 2006; He et al., 2006; Li et al., 2006; MRC, 2004).

2.2.2.2. Impacts from Dams

Over the past decade or so, concerns about the influences of large hydropower dams on the upper Mekong River and their related influences on ecological and social systems along the river downstream have been the focus of much heated debate. Many have suggested that the dams will improve downstream flood control, irrigation, navigation, pollution control, and aquaculture. Others have argued that the dams will obstruct the path of migratory fish, threatening biodiversity and reducing the catches upon which millions of human lives depend. Still others have raised concerns that sediment trapping behind the dams and flow pulse alterations may increase downstream bank erosion and reduce the quality of fish habitat as far downstream as the delta area in Viet Nam (Dore and Yu, 2004; Quang and Nguyen, 2003; Reuters News Service, 2001; Roberts, 2001). There is also some literature indicating that environmental changes as (e.g., climatic factors and land use) are the main cause of the hydro-meteorological variations in the Mekong River basin (Fu et al., 2006; He et al., 2006; Li et al., 2006; MRC, 2004). Dam proponents argue, however, that the dams have the potential to offer limited flood control, more assured dry-season flows, increased navigation options, reduced saline intrusion in the delta, and extra irrigation opportunities for downstream countries like Thailand.

For illustration in Kranz et al. (2010), the Chinese government tends to play down the influence of dam construction in Yunnan, since only a small part of the total flow originates within China. This argument, however, ignores the fact that the total flow is measured in the delta, whereas in the Laotian capital Vientiane approximately 60% of the Mekong water stems from China (Menniken, 2007; Osborne, 2000). This means that the impact of infrastructure development (mainly hydropower dams) on the upper stretches of the Mekong varies depending on proximity to these sites.

Potential impacts from dams on river flow are highlighted in Adamson et al. (2009). Dams are much more likely to affect low flows, but there is no evidence of such an effect on the Mekong. There has been a lot of debate about the dry season hydrology of the mainstream Mekong and there is a widespread belief that there has been significant change due to upstream reservoir storage in China. Over the next 20-30 years, the major area of water resource development is anticipated to be hydropower, the fundamental feature of which is the shift of water from the wet to the dry season via reservoir storage. Since hydropower schemes are in principle nonconsumptive, the "at site" mean annual flow remains the same except for evaporation. There is no doubt that the numerous hydropower dams planned for the Mekong basin will eventually change flows in the river, shifting flows from the wet to the dry season (Podger et al., 2004).

The checkered history of world-wide large dams offers considerable insight into the risks associated in dam construction as excellently reviewed by Brown (2009). For example, the adverse effects of dams on ecosystems, hydrology, and water quality often disrupt existing cultural and economic institutions and impact relationships between the dam community and communities both up- and downstream, which may include people in other political jurisdictions (Giordano et al., 2005). Risks associated with large dams also go beyond the immediate ecological and social impacts; for example, 46 large dams catastrophically failed between 1860 and 1995, eight of which resulted in the deaths of at least 1000 people (McCully, 2001).

2.2.2.3. Climate change

Increasing climate variability is acknowledged as a key concern to the Mekong's water resources and people's use of these resources. While it is still debated what part of this massive variability in water levels can be traced back to hydropower dams, a consensus is emerging that climate variability plays a strong role (Kranz et al., 2010).

There is also some literature indicating that environmental changes (e.g., climatic factors and land use) are the main cause of the hydro-meteorological variations in the Mekong River basin as mentioned in He et al. (2009).

Precipitation patterns will include a greater proportion of extreme events, leading to higher and more frequent flooding and lower dry season flows in rivers (Lunchakorn et al., 2008).

In recent years, droughts have been occurring frequently, and their impacts are being aggravated by the rise in water demand and the variability in hydro-meteorological variables due to climate change. As a result, drought hydrology has been receiving much attention. A variety of concepts have been applied to modeling droughts, ranging from simplistic approaches to more complex models. It is important to understand different modeling approaches as well as their advantages and limitations (Mishra and Singh, 2010).

2.2.2.4. Trans-boundary Governance

The challenge of governing trans-boundary water resources is expected to increase with climate change and the resulting need to adapt to its impacts such as temperature increase, more precipitation in the wet season and less in the dry season. In a number of trans-boundary basins, international regimes, and in particular river basin commissions, are emerging to account for this and other challenges (Kranz et al., 2010).

Lowering river flows in the low-discharge season may exacerbate international water-related conflicts, e.g. about the Farakka Dam and diversions from the Ganges by India, upstream of Bangladesh, exacerbating drought severity during low-discharge seasons (Kundzewicz et al. 2009).

Possible conflicts are also identified by McNally et al. (2009), if China does address large-scale hydropower construction's potential to create multi-scale geopolitical tensions, they may be vulnerable to conflict – though not necessarily violent – in domestic and international political arenas. Such changes have resulted in disputes in areas formerly under British administration (e.g., the Nile, Jordan, Tigris–Euphrates, Indus, and Ganges–Brahmaputra), as well as in the former Soviet Union (e.g., the Aral tributaries and the Kura-Araks). These examples suggest that without the capacity to seamlessly adjust to new governance structures, conflict of one sort or another is likely to erupt. Existing, ongoing, and proposed hydropower development by regionally dominant China on the upper Mekong has generally been construed as in conflict with downstream demands for fish habitat protection, shipping, and agriculture. Political obstacles and lack of data sharing have largely prevented any basin-wide research into the extent to which upstream dams may modify sediment transport, dissolved gases, and flow regimes downstream (see, for instance, He et al., 2006).

Given the fact that biological systems of the Mekong have developed in an environment of extreme predictability, even small shifts in low flows, and the timing of the wet season could have deleterious effects on the ecology of this large river. There is no question that issues of climate change, and issues of water resource development, should be treated together in planning the future of the Mekong River (Adamson et al., 2009).

The Mekong river faces a range of serious environmental challenges. Many of these are trans-boundary. In some cases the actions of one country will seriously impact downstream countries, as is the case with large dam construction. In other cases the resource is shared between all countries, and poor management in one will affect utilization in others, as is the case for the fisheries. There is an urgent need for an effective river management agency to coordinate and drive management of the Mekong. It will need clear objectives, and should be a source of high-quality technical capacity and reliable data. It must develop credible scenarios to allow the riparian countries and other stakeholders to discuss and debate possible futures for the Mekong, and how they may be achieved (Campbell, 2009).

Urgent need for regional cooperation is also expressed explicitly in the words of the Prime Minister of Thailand in the MRC Hua Hin Declaration in April 2010, "the Prime Ministers of MRC Member Countries highlight that further cooperation over the coming years will be required to optimize multiple-use of water resources and mutual benefits for all riparians, to avoid the risks of harmful effects that might result from natural occurrences, and man-made activities, and to protect the immerse value of the Basin's natural ecosystems." (MRC, 2010c).

2.2.2.5. Adaptation

With increasing water stress and other stresses from land degradation and lack of market access, farmers' coping mechanisms have evolved, expanding from one-time adjustments to long-term adaptations, and switching focus from securing reliable water sources to improving irrigation efficiency and diversifying both on-farm and off-farm production (Liu et al., 2008).

Adaptation measures refer to increased water storage (reservoirs, soil water, groundwater), but also to increased economic (savings/loans) and food buffer capacities. An increase in extremes includes also an increase in consecutive years of dry or wet periods, which are very difficult to overcome for poor people. A farmer might overcome the impact of an one-year drought followed by a normal year, but a period of two or more years of drought, even followed by a longer period of normal years, will be catastrophic to this farmer (Droogers and Aerts, 2005).

In a number of trans-boundary basins, international regimes, and in particular river basin commissions, are emerging to account for this and other challenges. Some basins are, however, rather advanced in terms of developing climate change adaptation strategies, while others are in a morenascent stage (Kranz et al., 2010).

2.3. Concluding Remarks

To conclude this chapter, we generally agree with Adamson et al. (2009) that when taken as a whole, there is scant evidence that humans have, as yet, altered the hydrology of the greater Mekong River. Nevertheless, both direct human impacts on the hydrology (irrigation diversions), and indirect impacts (deforestation and climate change) will tend to produce similar changes in the river's hydrology: namely, reduced dry-season flows, and shifts in the beginning and end of the wet season. Hydropower storage dams will tend to have a different effect, shifting flows from the wet season to the dry season. Overall, anthropogenic effects on low flows will be difficult to distinguish from natural inter-decadal changes. Shifts in the onset of the start and end of the wet-season flows will be easier to identify because they are so remarkably regular (always within 1-2 weeks of the same dates).

Given current gaps identified on limited evidence, especially on possible impacts from the dams on drought, then on downstream local people, we, in this study, will attempt to provide more evidence and fact-findings on the ground to provide additional insights on the complicated drought issues in our case study.

Chapter 3
Research Methodology

3.1. Assessment of Causes of Drought

Assessment of various possible causes of drought is a challenging task, especially the cause from upstream dams as upstream data are not available at all. Secondary data can be used for some possible causes as regional whether condition and deforestation. To assess possible cause from upstream dams, we also consider flood events for better insights, and have combined several methods, including the following:

- Correlation and comparative methods to relate status of a series of upstream dams with drought (and flood) events and water level and discharge downstream in the study area in order to detect any coincidence before and after dams. Long-term data series will be compared with recent short term data.
- Correlation analysis to relate river water discharges upstream and water levels downstream, especially during drought and flood events. River water discharges upstream are unavailable, but are almost directly related to these downstream (especially at Chiang Saen station) as there are no major lateral flows (especially during the drought period) in this river reach. So data at Chiang Saen station will be used instead for detail analysis.
- Comparative study of the long-term trend and recent changes in rainfall patterns (especially in Chiang Saen station) to detect abnormalities in recent years to show climate change evidences, namely rainfall pattern changes for illustration that climate change is a cause of drought. Data sources are selected when available.
- Field surveys and local endogenous knowledge and perceptions to supplement hydro-meteorological analyses.

3.2. Impact and Adaptation Assessment of Drought

In order to have better assessment, we first use household surveys for overall assessment, followed by focus group discussions for in-depth and specific assessment of target groups and locations.

The household survey is designed and conducted, based on the framework for social impact monitoring vulnerability assessment (SIMVA) as recently published by the MRC (SIMVA report, 2010) with relevant modifications.

In addition, a variety of primary and secondary sources are used in data collection. The secondary sources included government reports, national and regional newspapers, and documents on droughts in Chiang Rai province, Thailand.

The field survey is the questionnaire-based data of local households. The numbers of responses needed are determined using the formula (n=N/1+Ne^2) as described by Taro Yamane (1973). Primary data are collected through structured questionnaires with guidelines developed for asking such householders (including government officers, local communities and fishermen) to evaluate the entire drought cycle. The key aspects for questionnaires are related to (i) assessing the drought causes and types of drought impacts, (ii) monitoring local dependency on water resources and vulnerability, (iii) assessing adaptations to drought, including short-term support and long-term adaptation perspectives from local people in Chiang Saen, Chiang Kong, and Wiang Kaen districts.

3.3. Site Selection

The sites are selected in Chiang Rai provinces in the North of Thailand with three districts as shown in Figures 3-1, 3-2, and 3-3, along with Table 3-1. The size of questionnaire sample is 990 persons, which represents about 4% of the total population. The sample is distributed along all the villages based on their population size. Regarding focus group discussions, because of time and budget constraints, only two villages (Ban Xaew in Chiang Saen district and Ban Hat Khrai in Chiang Khong district) are selected.

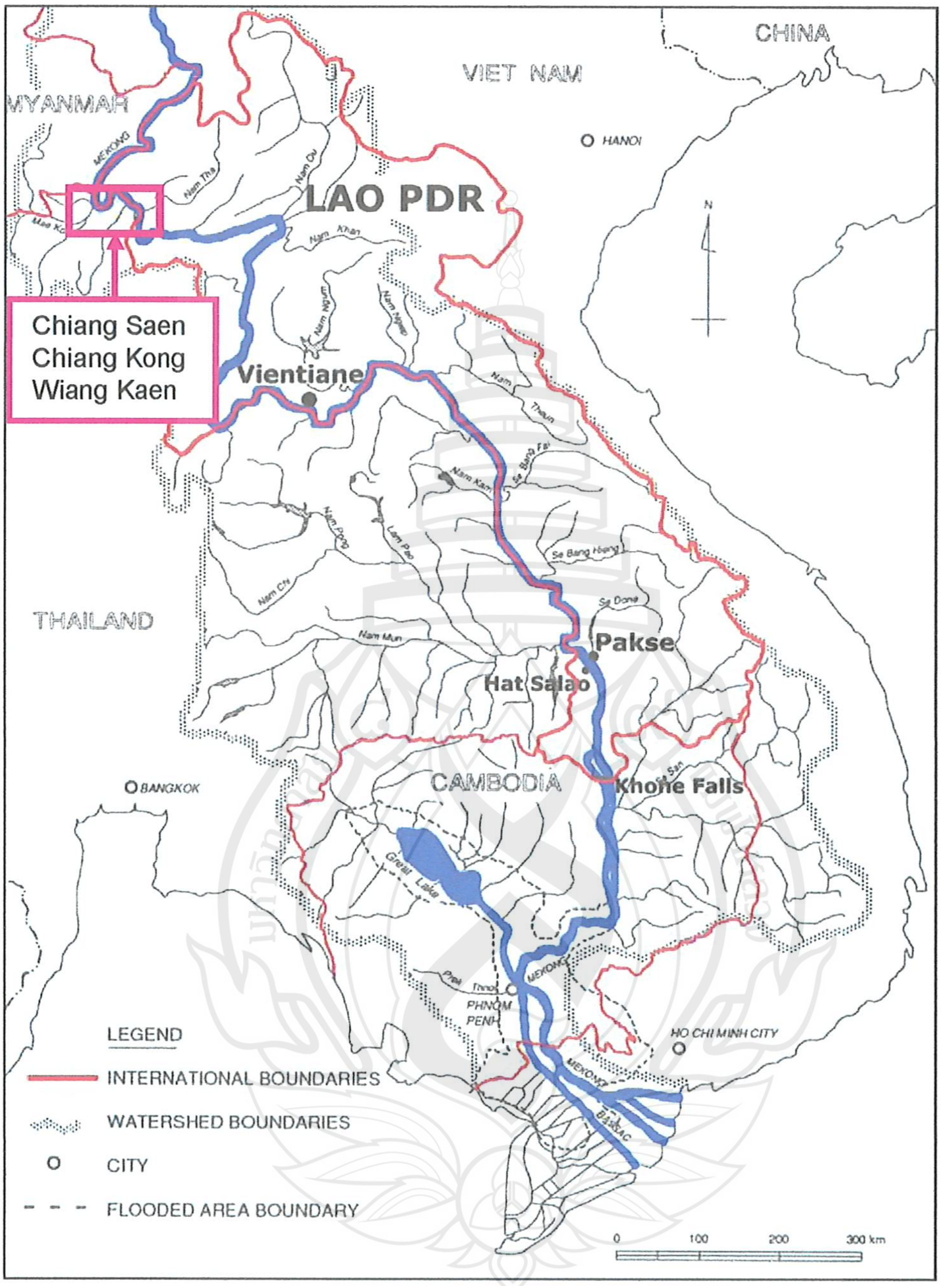


Figure 3-1: The Study Area in the Lower Mekong River Basin

Table 3-1: The Site Selection for Questionnaire Survey of Villages along the Mekong River

District	Sub-district	Village
Chiang Saen	Wiang Chiang Saen	Chiang Saen Noi
		Pa Sak Hang Wiang
		Hui Kiang
		Sop Ruak
	Mae Ngoen	Pong Khong
		Sop Yark
		San Ton Pao
		Pha Ka
	Ban Saew	Saew
		Tha Khan Thong
		Ko Pha Kham
		Sop Kok
		Suan Dok
		Hua Kwan
		San Sai Kong Ngyam
		Saew Klang
Chiang Khong	Rim Khong	Hat Sai Thong
		Hat Bai
		Don Thi
		Muang Kan
	Wiang Chiang Khong	Huai Meng
		Hua Wiang
		Wiang Kaew
		Nai Wiang
		Wiang Don Chai
		Sop Som
		Hat Khrai
		Don Maha Wan
	Si Don Chai	Pak Ing Tai
		Pak Ing
Wiang Kaen	Lai Ngao	Chaem Pong
		Hua Ian
	Muang Yai	Huai Luek

Source: Local Administrative Organizations (2010)

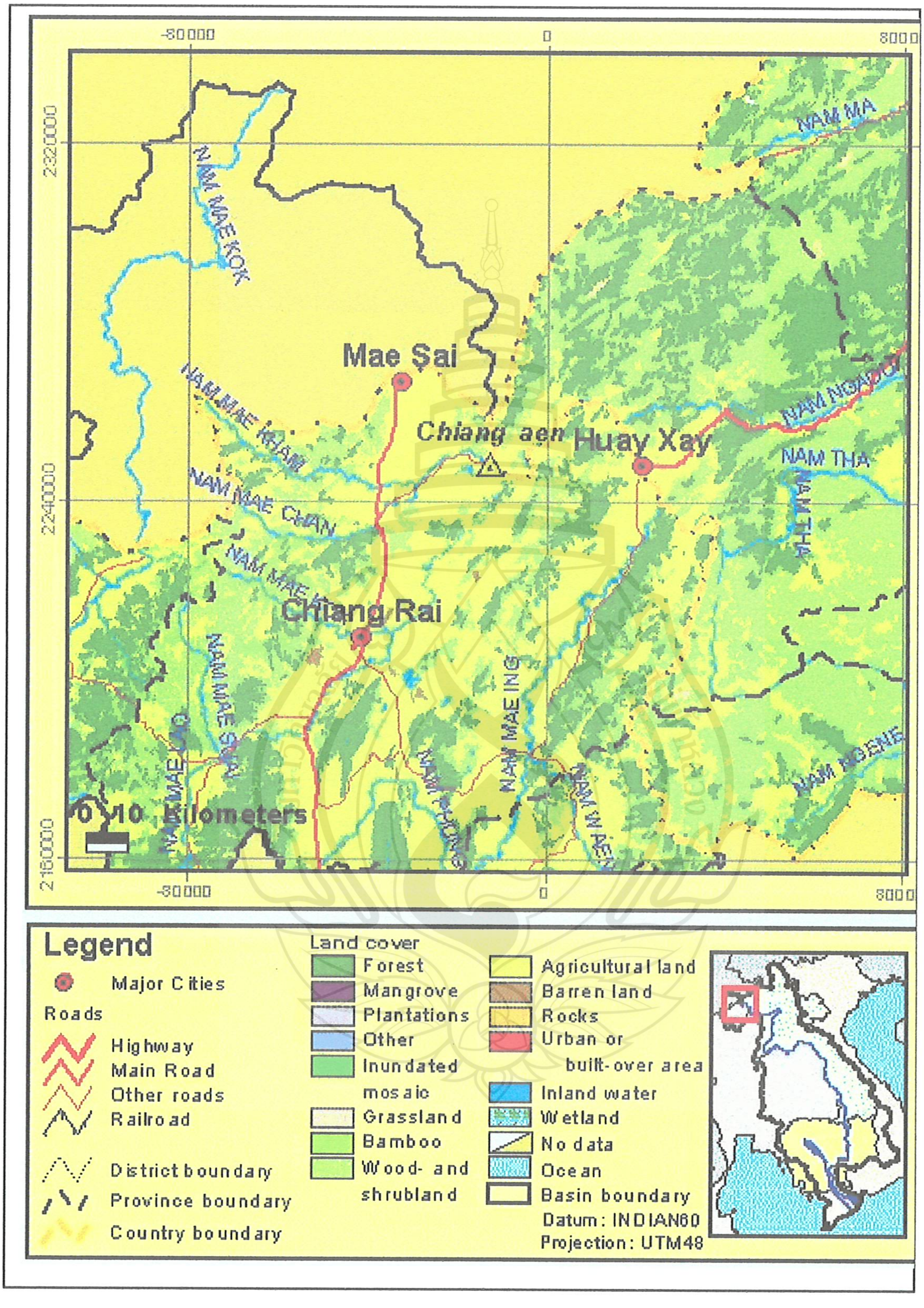


Figure 3-2: The Mekong River Basin in Chiang Rai Province

Source: MRC

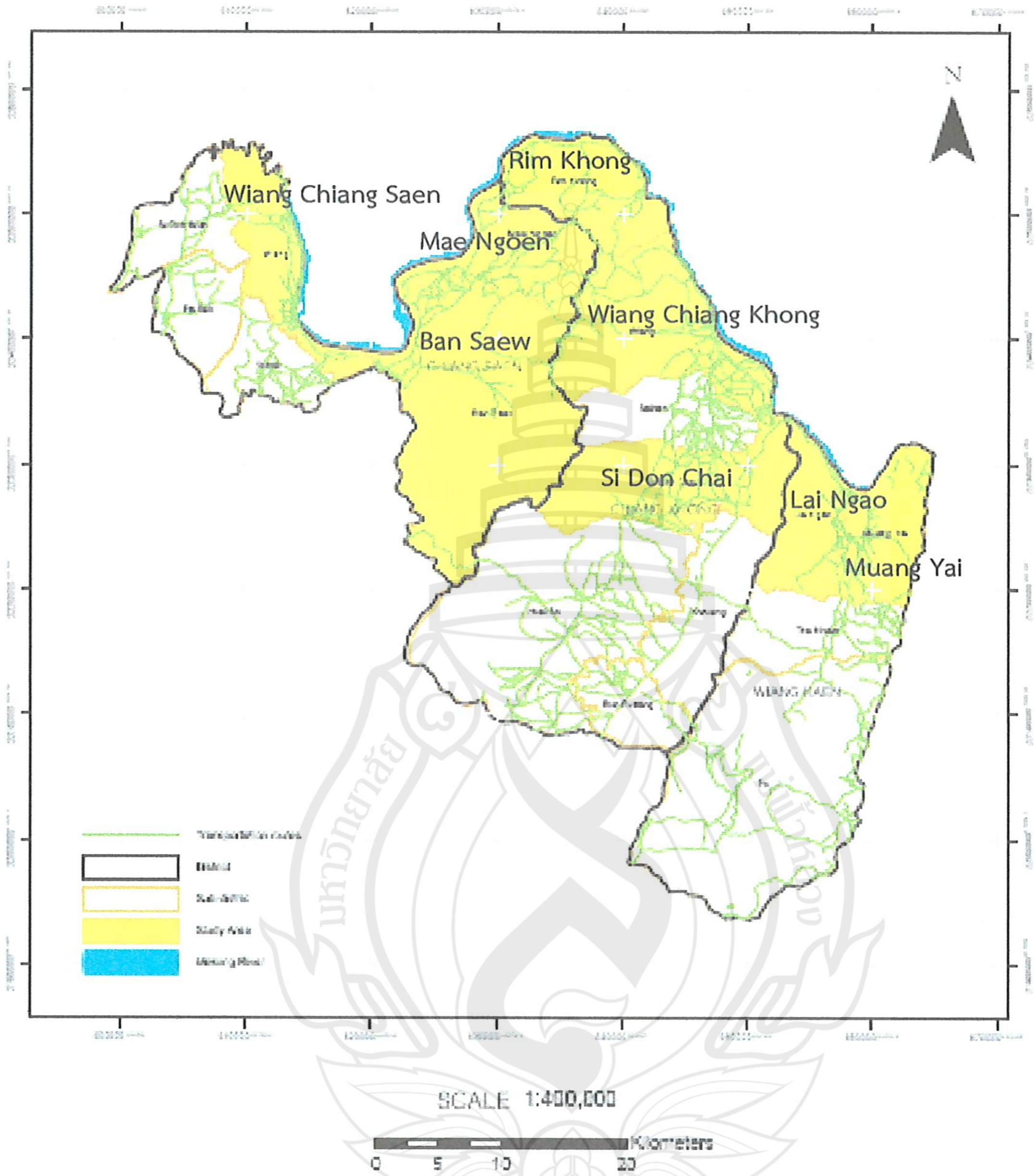


Figure 3-3: Survey Sub-districts along the Mekong River in Chiang Rai Province

Chapter 4
Results and Discussions

4.1. Causes of Drought

4.1.1. Correlations between Upstream Dams and Drought Occurrences

In general, there are many possible causes of drought (and flood). A major cause that is generally agreed upon is the regional climate change reflected by extreme rainfall conditions both locally and regionally. However, there is another possible perceived cause from upstream dams that are often controversial. In this connection, we have attempted to focus on the question related to possible correlations between upstream dams and downstream drought (and flood for supplementary analysis).

In order to answer such a sensitive question, it is important to note that the Mekong river basin in Chiang Saen that is the first entry point from upstream to Thailand receives water from upstream up to 95% in dry seasons, and some 75% in rainy seasons as generally understood. That means droughts and floods in Chiang Saen are mostly dependent on upstream water flows.

In order to relate upstream dams to downstream drought and flood events, a series of upstream dams over time as provided in Table 4-1 is analyzed for discerning some coincidence. First, to the flood event in August 2008, there are a total of three mainstream hydropower dams under operation to that point in time with a combined storage total/active being 3086/873 mcm. As a general safety rule, dams must release water when storages approach full capacity. Such releases if not properly managed in time and quantity can contribute to rapid water flow changes downstream.

To the drought event in early 2010, there is another huge dam added, which is Xiaowan dam. This dam alone has a storage total/active being as high as 14,560/990 mcm, which is resulted from its large size of nearly 300 m in height and 920 m in width. It is easy to imagine how much water that can be stored theoretically in all these four dams combined, and how much water to be kept to ensure a minimum level of water in the dams. The more water stored upstream, the less available downstream. Although no data are available on how much water is exactly stored and filled in the dams, cumulative coincidence in time is likely to be indicative of possible correlations between combined dams (and their operations rules and schemes) upstream and flood and drought events downstream. Such upstream data is really needed for further in-depth analysis.

Table 4-1: Mekong Mainstream Dams in China

Project	Status	Storage (MCM) total / active	Expected installed capacity (MW)	Commissioning
Manwan	operational	920 / 257	1500	1993–1996
Dachaoshan	operational	933 / 367	1350	2001–2004
Jinghong	operational	1233 / 249	1750	2008
Xiaowan	filling and commissioning stage	14,560 / 9900	4200	2009–2011
Gonguoqiao	under construction	510 / 120	750	2012
Nuozhadu	under design	22,400 / 12,300	5500	2014
Ganlanba	under design	– / 0.2	150	before 2025
		Total :	30400	

Sources: (i) Adapted from the presentation, Lancang River Hydropower Development (New Progress) presented by the China Hydropower and Water Resources Planning & Design General Institute Vientiane, Laos, 28 July, 2009
(2) Norplan and EcoLao, Cumulative Impact Assessment and Nam Theun 2 Contributions, Final Report to Government of Lao PDR and Asian Development Bank, October 2004 (except Jinghong: People's Daily Online, 19 June 2008).

Source: Status of existing and planned mainstream hydropower dams in the Lancang-Mekong cascade in Yunnan Province, PRC (January 2010)

A comparison of water levels during the droughts in 1992/1993 (before any upstream dams construction and operation) and 2009/2010 (after the four dams in operations/commissioning) as shown in Figure 4-1 for Chiang Saen reveals several important insights. First, more frequent short-term fluctuations of water level in 2009/2010 are seen clearly during the dry months (from November to April). The figure also shows more oscillations within a month, such as in February, March, November and December in 2009, and in January in 2010. In addition, the water level drops much steeper from the end of January to February to reach the same level in February in 1993. The water level then continues to drop further to the lowest level (see Figure 4-1 for February and March 2010). It is interesting to note here that the rate of decline of water level during the three week period (from 21th February to 10th February in 2010), after the Xiaowan dam, is much steeper than that in the same period in 2009 (see Figure 4-2 for more details).

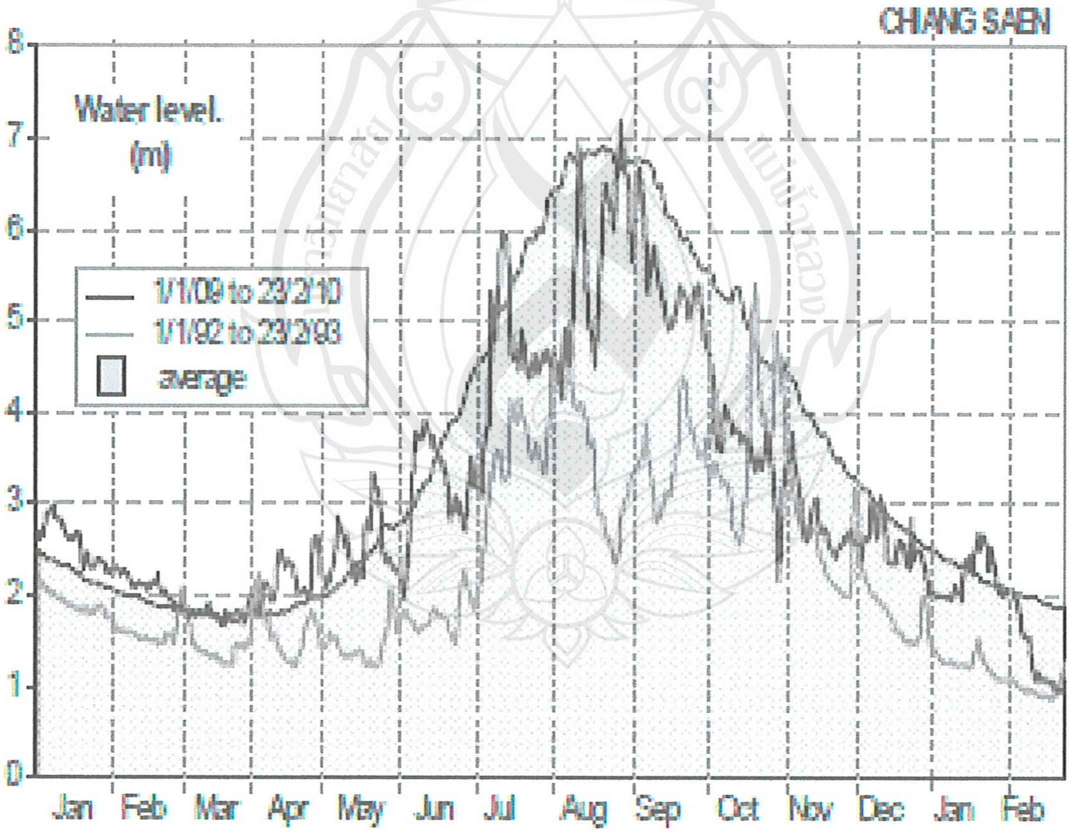


Figure 4-1: Mekong River Water Level in Chiang Saen Station

Source: MRC (2010b)

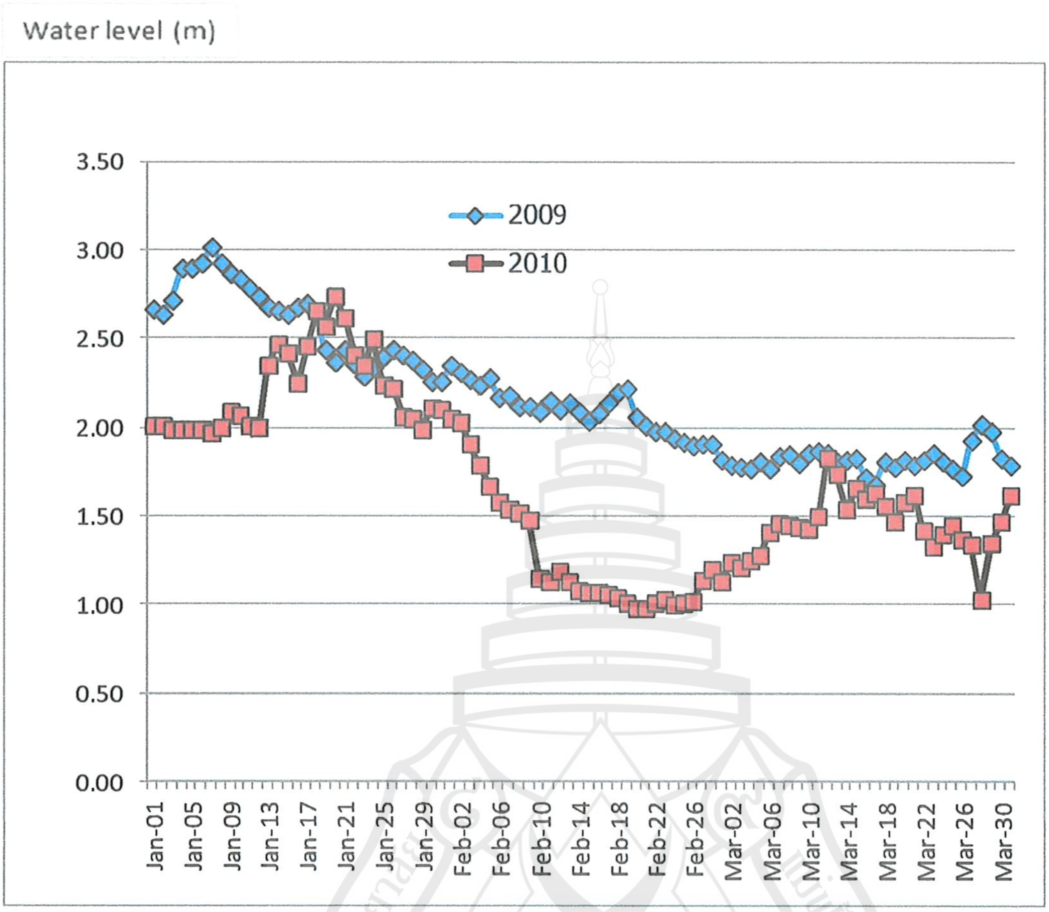


Figure 4-2: Water Level in the Dry Season (2009 and 2010) at Chiang Saen Station

Source: HWMC (Hydrology and Water Management Center, Chiang Saen), 2010

4.1.2. Relationships of River Water Levels and Discharges

A comparison between water level and water discharge (river flowrate) at Chiang Saen station can display a relatively perfect match between these two variables during the drought and flood durations as shown in Figure 4-3 and Figure 4-4, respectively. The correlation coefficients are as high as 0.99 to 0.98, respectively, as seen in Figure 4-5 and Figure 4-6. Combined with extremely low rainfall conditions in the region during the drought months of 2009/2010, as widely recognized (MRC, 2010b), and with an indication of no extremely heavy rainfalls before and during the flood peak in August 2008 (see Figure 4-4), existence of such a match implies that the immediate downstream water level at Chiang Saen station is considerably influenced by upstream flows from dams, as there are no other major lateral flows from upstream dams to Chiang Saen. Note again that discharges at Chiang Saen stations are largely dependent on discharges from the dams with only some phase lag in time (of a few days). More investigations are however needed to better understand if and how upstream flows can be contributed to by other factors other than releases from upstream dams, such as snow melting, landuse change, and/or deforestation.

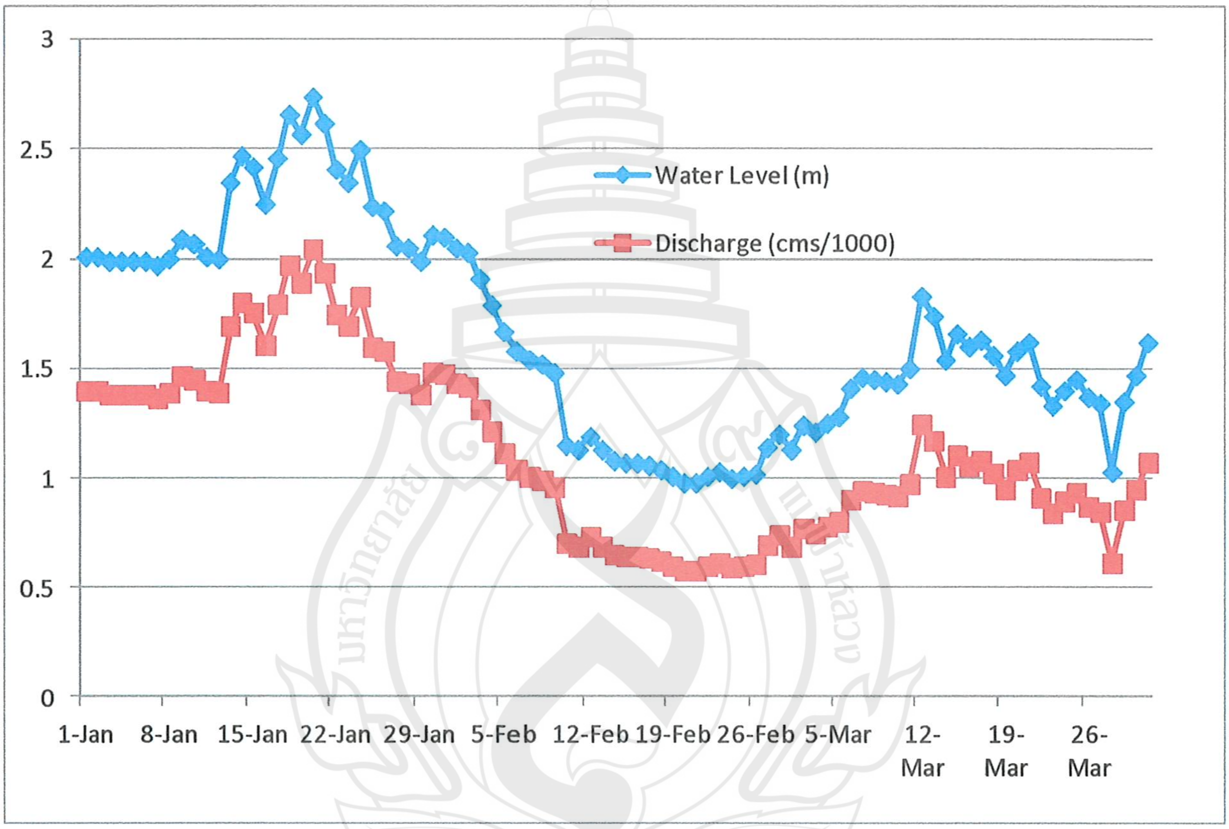


Figure 4-3: Water Level and Discharge in the 2010 Dry Season at Chiang Saen Station

Source: HWMC (Hydrology and Water Management Center, Chiang Saen), 2010

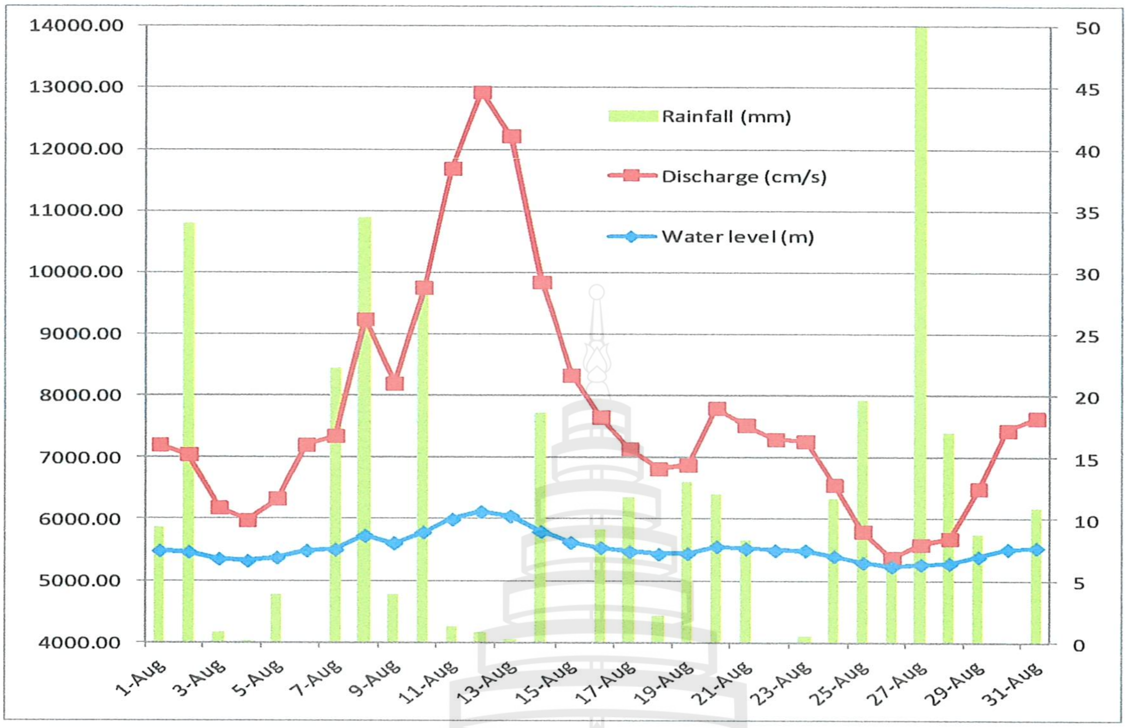


Figure 4-4: Water Level, Discharge and Rainfall in August 2008 at Chiang Saen Station

Source: HWMC (Hydrology and Water Management Center, Chiang Saen), 2010.

Note: Scales for rainfall and water level are on the right vertical axis.

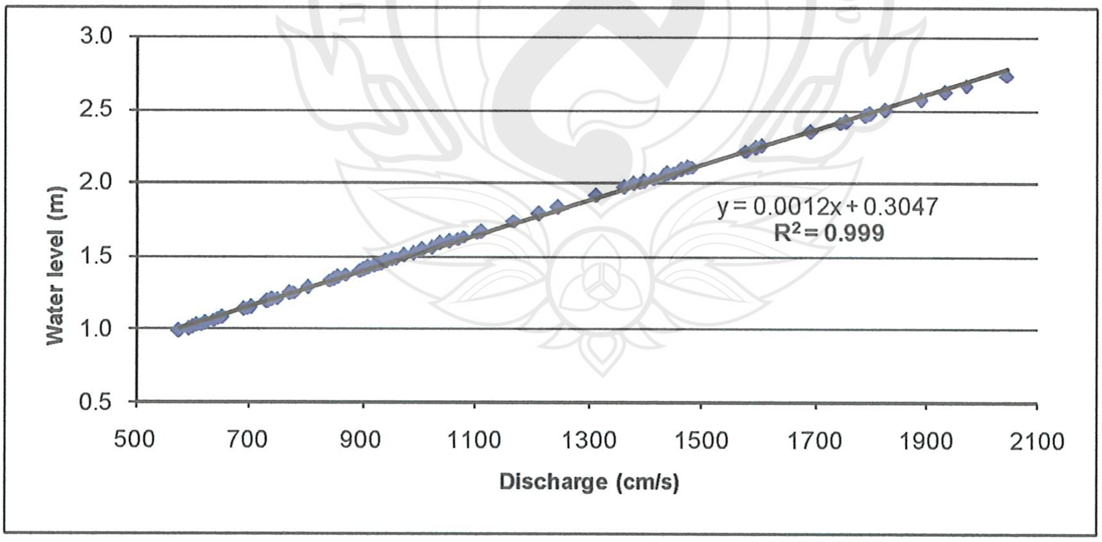


Figure 4-5: Correlation between Discharge and Water Level at Chiang Saen Station during the 2010 Drought Period (January 1 to March 31)

Source: HWMC (Hydrology and Water Management Center, Chiang Saen), 2010

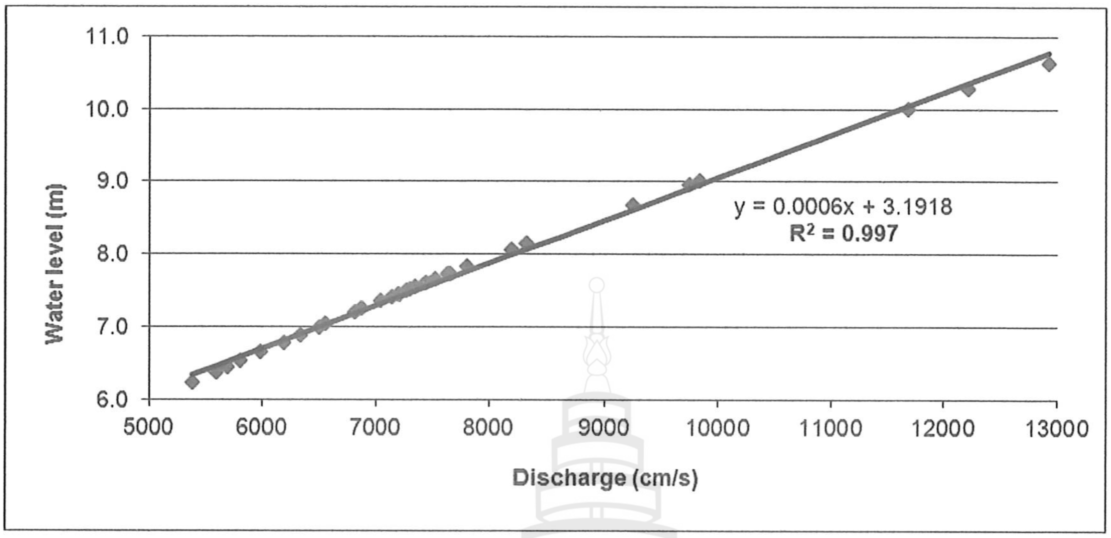


Figure 4-6: Correlation between Discharge and Water Level at Chiang Saen Station during the 2008 Flood Period (August 1 to August 31)

Source: HWMC (Hydrology and Water Management Center, Chiang Saen), 2010

4.1.3. Evidences of Rainfall Pattern Changes

Besides upstream impacts, there may be other important causes from climate change. Because of time constraints, we have managed to check only if there are possible changes detected of rainfall patterns over time at Chiang Saen. The answer is affirmative indeed as shown in Figure 4-7 that compares the rainfalls in 2009 and 2010 with the historical long-term monthly average data from 1960 to 2004 and the recent monthly average (from 2001 to 2010). It is seen clearly that the rainfall at Chiang Saen station from June to December 2009 and to February 2010 is considerably much less than normal, and also ends earlier than normal, which makes a prolonged lack of rain. This below normal rainfall situation is another cause of the drought.

In addition, it is also observed that the historical long-term monthly average data from 1960 to 2004 shows the monthly rainfall pattern with only a peak in August, but the recent monthly data from 2001 to 2010 clearly indicates rainfall pattern changes from one peak to two peaks, in addition to much larger deviations from the long-term average.

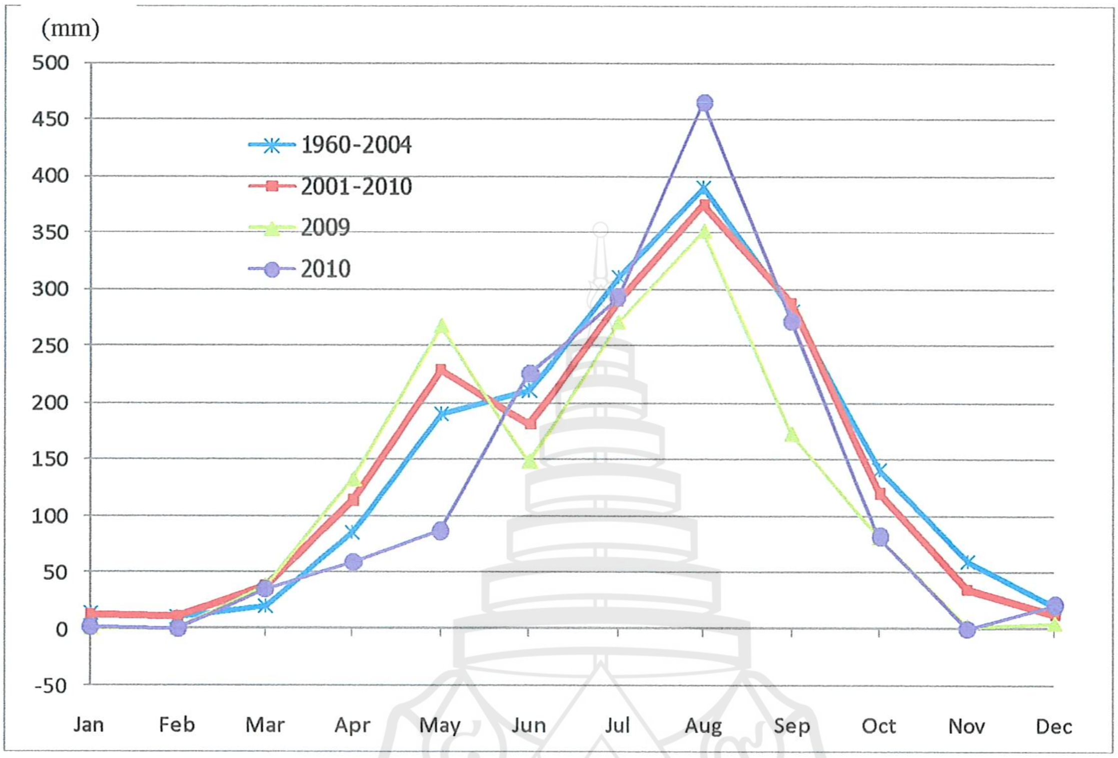


Figure 4-7: Changes in Rainfall Patterns at Chiang Saen Station

Source: HWMC (2010) for 2001-2010 data, and MRC (2005) for 1960-2004 data

4.1.4. Drought Causes Perceived by Local Villagers

In addition to hydro-meteorological data as analyzed so far, we also attempt to assess drought causes as perceived from local people in various sub-districts in our study area through our questionnaires designed. It is interesting to find out that, according to the respondents, droughts are caused mostly by climate change (28%), followed by a prolonged lack of rain (25.5%), and a depletion of precipitation over time (21%). In addition, respondents also thought that upstream hydropower dams (14%) and deforestation (12%) are additional causes accounting for the long story of the 2010 drought (See details in Table 4-2). In particular, causes from upstream hydropower dams are most felt by the three sub-districts of Ban Saew, Si Don Muang, and Muang Yai, perhaps due to lowest water levels seen clearly in the Mekong river in these sites. It should be noted here that these local perceptions should be used mainly for cross-references.

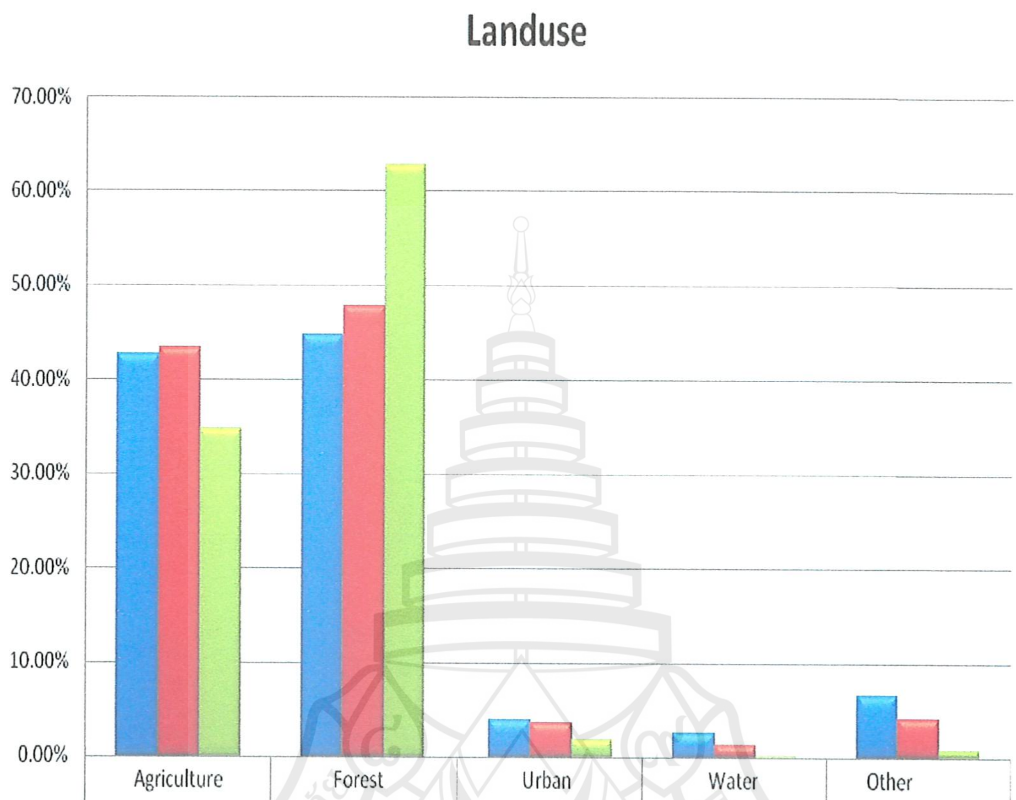
Table 4-2: Causes of Drought Perceived by Survey Sub-districts by Number and Percentage of Survey Responses

Causes		Chiang Saen District			Chiang Khong District			Wiang Kaen District		Total
		Wiang Chiang Saen	Mae Ngoen	Ban Saew	Rim Khong	Wiang Chiang Khong	Si Don Chai	Lai Ngao	Muang Yai	
Survey sample	persons	189	105	151	95	324	47	37	25	973
Declining precipitation	count	60	10	17	43	146	13	3	5	297
	% of total	31.75%	9.52%	11.26%	45.26%	45.06%	27.66%	8.11%	20.00%	30.52%
Prolonged lack of rain	count	25	17	27	64	179	10	34	7	363
	% of total	13.23%	16.19%	17.88%	67.37%	55.25%	21.28%	91.89%	28.00%	37.31%
Deforestation	count	5	21	18	40	48	15	11	11	169
	% of total	2.65%	20.00%	11.92%	42.11%	14.81%	31.91%	29.73%	44.00%	17.37%
Climate change	count	69	29	25	47	143	28	32	22	395
	% of total	36.51%	27.62%	16.56%	49.47%	44.14%	59.57%	86.49%	88.00%	40.60%
Hydropower dams	count	1	6	23	39	98	17		13	197
	% of total	.53%	5.71%	15.23%	41.05%	30.25%	36.17%		52.00%	20.25%
Other	count			1						1
	% of total			.66%						.10%

4.2. Impacts of Drought

4.2.1. Local Livelihood Dependence on Water Resources

In order to serve as a sound basic for impact and adaptation assessment of drought, an initial assessment is made of current livelihood conditions, especially in terms of dependence of water and water related resources. The overall baseline data are analyzed from questionnaire designed and responded by local villagers. In particular, the aim of the survey on current livelihood situation is to obtain general information on household members, occupations, fishing, inland aquaculture, collection of other aquatic animals, collection of useful plants, inland agriculture/ riverbank gardening, key sources of income, etc. Major landuse types in the study area that have been compiled from different sources are for agriculture, beside forestry, as shown in Figure 4-8.



	Agriculture	Forest	Urban	Water	Other
Chiang Saen	42.68%	44.67%	3.81%	2.39%	6.46%
Chiang Khon	43.34%	47.78%	3.57%	1.23%	4.01%
Wiang Kaen	34.64%	62.78%	1.79%	0.12%	0.66%

Figure 4-8: Major Landuse Types in the Study Area

The data from local responses show that farming is the main occupation of 39% of household members, especially for non-youth members. Geographical deviations of the main occupation (farming) appears to be high (see in Table 4-3), in the three sub-districts, namely Lai Ngao (90%), Muang Yai (71%), and Rim Khong (65%), indicating farming concentration more toward south of the Mekong river. Moreover, it appears that farming diversification is very limited, indicating more risks to farmers under unfavorable conditions. Maize is seen as dominating crop as practiced by majority of households (61%), followed by rice (20%), and beans (8%). These crops are mainly rain-fed, and cultivated along the river side (55%). Irrigation coverage and efficiency seem to be low, with more than two-third (69%) of households reporting that irrigation schemes are not available or not in operation.

Table 4-3: Most Important Occupations by Survey Sub-districts by Number and Percentage of Survey Responses

Main Occupation		Chiang Saen District			Chiang Khong District			Wiang Kaen District		Total
		Wiang Chiang Saen	Mae Ngoen	Ban Saew	Rim Khong	Wiang Chiang Khong	Si Don Chai	Lai Ngao	Muang Yai	
Survey sample	Persons	191	105	151	95	324	47	52	25	990
Fishing	Count	35	7	5		13	13			73
	% of total	18.32%	6.67%	3.31%		4.01%	27.66%			7.37%
Collecting other aquatic animals	Count			2			1			3
	% of total			1.32%			2.13%			.30%
Collecting edible plants	Count	2	3	6		1				12
	% of total	1.05%	2.86%	3.97%		.31%				1.21%
Fish processing	Count			2			2			4
	% of total			1.32%			4.26%			.40%
Fish marketing	Count	13	3	4			2			22
	% of total	6.81%	2.86%	2.65%			4.26%			2.22%
Net making/repairing	Count			2			2			4
	% of total			1.32%			4.26%			.40%
Marketing other water-dependent products	Count	2	1				1			4
	% of total	1.05%	.95%				2.13%			.40%
Riverbank gardening	Count			5		1	9			15
	% of total			3.31%		.31%	19.15%			1.52%
Aquaculture	Count			1			4			5
	% of total			.66%			8.51%			.51%
Farming	Count	137	28	87	60	74	16	45	17	464
	% of total	71.73%	26.67%	57.62%	63.16%	22.84%	34.04%	86.54 %	68.00%	46.87%
Farm labourer	Count		21	17	2		8	1		49
	% of total		20.00%	11.26%	2.11%		17.02%	1.92%		4.95%
Hotel/Homestay	Count	2		4						6
	% of total	1.05%		2.65%						.61%
Port laborer	Count	1								1
	% of total	.52%								.10%
Collecting fuelwood	Count			2			1			3
	% of total			1.32%			2.13%			.30%

Main Occupation		Chiang Saen District			Chiang Khong District			Wiang Kaen District		Total
		Wiang Chiang Saen	Mae Ngoen	Ban Saew	Rim Khong	Wiang Chiang Khong	Si Don Chai	Lai Ngao	Muang Yai	
Government officers/civil servants	Count			2	3	26				31
	% of total			1.32%	3.16%	8.02%				3.13%
Other permanent employment	Count	1	2	5	6	1		1	1	17
	% of total	.52%	1.90%	3.31%	6.32%	.31%		1.92%	4.00%	1.72%
Students	Count	2			1					3
	% of total	1.05%			1.05%					.30%
Business	Count	12	1	9	9	101		1	3	136
	% of total	6.28%	.95%	5.96%	9.47%	31.17%		1.92%	12.00%	13.74%
House work	Count	3	6	7	3	7	5		1	32
	% of total	1.57%	5.71%	4.64%	3.16%	2.16%	10.64%		4.00%	3.23%
Other irregular work	Count	40	56	53	11	123	8	4	2	297
	% of total	20.94%	53.33%	35.10%	11.58%	37.96%	17.02%	7.69%	8.00%	30.00%
No job	Count			2		10				12
	% of total			1.32%		3.09%				1.21%

Relatively few members (12%) describe fishing and other water dependent activities (such as collecting other aquatic animals, edible plants, fish processing and marketing, net making/repairing, marketing other water-dependent products, riverbank gardening, and aquaculture) as their main occupation. A closer look at geographical difference reveals clear uneven distribution pattern. Fishing is mainly concentrated in the three sub-districts of Si Doi Chang (26%) and Wiang Chiang Saen (21%), and Mae Ngoen (%), which are located in upper and lower riches of the Mekong river. Fish is mainly caught from the Mekong mainstream. Boats with engine are used by most fishing households (38%). Most households consumed some of the fish caught, leaving the bulk of the catch for sale, which underlines the dependence of urban and other areas on this catch.

Collecting useful plants and other aquatic animals is seen mainly in the three sub-districts of Ban Saew (4%), Mae Ngoen (2.5%) and Si Doi Chang (1.5%). The main types collected are Kai, a famous Mekong water weed, which stands out as 77%, followed by morning glory (18%) and vegetables (3%). River gardening is largely concentrated in the two sub-districts of Si Doi Chang (26%) and Ban Saew (2.5%).

If farming, fishing and other water dependent activities are taken as a whole, more than half (55%) of the household members are involved. There is some indication of division of work by gender with men being more predominant in fishing and fishing-related activities and also in farming and government services, and with women being more engaged in riverbank gardening, fish-related product marketing, business or farm labouring, and housework.

A substantial number of households (77%) are found to have no second occupation as seen in Table 4-4, indicating their vulnerability to change, should their primary occupation come under threat, which is particularly noticeable in Wiang Chiang Saen, Mae Ngoen, Ban Saew, Rim Khong, Wiang Chiang Khong and Lai Ngao sub-districts. The second occupations are seen as mainly fishing (6%), irregular job (6%) and farming (4%). The importance of fishing emerges very clearly in Si Don Chai sub-district where 43% cited this as their second most important occupation, followed by Muang Yai sub-district (24%). Irregular work stands out for Muang Yai, as 32% of the household cite other irregular work as their second most important occupation, far higher than in any other sub-districts (the next one is 17% in Si Don Chai and 15% in Lai Ngao). Farming is predominant in Wiang Chiang Khong (7%) and Si Don Chai (6.5%)

Table 4-4: Second Most Important Occupations by Survey Sub-districts by Number and Percentage of Survey Responses

Main Occupation		Chiang Saen District			Chiang Khong District			Wiang Kaen District		Total
		Wiang Chiang Saen	Mae Ngoen	Ban Saew	Rim Khong	Wiang Chiang Khong	Si Don Chai	Lai Ngao	Muang Yai	
No second most important occupations	Count (persons)	178	84	93	83	270	7	41	7	763
	% of total	93.19%	80.00%	61.59%	87.37%	83.33%	14.89%	78.85%	28.00%	77.07%
Fishing	Count		4	17	3	12	20		6	62
	% of total		3.81%	11.26%	3.16%	3.70%	42.55%		24.00%	6.26%
Farming	Count	1	6	7		22	3	1	1	41
	% of total	.52%	5.71%	4.64%		6.79%	6.38%	1.92%	4.00%	4.14%
Business	Count	2	2	11	3	17		1	2	38
	% of total	1.05%	1.90%	7.28%	3.16%	5.25%		1.92%	8.00%	3.84%
Other irregular work	Count	9	7	19	2	2	8	8	8	63
	% of total	4.71%	6.67%	12.58%	2.11%	.62%	17.02%	15.38%	32.00%	6.36%

Main Occupation		Chiang Saen District			Chiang Khong District			Wiang Kaen District		Total
		Wiang Chiang Saen	Mae Ngoen	Ban Saew	Rim Khong	Wiang Chiang Khong	Si Don Chai	Lai Ngao	Muang Yai	
Sub-total	Count	190	103	147	91	323	38	51	24	967
	% of total	99.47%	98.09%	97.35%	95.80%	99.69%	80.84%	98.07%	96.00%	97.67%

4.2.2. Impacts of Declining Resource Productivity

General impacts are assessed broader through responses of local villagers to the questionnaires. The fishing households have perceived a significant time-spent increase in catching fish by more than 5 hours (57.25%) and 37.68% of households spent 5-10 hours on fishing as compared to 5 years ago. They also have had perceived a significant decline in fish catch over the last five years (see Table 4-5). Across all sites, the overall decline combined is reported by 81% of households, while only 3% of total households see an improvement in catch, although some 8% of fishing households which reported 'much more' fish being on the Muang Yai sub-district, the most downstream area (where water level may not be much affected). Decline in fish catch is perceived by all households in Wiang Chiang Saen (100%), followed by Si Don Chai (85%).

Perceived causes of fish catch decline are predominant by decline in fish and disappearance of some species (27%), in addition to an increase of number of fishermen (26%), hence more competition, and abnormal water level fluctuation (12%), then reduced water level (11%). Perceived consequences of change are less income as reported by majority of households (80%), most notably in Wiang Chiang Saen (100%) and Wiang Chiang Khong (92%). Another important consequence is less food reported by an average of 11% of all households, but as high as 50% in Rim Khong sub-district. More critically, about 3% of households had to change fishing occupation, especially in Rim Khong (17%).

Table 4-5: Perceived Trends in Fish Catch and Causes by Survey Sub-districts by Number and Percentage of Survey Responses

	Chiang Saen District			Chiang Khong District			Wiang Kaen District		Total
	Wiang Chiang Saen	Mae Ngoen	Ban Saew	Rim Khong	Wiang Chiang Khong	Si Don Chai	Lai Ngao	Muang Yai	
Perceived trends in fish catch									
Little less (# and % of responses)	26	4	15	5	13	19		9	91
	83.87%	36.36%	37.50%	71.43%	43.33%	57.58%		69.23%	55.15%
Less (# and % of responses)	3	2	8		6	3			22
	9.68%	18.18%	20.00%		20.00%	9.09%			13.33%
Much less (# and % of responses)	2	1	6		5	6		1	21
	6.45%	9.09%	15.00%		16.67%	18.18%		7.69%	12.73%
Sub-total (# and % of responses)	31	7	29	5	24	28	0	10	134
	100.00%	63.63%	72.50%	71.43%	80.00%	84.85%	0.00%	76.92%	81.21%
Perceived causes of change									
Decline in fish and disappearance of species (# and % of responses)	1	2	7	1	18	5		9	43
	2.78%	33.33%	16.28%	16.67%	62.07%	17.24%		69.23%	26.54%
Reduced water level (# and % of responses)	1	1	4	1	7	4			18
	2.78%	16.67%	9.30%	16.67%	24.14%	13.79%			11.11%
Uncertainly in water level fluctuations (# and % of responses)	1		9	3	1	5			19
	2.78%		20.93%	50.00%	3.45%	17.24%			11.73%
Increased water quantity (# and % of responses)					1	1			2
					3.45%	3.45%			1.23%
competition from more fishermen (# and % of responses)	29	1	7		1	4			42
	80.56%	16.67%	16.28%		3.45%	13.79%			25.93%
Sub-total (# and % of responses)	32	4	27	5	28	19	0	9	124
	88.90%	66.67%	62.79%	83.34%	96.56%	65.51%	0.00%	69.23%	76.54%

Collection of other aquatic animals also shows a decline tendency as reported by majority of households (76%), which has adverse impacts on income reported by 54% of householdes and on food security of 40% of all the household. More critically, about 98% of households perceived apparent decline in quatic animals collected in Wiang Chiang Saen. Collection of useful plants (notably, Kai) also shows a decline tendency as reported by most of households (86%), which has adverse food security impacts on more than one-thirds of all the households (35%). More critically, about 3% of households had to change fishing occupation, especially in Rim Khong (17%).

Decline in crop production including riverbank gardening (see Table 4-6) is reported by majority of farmers (80%), which is contributed by a decline in yield as perceived by 71% of the farmers. Drought stands as 23% of all the causes as recognized by farmers.

Table 4-6: Crop Cultivation and Yield Trend by Survey Sub-districts by Number and Percentage of Survey Responses

	Chiang Saen District			Chiang Khong District			Wiang Kaen District		Total
	Wiang Chiang Saen	Mae Ngoen	Ban Saew	Rim Khong	Wiang Chiang Khong	Si Don Chai	Lai Ngao	Muang Yai	
Crops cultivated									
Total sample (persons)	132	**98**	148	95	321	45	**32**	24	**895**
Maize (# and % of responses)	82	18	26	37	56	20	29	12	280
	62.12%	18.56%	17.57%	38.95%	17.45%	44.44%	90.63%	50.00%	31.32%
Rice (# and % of responses)	2	8	6	1	42	2	24	7	92
	1.52%	8.16%	4.05%	1.05%	13.08%	4.44%	75.00%	29.17%	10.28%
Location of crops culativated									
Total sample (persons)	**99**	98	**146**	**95**	321	**45**	**21**	24	**849**
Foothills (# and % of responses)	24	9	7	22	32	6	10	10	120
	24.24%	9.18%	4.79%	23.16%	9.97%	13.33%	50.00%	41.67%	14.15%
Riverside (# and % of responses)	23	7	16	40	64	24	8	8	190
	23.23%	7.14%	10.96%	42.11%	19.94%	53.33%	38.10%	33.33%	22.38%
Change in yields in the last five years									
Increase (# and % of responses)		2	7	28	4	3		8	52
		2.67%	4.96%	29.79%	1.25%	6.67%		33.33%	6.76%
Decline (# and % of responses)		5	11	33	66	26	10	9	160
		6.67%	7.80%	35.11%	20.63%	57.78%	52.63%	37.50%	20.81%
Sub-total (# and % of responses)		7	18	61	70	29	10	17	212
		9.34%	12.76%	64.90%	21.88%	64.45%	52.63%	70.83%	27.57%
Perceived causes of change									
Droughts (# and % of responses)			1	19	6	7	5	7	45
			.72%	20.21%	1.88%	15.56%	33.33%	30.43%	5.91%

	Chiang Saen District			Chiang Khong District			Wiang Kaen District		Total
	Wiang Chiang Saen	Mae Ngoen	Ban Saew	Rim Khong	Wiang Chiang Khong	Si Don Chai	Lai Ngao	Muang Yai	
High expenses (# and % of responses)				15	52	10			77
				15.96%	16.25%	22.22%			10.10%
Sub-total (# and % of responses)			1	34	58	17	5	7	122
			0.72%	36.17%	18.13%	37.78%	33.33%	30.43%	16.01%

Overall economic impacts in all the study sites are found out to be severe by majority of households, notably in fish catch reduction by 85% (of households), followed by riverbank gardening (83%), paddy/rice cultivation (80%), and other crops (77%). Beside economic impacts, social impacts of drought appear to be insignificant, although there are some signs of out-migration. Some social conflicts stand out as in water use conflict as perceived 29% of households, followed by political conflict (23%), management conflict (22%). In addition, according to the respondents, there has been a slight tendency (7.5%) for local people who had to change their occupation because of declining resource productivity, notably in Muang Yai, Ban Saew and Si Don Chang.

4.2.3. Specific Impacts of Drought

Specific impacts of the 2010 drought are further assessed specifically by focus group discussions. After the overall picture is outlined, the two villages (Ban Xaew and Ban Hat Khrai) with adverse impacts are selected for more concrete assessments of the drought impacts. It is noted here that both social and ecological impacts of the drought are not perceived as significant by the villagers. The major impacts are economic impacts that are in the same lines with the impacts that have been analyzed earlier for the three sub-districts, namely on fish catch, river weed collection, riverbank gardening and agricultural crops. However, more specific impacts in these target villages are provided below.

The first severe impacts are a substantial decline of fish stocks of most of fish species (such as Mekong Giant Fish, Julliens mud carp, Sheatfish, Striped catfish, and Redtail catfish). This decline leads to a decline of fish catches, which then reduces the incomes from fish catches by as high as 50% in the second village. Additional causes include more fishermen and some destructive fishing tools (such as using gill nets) along with some explosive methods used from the Lao side.

The second impacts are river weeds, especially in the second village, and agricultural crops in the first village. Regarding river weeds, both quality and quantity of river weeds (notably Kay) decline, mainly due to low water level and rapid water fluctuations, and partially to waste water from river boats and ships. Agricultural products in the first village decline by as very high as 90%, especially in 2010 and 2011 with the income from these products reduced to Baht 3,000 from Bath 30,000. The major reasons are reported as decline in water level.

The third impacts are on riverbank gardening, more notably in the second village, as it depends on water in the Mekong river to grow various vegetable types (such as Chinese cabbages, broccoli, cabbages and tomatoes) and some cash crops (as maize). Decline of income from all riverbank gardening products is reported by 30% for the second village.

The fourth impacts are on boat traveling, especially for tourist boats (in the first village), and water supply from Mekong river for both residential and agricultural purposes (in the second village).

4.3 Adaptations to Drought

4.3.1 General Adaptations

As a normal practice in Thailand, a compensation for natural damages (such as from droughts and floods) is provided to impacted people after necessary assessments. The total support from many sources (as shown in Table 4-7) to compensate various damages for drought affected households is assessed overally by local people is relatively sufficient at the comparable high level from 77% to 86% for each type of economic impacts (fishing, riverbank gardening, paddy/rice cultivation, and other crops). On the average, support is highest from local government (55%), followed by national government (25%), and community (10%). There are some apparent deviations across study sites: highest level of support as compared with average is found out at Si Don Chai (70%) and Muang Yai (67%) from local government, at Wiang Chiang Khong (25%) from national government, and at Mae Ngoen (29%) and

Wiang Chiang Saen (23%) from local community. Such spatial variations clearly disclose some different management weaknesses and strengths across sub-districts and can be used as important lessons learnt for better reduction of impacts on affected local residents.

Table 4-7: Support for Damage Compensation by Survey Sub-districts by Number and Percentage of Responses

Supporter from drought demaged	Chiang Saen District			Chiang Khong District			Wiang Kaen District		Total
	Wiang Chiang Saen	Mae Ngoen	Ban Saew	Rim Khong	Wiang Chiang Khong	Si Don Chai	Lai Ngao	Muang Yai	
Survey sample (persons)	189	105	151	95	324	47	35	25	971
National Government (# and % of responses)	2	4	15	28	181	8	12	6	256
	1.06%	3.81%	9.93%	29.47%	55.86%	17.02%	34.29%	24.00%	26.36%
Local Government (# and % of responses)	8	27	43	76	309	42	33	21	559
	4.23%	25.71%	28.48%	80.00%	95.37%	89.36%	94.29%	84.00%	57.57%
International NGOs (# and % of responses)			1	1	1	1	2		6
			.66%	1.05%	.31%	2.13%	5.71%		.62%
Local NGOs (# and % of responses)		1	12			1	6		20
		.95%	7.95%			2.13%	17.14%		2.06%
Family/Friends (# and % of responses)		2	11	35	2	1	6	2	59
		1.90%	7.28%	36.84%	.62%	2.13%	17.14%	8.00%	6.08%
Community (# and % of responses)	3	14	13	46	8	7	15	2	108
	1.59%	13.33%	8.61%	48.42%	2.47%	14.89%	42.86%	8.00%	11.12%

Now we move to assess adaptation strategies by local people as seen in Table 4-8. Overall, most respondents in all sub-districts believed it would be difficult to find an alternative to their current water-dependent livelihood activity, with 71% being unable to think of any alternative to their current activities in the event of a significant decline in the productivity of current resources like drought occurrence, notably in Wiang Chiang Khong and Rim Khong districts. Some possible options are however available and can be adopted. Households are likely to shift to farming (11%), followed by seek additional employment (7%) and collecting edible plants and other useful plants (6%). The options are more promising in Ban Saew with 22.5% of household seeing a range of alternatives with farming such as irrigated rice, rain-fed rice, and maize. Changes of crops are more pronounced options for Si Don

Chai and Muang Yai. Aquaculture is desirable option for Si Don Chai. There are also some indications of need to out-migrate to urban areas.

Furthermore, at the community level, desirable options stand out as building of storage tanks and ponds for collecting excess rainfall water (52%), followed by development of mountain-baed water supply (31%), and pipeline extension installation (25%). More details are provided in Table 4-9. Development of water storages is most important for the three sub-districts of Wiang Chiang Khong, Rim Khong and Lai Ngao, while development of mountain-based water supply system is pronounced in the three sub-districts of Rim Khong, Muang Yai and Lai Ngao, and water supply extention need is more important in Lai Ngao and Rim Khong sub-districts.

Table 4-8: Perceived Alternative Individual Livelihood Options by Survey Sub-districts by Number and Percentage of Responses

Perceived Alternatives	Chiang Saen District			Chiang Khong District			Wiang Kaen District		Total
	Wiang Chiang Saen	Mae Ngoen	Ban Saew	Rim Khong	Wiang Chiang Khong	Si Don Chai	Lai Ngao	Muang Yai	
Survey sample (persons)	**189**	**105**	**151**	**95**	**324**	**47**	**49**	**25**	**985**
- Cannot think of anything/ No alternative suggested	153	57	29	86	318	14	33	13	703
	80.95	54.29	19.21	90.53	98.15	29.79	67.35	52.00	71.37
- Shift to another natural resource based activity		7	8		2	11	1	7	36
		6.67	5.30		0.62	23.40	2.04	28.00	3.65
- Shift to livestock rearing			4			1		1	6
			2.65			2.13		4.00	0.61
- Shift to farming (e.g. irrigated rice; rainfed rice; cassava; maize)	1	20	34	10	3	32	2	9	111
	0.53	19.05	22.52	10.53	0.93	68.09	4.08	36.00	11.27
- Seek employment locally		20	15	8	5	9	1	8	66
		19.05	9.93	8.42	1.54	19.15	2.04	32.00	6.70
- Changing crops	1	8	5	7		15		6	42
	0.53	7.62	3.31	7.37		31.91		24.00	4.26
- Migration									
To urban areas			3		1	3		3	10
			1.99		0.31	6.38		12.00	1.02

Perceived Alternatives	Chiang Saen District			Chiang Khong District			Wiang Kaen District		Total
	Wiang Chiang Saen	Mae Ngoen	Ban Saew	Rim Khong	Wiang Chiang Khong	Si Don Chai	Lai Ngao	Muang Yai	
Across rural communities			1					2	3
			0.66					8.00	0.30
Other destinations								2	2
								8.00	0.20
- To start doing something, examples									
Raising animals	2	3	12	7		8	3	2	37
	1.06	2.86	7.95	7.37		17.02	6.12	8.00	3.76
Collecting non-timber forest products (NTEPs)	1	3	4	3	3	1		1	16
	0.53	2.86	2.65	3.16	0.93	2.13		4.00	1.62
Collecting edible/useful plants	6	4	17	24	3	2	2	2	60
	3.17	3.81	11.26	25.26	0.93	4.26	4.08	8.00	6.09
Collecting other aquatic animals	1	1	7	5	2	3		1	20
	0.53	0.95	4.64	5.26	0.62	6.38		4.00	2.03
Handicraft		1	2					1	4
		0.95	1.32					4.00	0.41
Aquaculture	3	2	10	3		7			25
	1.59	1.90	6.62	3.16		14.89			2.54
Fish processing/marketing	5		4		2	7		3	21
	2.65		2.65		0.62	14.89		12.00	2.13
Fish marketing	2		3	1	1	2			9
	1.06		1.99	1.05	0.31	4.26			0.91
- Borrow money or food	1	6	15	5	10	5	1	3	46
	0.53	5.71	9.93	5.26	3.09	10.64	2.04	12.00	4.67
- Reliance on help from others		5	10	1	1	2	1	1	21
		4.76	6.62	1.05	0.31	4.26	2.04	4.00	2.13
- Other			4						4
			2.65						0.41

Table 4-9: Perceived Alternative Community Options by Sub-districts by Number and Percentage of Responses

Perceived alternative	Chiang Saen District			Chiang Khong District			Wiang Kaen District		Total
	Wiang Chiang Saen	Mae Ngoen	Ban Saew	Rim Khong	Wiang Chiang Khong	Si Don Chai	Lai Ngao	Muang Yai	
Survey sample (persons)	189	105	151	95	324	47	49	25	985
More water storage tanks/ponds (# and % of responses)		44	26	74	300	18	35	10	507
		41.90	17.22	77.89	92.59	38.30	71.43	40.00	51.47
Develeopmet of mountain water supply (# and % of responses)	1	43	27	93	56	28	37	19	304
	0.53	40.95	17.88	97.89	17.28	59.57	75.51	76.00	30.86
Pipelink installation (# and % of responses)	3	44	30	72	20	14	37	11	231
	1.59	41.90	19.87	75.79	6.17	29.79	75.51	44.00	23.45
Other (# and % of responses)		1	7	1				1	10

4.3.2 Specific Adaptations to Drought

The focus group discussions for the two villages of severe impacts from the drought reveal several important insights for adaptations. These villages are Ban Xaew and Ban Hat Khrai.

First, in both villages, compensation for crop damages by the government is provided for local famers (in the following year). It is noted that there are various impacts as analyzed, but compensation is mainly for impacts on grown crops. Immediate compensations can be considered as a quick adaptation to the drought by higher administrative units.

Besides the compensation by the government, adaptations by local people at both individual household and village levels are rather limited and vary from village to village. More active adaptations are seen in the first village than in the second one.

In the first village (Ban Xaew), the current adaptation methods are changing some crops grown, digging groundwater wells and ponds, and constructing of weirs. A typical crop is changed to soybeans, although rice is still preferred if water is available. Some wells and ponds are digged in the soil as deeply as 16 meters. Some weirs are constructed by sandbags for water storage. At the village level, some efforts have been made, starting with distribution of some crop seeds for local cultivation. Infrastructure for dealing with droughts is being developed, including construction of some water reservoirs and storages, and extension of water supply canals and pipes. A three-year development plan is also set up by the local administrative organization for such infrastructure development. Future adaptations that are recommended by the local villagers are mainly to have more wells and ponds to be digged for both residential and agricultural purposes, and more extensions of stream canals for more water storages and also for mini-hydropower generation. The villagers here expect more droughts in the future.

In the second village (Ban Hat Khrai), no specific adaptations are adopted. The villagers here generally accept the drought situation and continue their normal farming activities based on seasonal crops even though some adverse impacts are experienced. Water used is still mainly from rainfalls and from the Mekong river, without any water storages developed yet. However, the local people expect to have some adaptation options in the future. These include digging of groundwater wells and ponds for both residential and agricultural purposes, and development of fish farming for some suitable fish species (such as catfish and Nile Tilapia) in other water sources including ponds and swamps, as they think their fishing in the Mekong river is unlikely to continue.

In summary, adaptations to drought are seen rather limited and vary from village to village, besides some common compensation provided by the government. Based on the assessment of adaptation measures and strategies made so far at various levels, a roadmap for adaptation based on impact groups and levels can be developed as follows:

Compensation by the government for all impacted households should be made as immediately as possible and should go beyond crop damages to cover other damages such as from fishing.

Regarding fishermen and river weed collectors, adaptation priority should be focused on development of inland fish farming to supplement river fish catching. This should be implemented wherever applicable and should be considered as a short-term alternative.

Regarding crop farmers, new crops that require less water should be adopted. Lessons from existing changes to new crops (such as soybeans) should be learned for other sites and target groups. These options can be considered as both short- and long-term alternatives wherever appropriate, along with other supporting measures such as marketing surveys for new crops.

Adaptations at community level should be considered from both short and long term perspectives and can be implemented gradually over time, depending on resources available. Typical options include infrastructure development and/or extension for more water available in the dry season through building water reservoirs and storages, digging groundwater wells and ponds, and extending water supply canals and pipes. Community-based development of such infrastructure should be encouraged with financial supports from national and local governments.

Chapter 5
Summary and Recommendation

The recent historical 2010 drought in the Mekong region, especially in trans-boundary areas, have raised various critical concerns from stakeholders at various levels and scales. Partial views on the causes of such droughts and floods include hydro-climate causes (related to extreme rainfall changes), man-made upstream dams, and upstream and local landuse changes (including widespread deforestation). In addition, both economic impacts of droughts and adaptations to droughts are not assessed in sufficient details.

This preliminary study is conducted mainly to investigate these issues (from causes and impacts to adaptations) facing the Mekong river basin in Northern Thailand, with a focus on the bordering areas of Chiang Saen, Chiang Khong and Wiang Kaen districts along the Mekong river in Chiang Rai province, as a case study for illustration. Available reliable data on both long-term and recent hydro-meteorological patterns are used to identify possible recent changes and correlations with a series of upstream dams to provide additional evidences on causes of the drought. Field surveys based on questionnaires designed are used to assess an overall social impact monitoring vulnerability, and then to identify target groups and locations. Focus group discussions are further conducted for specific assessment of such targets.

First regarding causes to the drought, our main findings show that there are additional evidences to correlate upstream dams with the drought in the study area. Namely, upstream flows are indicated to have some correlations with downstream drought and flood events through (i) existence of timing coincidence of combination of more upstream hydropower dams with downstream drought and flood events; and (ii) close relationships between downstream water levels and discharges. It must be noted here that discharge downstream at Chiang Saen station is related almost directly to upstream discharges, only with some time delay of a few days as there are no major lateral flows between upstream and downstream in this case. So, upstream discharges are strongly correlated to downstream discharges (in Chiang Saen station). In addition, evidences of climate changes in terms of regional drought conditions through extremely low precipitation and early ending of rainy season in the study site are also found clearly. Besides these causes that have been analyzed in this study, there are still other causes that are generally recognized and understood, including landuse changes (both upstream and local) and widespread deforestation, along with possible ice melting conditions, which need further investigations in details.

The social monitoring result shows that local people vulnerability to changes in resources such as drought seem to be high because (i) majority of households have no second most important occupations, (ii) farming diversification seems limited, and (iii) decline of resource productivity is apparent during the last five year, especially in the long drought duration, in terms of reduction of fish catch, and other water-related products, along with decline in crop productivity due to drought, etc.

Economic impacts of the drought, from our result from questionnaire survey and focus group discussions, are assessed to be most severely on river fishing and collection of riverweeds, followed by riverbank gardening and agricultural crops. These impacts vary, however, from village to village, depending on levels of dependence of local people on water resources, as well as their occupations.

Adaptations to the drought, from questionnaire surveys and focus group discussions, are assessed to be limited, and also vary from site to site, except for compensation by the government for crop damages that is common throughout the study sites. Although majority of local households have found very difficult to think of an alternative for adaptation, there are still some possible adaptation options that have been adapted by some proactive households, or proposed elsewhere in the study areas. Most preferred options from local perspectives are on physical infrastructure to have more water supplies, through building water reservoirs/storages, digging wells and ponds, and extending existing water supply canals and pipes. Typical non-physical options are suggested by local villagers include developing inland fish farming as an alternative to river fishing, and changing to some suitable crops that require less water (such as soybeans). These initial options, based on local people perspectives, can be used for further in-depth study. Other adaptations related to development of more integrated farming systems to integrate fishing, cropping and animal raising that are not mentioned by local villagers need to be further explored.

Continuous monitoring of drought situations from now onward is really needed to serve as updates for developing more suitable adaptation plans, especially for target groups and sites. In this connection, sharing data from upstream and downstream is most important. In addition, possible mitigation measures for upstream dams are recommended on ensuring minimum water flows in the Mekong river in the dry season and on minimizing water fluctuations downstream to some extent acceptable by both up and down stream. These measures are not new as they are adapted elsewhere in many trans-boundary rivers.

REFERENCES

Adamson P., and J. Bird (2010), The Mekong: A Drought-prone Tropical Environment? International Journal of Water Resources Development. http://www.informaworld.com/

Adamson P.T., I.D. Rutherfurd, M.C. Peel, and I.A. Conlan (2009), The Hydrology of the Mekong River. Chapter 4 in the Mekong – Biophysical Environment of an International Basin. Academic Press. Elsevier Inc.

Asia Times Online. (2002), Mekong's dams wreak havoc on rural poor. www.atimes.com/se-asia/DD10Ae04.html.

Bangkok Post 05.04.2010: Drought, Floods Seize Agenda: http://www.bangkokpost.com/news/local/35598/drought-floodsseize-agenda.

Bangkok Post 16.03.2010: Low Water Levels Caused by Extreme Low Rainfall, Op-Ed by Jeremy Bird, CEO of the MRC: http://www.mrcmekong.org/MRC_news/press10/Op-Ed-13-3-10.htm.

Bangkok Post (2005), Green weed hopes wither. Bangkok Post, 11 June 2005.

Bangkok Post (2006), Going against the current. Bangkok Post, Outlook, 13 March 2006.

Bird J. (2010, April 2), Mekong body 'fails to protect waterway' [Electronic version]. *The Bangkok Post.*

Bird J. (2010, March 16), Op-Ed: Low river levels caused by extreme low rainfall [Electronic version]. *The Bangkok Post.*

Bossio D., W. Critchley, K. Geheb, G. van Lynden, and B. Mati (2007), River basin development and management. In Molden, D. (Ed.), Water for Food-Water for Life. Comprehensive Assessment of Water Management in Agriculture. Earth-Scan, London, (Chapter 15), pp. 551–585.

Brown P.H., D. Tullos, B. Tilt, D. Magee, and A.T. Wolf (2009), Modeling the costs and benefits of dam construction from a multidisciplinary perspective. Journal of Environmental Management 90 (2009) S303–S311

Cambodianonline (2004), Environmentalist warns of damage from Chinese damming. March 18, 2004. http://www.cambodianonline.net/homerivers.htm.

Campbell I. (2009), Development Scenarios and Mekong River Flows. Chapter 16 in the Mekong – Biophysical Environment of an International Basin. Academic Press. Elsevier Inc.

Campbell I. (2009), The Challenges for Mekong River Management. Chapter 17 in the Mekong – Biophysical Environment of an International Basin. Academic Press. Elsevier Inc.

Campbell I. C. (2007), Perceptions, data and river management—Lessons from the Mekong River. Water Resources Research 43, doi:10.1029/2006WR005130.

Dore J., and X.G. Yu (2004), "Yunnan Hydropower Expansion: Update on China's Industry Reforms and the Nu, Lancang, and Jinsha Hydropower Dams," Working Paper from Chiang Mai University's Unit for Social and Environmental Research, and Green Watershed. Thailand, Chiang Mai University, Chiang Mai, 38pp. http://www.mpowernet.org/download_pubdoc.php?doc=2586.

Droogers P., and J. Aerts (2005), Adaptation strategies to climate change and climate variability: A comparative study between seven contrasting river basins. Physics and Chemistry of the Earth 30, 339–346.

Fu K.D., D.M. He, and S.J. Li (2006), Response of downstream sediment to water resource development in mainstream of the Lancang River. Chinese Science Bulletin 51(Suppl.), 119-126.

Giordano M., M. Giordano, and A. Wolf (2005), International resource conflict and mitigation. Journal of Peace Research 42 (1), 47–65.

Giril C., S. Shrestha, and M. Levy (2001), Assessment and monitoring of land use/land cover change in continental Southeast Asia. In "Paper prepared for presentation at the Open Meeting of the Global Environmental Change." Research Community, Rio de Janeiro, 6-8 October.

He D., Y. Lu, Z. Li, and S. Li (2009), Watercourse Environmental Change in Upper Mekong. Chapter 14 in the Mekong – Biophysical Environment of an International Basin. Academic Press. Elsevier Inc.

He D.M., Y. Feng, S. Gan, D. Magee, and W.H. You (2006), Transboundary hydrological effects of hydropower dam construction on the Lancang River. Chinese Science Bulletin 51 (Suppl.), 16-24.

He D., Y. Feng, S. Gan, D. Magee, and W, You (2006), Transboundary hydrological effects of dam construction on the Lancang River. Chinese Science Bulletin 51(Suppl.), 16–24. http://www.lancang-mekong.org/Upload/upfile/2007713102648488.pdf.11920.

Kampragou E., S. Apostolaki, E. Manoli, J. Froebrich, D. Assimacopoulos (2011), Towards the harmonization of water-related policies for managing drought risks across the EU environmental science & policy 14, 815-824.

Kranz N., T. Menniken, and J. Hinkel (2010), Climate change adaptation strategies in the Mekong and Orange-Senqu basins: What determines the state-of-play? Environmental science & policy 13, 648-659.

Kundzewicz Z.W., D. Nohara, J. Taikan Oki, S. Buda, and K. Takeuchi (2009), Discharge of large Asian rivers – Observations and projections. Quaternary International 208, 4–10.

Lamun N. (2010), Two Lessons Learned from Mekong Mainstream Dams in China. Mekong Community Media project

Li S.J., D.M. He, and K.D. Fu (2006), The correlation of multi-timescale characteristics of water level processes in Lancang-Mekong River. Chinese Science Bulletin 51 (Suppl.), 50-58.

Liu C., D. Golding, and G. Gong (2008), Farmers' coping response to the low flows in the lower Yellow River: A case study of temporal dimensions of vulnerability. Global Environmental Change 18 (2008) 543–553

Lunchakorn P., S. Suthipong, and W.K. Kyoung (2008), The relationship of climatic and hydrological parameters to surface water quality in the lower Mekong River. *J Environmental International* 34, 860-866.

McNally A., D. Magee, and A.T. Wolf (2009), Hydropower and sustainability: Resilience and vulnerability in China's powersheds. Journal of Environmental Management 90 (2009) S286–S293.

Menniken T. (2007), China's performance in international resource politics: lessons from the Mekong. Contemporary Southeast Asia 1, 97–120.

Mishra A. M., and V. P. Singh (2010), A review of drought concepts. Journal of Hydrology 391 (2010) 202–216

Mishra A. M., and V.P. Singh (2010), Drought modeling – A review. Journal of Hydrology 403 (2011) 157–175

Molle F., P. Wester, and P. Hirsch (2010), River basin closure: Processes, implications and responses. Agricultural Water Management 97, 569-577.

MRC (2004), Mekong's low flows linked to drought. http://www.mrcmekong.org/MRC_news/press04/26-mar-04.htm.

MRC (2004a). "Dams on the Upper Mekong in China and the Present Flows in the Lower Mekong Basin,". MRC Technical paper and Media Release. 26 March 2004. on Development Scenarios in the Lower Mekong Basin," World Bank, Vientiane, 122pp.

MRC (2005), Overview of the Hydrology of the Mekong Basin. November 2005.

MRC (2009), State of the Basin Report 2010.

MRC (2010a), Mekong Prime Ministers agree to prioritise climate change as summit ends. MRC Press Release on 05/05/2010: http://www.mrcmekong.org/MRC_news/press10/pr-end-ofsummit5-Apr-10.htm.

MRC (2010b), Preliminary report on low water level conditions in the Mekong mainstream, 5 March 2010: http://www.mrcmekong.org/download/REVISED_Report-on-low-Mekong-Flows-5mar10.pdf.

MRC (2010c), Summary of MRC Hua Hin Declaration presented by H.H. the Prime Minister of Thailand. http://www.mrcmekong.org/MRC_news/speeches/Summary-of-MRC-Hua-Hin-Declaration5-Apr-10.htm

Osborne M. (2000), The Mekong. Turbulent Past, Uncertain Future. Canberra. Pahl-Wostl, C., Craps.

Pacific Disaster Center. 2011. Pacific Disaster Center website. http://www.pdc.org/iweb/drought.jsp?subg=1

Pearce F. (2004), Chinese dams blamed for Mekong's bizarre flow. New Scientist, 25 March 2004.

Peduzzi P., H. Dao, C. Herold, and F. Mouton (2009), Assessing global exposure and vulnerability towards natural hazards: the Disaster Risk Index. Nat. Hazards Earth Syst. Sci., **9**: 1149–1159. www.nat-hazards-earth-syst-sci.net/9/1149/2009/

Permpongsacharoen W. (2010, April 2). Mekong power plan will affect millions of lives: activists [Electronic version]. *The Nation.*

Podger G., R. Beecham, D. Blackmore, C. Perry, and R. Stein (2004). "World Bank Mekong Regional Water Resources Assistance Strategy: Modeled Observations

Quang M., and P.E. Nguyen (2003), Hydrological impacts of China's Upper Mekong dams on the lower Mekong river. http://mekongriver.org/publish/qghydrochdam.htm.

Reuters News Service. (2001), China dams could help Laos fight floods. August 7, 2001, Bangkok, Thailand. http://www.planetark.org/dailynewsstory.cfm?newsid=

Roberts T. (2001), Downstream ecological implications of China's Lancang Hydropower and Mekong Navigation Project. International River Network (IRN). http://www.irn.org.

Samabuddhi K. (2004), Chinese dams upstream blamed for drastic decline in fish stock. Bangkok Post, 10 March 2004.

Taddese G., K. Sonder, and D. Peden (2003), The Water of the Awash River Basin a Future Challenge to Ethiopia. International Livestock Research Institute, Addis Ababa.

The Nation Business (2010, April 2), Drought to have small impact on economy: survey [Electronic version]. *The Nation.*

UN/ISDR (2007), Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action. United Nations secretariat of the International Strategy for Disaster Reduction (UN/ISDR), Geneva, Switzerland.

Vidal, J. (2004). Dammed and dying: The Mekong and its communities face a bleak future. The Guardian, London, 25 March 2004.

Wilhite D.A. (2007), Drought, International perspectives on natural disasters: occurrence, mitigation and consequence, 2007; 147-162. Springer.

Wilhite D.A., and M.H. Glantz (1985), Understanding the drought phenomenon: The role of definitions. Water International. 10:111-120.

World Commission on Dams (2000). Dams and Development: a New Framework for Decision-Making. Earthscan, London. www.irn.org.www.mrcmekong.org/MRC_news/press04/26-mar-04.htm.

Yamane T. (1973), Statistics: an introductory analysis, New York Harper and Row. 1130p.

Zhao Q., S. Liu, and S. Dong (2010), Effect of Dam Construction on Spatial-Temporal Change of Land Use: A Case Study of Manwan, Lancang River, Yunnan, China. Procedia Environmental Sciences 2 (2010) 852–858.