SOCIAL IMPACT ANALYSIS OF LARGE DAMS: A CASE STUDY OF CASCADING DAMS ON THE UPPER-MEKONG RIVER, CHINA

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ABSTRACT

Large dam construction has significant environmental and social impacts at different scales. This thesis first summarizes and updates information about the history, distribution, functions, and impacts of large dams, both globally and at China's national level. It then addresses the social impacts of large dams, and introduces an empirical study conducted during the summer of 2010 in areas affected by dams along the Upper-Mekong River, China. The construction of large hydropower dams in this region has significantly impacted local communities. Numerous governmental policies have been designed to compensate for losses in wealth incurred by people relocated in the wake of new dam construction. I argue that wealth is a multi-dimensional attribute; identify three classes of wealth that are impacted by dam construction, namely material (land, houses), embodied (knowledge, skills), and relational (infrastructure); and compare losses and compensations for each class. Farmer interviews were conducted in ten villages affected by three dams built in 1995 (Manwan), 2003 (Dachaoshan), and 2009 (Xiaowan), and government statistics and documents were also analyzed to complement the empirical study. Results indicated that villagers often suffer from wealth loss in all three characterized dimensions, but government compensation policies typically consider only material wealth. This inequity leads to dissatisfaction on both sides, and is the root cause for disagreements and conflicts. The analysis further indicated that the degree of impact on the different dimensions of wealth varies among relocated communities, and that effects can sometimes be positive. These results will prove important to future dam projects in China, as they suggest that less dissatisfaction will arise from community relocation projects when the affected villagers and decision-makers acknowledge and

agree on the degree of losses and resulting compensations in all three dimensions of wealth.

BIOGRAPHICAL SKETCH

Pu Wang was born and grew up in Shaanxi, China. He completed his high school education in Xi'an, the capital city of Shaanxi. He then entered Beijing Normal University in Beijing, China, majoring in Resources Science and Technology. Durng his undergraduate program, he studied earth sciences, calculus, statistics, and remote sensing. His undergraduate project focused on using remote sensing methods to detect the integrated water content of wheat fields. Pu started his master program at Cornell University in the fall of 2009, where he focused on resources management and environmental governance. Upon completion of his M.S. degree, Pu will continue his graduate education as a Ph.D. student in the Field of Natural Resources at Cornell University.

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CHAPTER 1 INTRODUCTION

1.1 The large dam Dilemma

Food, water, and energy, three of the most critical issues for human development, are all connected with one facility — large dams. By International Commission on Large Dams' (ICOLD) definition, large dams are those with heights larger than 15 m (WCD 2000). It is estimated that 30-40% of irrigated land around the world relies on dams, and irrigated land contributes approximately 40% of the world agricultural production (WCD 2000; Shah and Kumar 2008). Large dams also have guaranteed water security in many urban and industrialized regions, with reports showing high positive relationship between dam density and water security level (Vorosmarty, McIntyre et al. 2010). They have also been used as an important way to control floods, and presently about 13% of existing dams have flood control functions (WCD 2000). Electricity generation is another important reason for building large dams, and about 19% of electricity worldwide is generated by hydropower dams; in 63 countries, hydropower supplies more than 50% of the electricity (WCD 2000).

Even though large dams have been taken as a means of development for a long time, they also have caused various environmental and social problems at different scales. Dams block water and alter natural flow regimes of rivers, which has significant impacts on river ecosystems and fisheries (Poff, Allan et al. 1997); the reservoirs formed after dam construction submerge farmland and terrestrial ecosystems (WCD 2000); and dams change the geological conditions of reservoir areas, having the potential to trigger landslides and earthquakes (Deji 1999; Pandey and Chadha 2003; Kerr and Stone 2009).

In addition, the social consequences of large dams include the effects of millions of people being relocated or displaced, uneven benefit and cost distribution among different groups, and impacts on indigenous and tribal people and their cultures (Égré and Senécal 2003; Tilt, Braun et al. 2009).

After the rise of environmentalism (1960s), and especially after the concept of sustainable development became prevalent (1980s), the benefits and costs of building dams are now more comprehensively scrutinized. People first began to question the rationale for using large dams to promote development in the 1970s, and the dam debate intensified worldwide during the 1990s. Since, the rate of dam construction has slowed markedly in developed countries, and in the United States, the rate of decommissioning old dams actually exceeded the rate of construction by 1998 (WCD 2000). However, in developing countries, there are still many large dams under construction or being planned.

The future of large dams remains unclear, with many pertinent questions. For example, do we still need to rely heavily on dam-irrigated agriculture, or we can avoid global food crises by applying water-saving technologies and using drought-resistant agricultural crops? Should we continue to control floods with hydrologic engineering methods, which change the natural features of rivers, or do we appeal to more fundamental approaches, such as restoring degraded environments and reestablishing natural flow regimes? Is hydropower a renewable and clean alternative for fossil fuels, or does energy from dammed rivers have even higher environmental and social costs?

The complete answers to these major questions are beyond the scope of this thesis. However, this thesis does endeavor to provide clues and pathways to finding the correct answers. It synthesizes abundant information about the facts and trends of large dams at different scales, and summarizes and discusses the opinions from both sides of the large dam debate. Furthermore, a social impact analysis based on a case study investigation is provided. It is hoped that this thesis is a modest, but solid and accurate step toward identifying final solutions.

1.2 Research Goals

My first research goal was to summarize and update the information on large dams globally and at China's national level. The World Committee on Dams (WCD) published its milestone report, *Dams and Development: A New Framework for Decision-Making*, in 2000, in which it summarized knowledge and opinions on large dams worldwide. In the same year, China WaterPower Press also published an encyclopedic report, *Large Dams in China: A 50-Year Review* (in Chinese), to systematically introduce the technical, social, and environmental aspects of large dams in China. One decade has passed since the publication of these two important reports, during which the status of large dams has changed significantly and some new trends, both globally and within China, have emerged. Therefore, summarizing and updating the information on large dams will have significant meaning for research and policy development. This information is provided in Chapter 2 and Appendix I.

This study integrates information about large dams from many different sources. First, I extensively cite literature on large dams, written both in English and Chinese, including papers published in peer-reviewed journals, reports from different organizations, and official documents and statistics. Second, I examine large dam problems from different perspectives, ranging from their spatial and temporal distribution and their social and environmental impacts, to the discussions and debates centered on them. Third, I incorporate the analysis and results of field investigations on large dams on the Upper-Mekong River, China, and draw solid conclusions out of the analysis.

Another contribution of this study to research on large dams is the incorporation of China's large dam information into the world-level database. For a long time data about large dams in China were not included in global reports, such as the cases of many tables and graphs in WCD's report in 2000. However, China alone has built almost half of the 45,000 large dams that have been constructed worldwide. There are also many new large dams under construction in China, and it has the second fastest construction rate in the world, only after India (WCD 2000; Bawa, Koh et al. 2010). This study emphasizes the significance of China's dam information; summarizes the history, distribution policies, and trends of large dams in China; and provides several case studies of China's most famous large dams.

My second goal was to provide an analysis framework to understand the social impacts of dam construction on local communities and the resulting social inequity at different scales, as well as to offer recommendations for improving compensation policies. Dam construction always causes the relocation of people, and compensation programs associated with such disruptions to community structure and human livelihoods generally fail to take many of the impacts into consideration. Therefore, a comprehensive understanding of impacts on the livelihoods of local people is critical to designing reasonable compensation policies. This analysis was based on an empirical investigation conducted in the summer of 2010 and appears in Chapter 3.

Chapter 3 proposes a framework in which wealth is divided into three dimensions, namely material wealth, embodied wealth, and relational wealth. In this context, the loss and compensation of the villagers is compared in each dimension in order to understand the impacts on local livelihoods. This framework is applied to field interview and survey data to assess changes in local livelihood and social inequity at household, community, and regional levels. Along with the data-based analysis, I also include descriptions about the changes I sensed in the villages I visited.

To provide recommendations for improving compensation policies, this study compares the perception of loss and compensation from insiders, local people affected by dam construction, and outsiders, the policy makers. The intent was to identify and illustrate the gaps in recognition about dam impacts between the two groups. This insider-outsider analysis highlighted specific dimensions where compensation policies could be improved.

My third research goal was to provide clues and suggestions for further studies on large dams. The construction of large dams is proceeding rapidly in different parts of the world, despite the heated debates on whether to build dams at all. The decision-making process related to building large dams involves considerations of economic viability, environmental sustainability, and social equity. Therefore, interdisciplinary collaborations are required in large dam research in order to reconcile the interests of different stakeholders and avoid harming ecosystems, biodiversity, and human welfare. My study facilitates future research on large dams by providing summaries of existing data and research related to large dams, and offering a framework to understand and analyze the social impacts of large dams. Conclusions are provided in the last chapter of this thesis (Chapter 4), where I also provide suggestions for potential methodologies and directions of future studies.

1.3 General Research Framework

For my study, I collaborated with Professor DONG Shikui at Beijing Normal University, China, in a national project, entitled: “Eco-environmental Risk of Dam Projects and the Integrated Control of Ecological Security”. The focus of this project was balancing environmental protection and dam operation, maintaining health of the river ecosystem, and promoting sustainable regional development. Since the affected people were mainly farmers living around dam projects, one of the major concerns of this project was to assess the impacts of dam construction on local farmers and agriculture. I was responsible for researching this part of the project.

In January, 2010, Professor DONG Shikui sent me general socioeconomic and agricultural statistics about Yunnan Province. I then started a preliminary analysis of the dataset, and also began to search literature on dam impacts and various studies about the Mekong River. In April, I designed a research proposal and the survey and interview questionnaires. I then met with my advising committee on May 12, 2010 at Cornell University, where we discussed my proposal and questionnaires with Professor James Lassoie, my major advisor, Professor Jon Conrad, and Dr. Stephen Morreale, and added their feedback to my original materials.

I arrived at Kunming, the capital city of Yunnan Province, on June 7. From June 8 to June 24, I first interviewed local researchers and government officials, and then conducted interviews in ten villages affected by three dams on the Upper-Mekong River.

At the beginning of the field season, I interviewed two renowned researchers at Yunnan University located in Kunming. On June 8 I met with Professor OU Xiaokun in the Institute of Ecology and Geobotany, and discussed the botany and landscape characteristics of the Lancang River region. On June 9 I interviewed Professor HE Daming in the Asian International Rivers Centreto discuss socioeconomic factors and impacts of dam projects on the Lancang River.

I then visited three dam sites that I had identified as my primary research sites, Manwan, Xiaowan, and Dachaoshan, and began conducting interviews in dam-affected villages associated with each. As I will explain in detail in Chapter 3, I identified two types of dam-affected villages: near-relocated and far-relocated. Taking both feasibility and representativeness into consideration, I selected 10 villages, which well represented both near-relocated and far-relocated villages from each of the three dams. Five villages were selected from each category.

The first two locations where I conducted interviews were Wayaoqing Village, on June 11, and Hongdouqing Village, on June 12. Both are a relatively long distance from Dachaoshan Dam (i.e., far-relocated villages). To help me find interviewees and translate the local dialect if I had difficulties, I recruited a guide, who was a retired village official. After that I realized that a local guide was really helpful in improving the effectiveness of my interviews. Besides translation, the presence of a local guide made my interviewees feel more comfortable, allowing them to respond more genuinely to my questions. If the villagers had any misgivings about my purpose, the guide would explain to them and alleviate their doubts. In addition to my questionnaires, I talked with villagers in an open, conversational way about various changes they had felt after dam construction, and their opinions on government compensation policies. On June 13 I entered a village along a main road, but this time along with four Chinese colleagues and no local guide. This village was a far-relocated village from the Xiaowan dam-affected area, and from the outside it looked much more developed than other rural communities in that region. It was here that I encountered the biggest problem I confronted during my field research. We first randomly selected people on the street and began interviewing them. But, about 15 minutes after we arrived at the village, a local policeman stopped our interviews, and brought us to his office. He told us that we were violating the interview policies in this area, and we had to get a recommendation letter from our school, as well as the permission of the propaganda department of the local government. However, we knew very well that if we went through the official protocol and got permission, we would be "escorted" by a government official, and would not have the freedom to choose interviewees ourselves. Rather, the government official might lead us to certain families, who would respond to our questions with answers previously prepared by the propaganda department. Such a survey procedure would skew the results, so we did not go through the official procedure. The policemen forbade us from contacting the villagers, and told us that we could interview two staff in his office instead. But very soon, the villagers heard about our arrival and dozens of them began to assemble in front of the police office. They thought that we were journalists looking for news-worthy issues, and wanted to reveal to us their unfair compensation and the serious corruption associated with the relocation process. Quarrels, and even light physical conflicts occurred between villagers and the people in the police office, and the situation almost escalated out of control. The policeman asked us to leave immediately without taking away the notes we had recorded during our interviews. After this event we always involved a local guide during the interview process, because they were familiar with any special regulations and could help us conduct the interviews smoothly without triggering such a crisis.

On June 14 we conducted interviews in Xiaowan Village, which is located very near Xiaowan Dam (i.e., near-relocated village). This time we obtained permission from the town government to freely interview villagers, which we did. However, the next day, the town mayor was reprimanded by higher-level government officials for allowing us to conduct interviews in his village.

We arrived at the Manwan Reservoir area on June 15, and hired a guide the next day. This time the villages were quite different, because we had to use a boat to reach them. The three near-relocated villages I visited on that day were Yuluo, Dapingzhang, and Yakoutian, which were among the poorest of all the villages we investigated. The rising water had submerged roads after the dam was built, and the worse transportation conditions significantly impacted the standard of living of the villagers. The detailed analysis of these villages also is presented in Chapter 3.

On June 19 I conducted successful interviews with a local guide in two far-relocated villages in the Manwan Dam area, Hewan and Tianxin. On June 20 I interviewed individuals in the near-relocated village of Dachaoshan, but in the middle of the process, a local official asked for our identifications. That night our activities were reported to a higher-level government official, and we were informed to halt our interviews. Fortunately, we had already collected interview data covering all the categories of villages in my plan, even though the number of the interviews was less than I had originally planned. We then left the Lancang River area and returned to Kunming on June 24.

During the following six months the data were analyzed using various methods. During this period I also conducted an extensive literature review of large dams and social and environmental issues related to dams, which is presented in Appendix I and Chapter 2. I began writing my thesis in December 2010, which herein provides an overview of the large dam problem at both global level and China's national level. It also provides a recommended framework to analyze the social impacts of dams.

1.4 Thesis structure

This first chapter introduces my thesis and provides a topical context for this work, outlines my study goals, and provides a general approach for the work. The main body of this thesis pursues three main goals: to update information on large dams globally and nationally for China, to provide a framework for a social impacts analysis of large dams, and to provide a knowledge base and suggestions for future studies on large dams. These three goals form the basis for Chapters 2, 3, and 4, respectively. In further support of this work, Appendix I provides reviews and summaries for several important publications on large dam studies.

In the second chapter of this thesis I provide an overview for large dams, first at global level, then at China's national level, and then I focus specifically on Yunnan Province. The global view covers the history and distribution of large dams worldwide, and then discusses the various purposes for their construction, including hydropower, flood control, irrigation, water supply, and navigation. Then the social and environmental impacts of building large dams are discussed, followed by a summary of the major debates associated with dam related problems worldwide.

After the global view, I focus on China by examining its national hydraulic plan and the history, major functions, and representative dams in China. I separate China's case for three reasons. First, my research field sites are in China, so a broad discussion of this nation's large dam development will provide needed background information for my research. Second, China has built the greatest number of large dams among all countries. Therefore, the impacts of large dams nationally might be better delineated in China rather than in other countries. Third, in developed countries, such as in the United States, the decommissioning of dams has actually exceeded the construction of new dams, while in developing countries, the number of new dams is still increasing. Therefore, China can serve as an appropriate representative for developing countries, many of which are ambitiously developing their hydrologic resources.

I then further narrow my scope to the provincial level, selecting Yunnan Province to represent Chinese development. Yunnan has the largest hydropower potential among all provinces in China, and is therefore the location for intensive studies such as the "Eco-environmental Risk of Dam Projects and the Integrated Control of Ecological Security" project. I analyze the history and current status of cascading dams on three important rivers in Yunnan: the Nu, Lancang, and Jinsha Rivers. Also covered in this part are problems associated with regional development and inequity, the decision-making process, the growth of civil society, and the relevant institutional changes. Last, the future of Yunnan hydropower and the potential impacts on local livelihoods and community dynamics are discussed.

Chapter 3 is a specific analysis of the social impacts of cascading dams on local communities based on field surveys and interviews. Here I provide an analysis framework that identifies three dimensions of wealth, and compares the loss and compensation in each dimension to define overall impacts. This framework also is used to analyze the effects of dam construction on social inequity and the design of current compensation policies. Last, an 'insider-outsider' analysis of the framework is used to identify implications for improving compensation policies, and provide suggestions for further study.

The last chapter consists of three parts. The first part summarizes the findings and conclusions, particularly facts about large dams in China and elsewhere in Chapter 2, and the social impact analysis in Chapter 3. This is followed by a discussion of the limitations of the thesis research, including limitations in literature review and empirical study. The final part offers suggestions and recommendations for future research on large dam issues.

CHAPTER 2 OVERVIEW OF LARGE DAMS

2.1 Large dams: a global view

2.1.1 History and distribution of large dams

The history of dam construction is as old as human civilization. In ancient Chinese mythology, the legendary tribal leader Yao assigned one of his subordinates, Gun, to lead the people to fight a great flood. Gun built dams to block the flood, but it broke the dams and caused an even larger disaster. As punishment, Yao's successor, Shun, killed Gun, and then assigned Gun's son, Yu, to lead the fight against the flood. Yu removed the dams and other barriers blocking the river, allowing the water to flow freely to the ocean, and finally overcame the flood. This story shows the long history of the impacts of dam construction on attempts to control the flow of rivers.

The remains of dams dating back to 6000 BP have been found in Mesopotamia; and irrigation and water supply dams became widespread in many parts of the world by 2000 BP (WCD 2000). The oldest continuously functioning dam is likely the one associated with the Dujiangyan irrigation project in Sichuan Province, China, which was built in 256 BP and is still providing irrigation water for a large area of farmland on the Chengdu Plain (Zhang and Jin 2008). The first hydropower dam in the world was built about 1890 (WCD 2000).

Before 1900, there were only about 700 dams worldwide (Figure 2.1). Most of the large dams currently in existence were built during the 20th Century. About 5,000 large dams were built during the first half of the century, three-quarters of them in developed countries. After the Second World War, the dam construction rate rapidly increased globally, with the peak occurring between 1970 and 1975, when nearly 5,000 large dams were built worldwide. The rate declined after the 1980s in most parts of the world, especially in North America and Europe (WCD 2000; Shah and Kumar 2008).

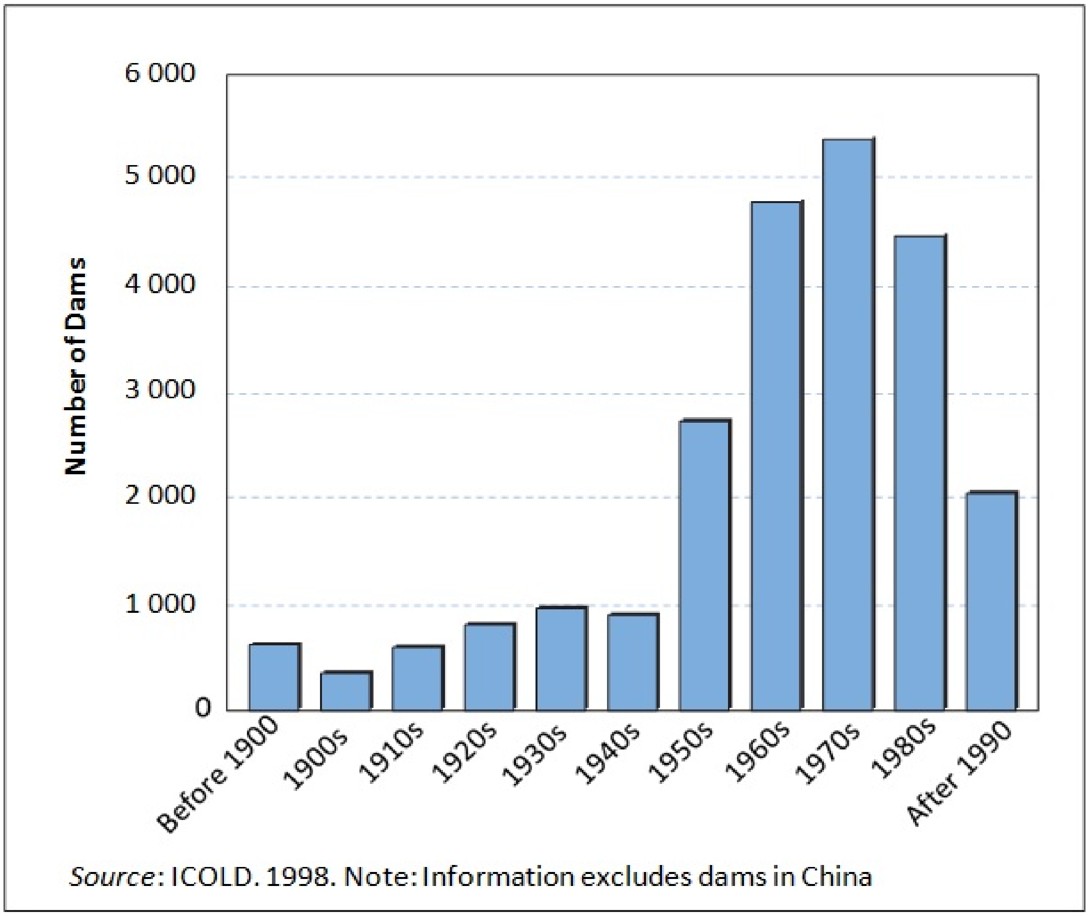


Figure 2.1 Construction of dams by decade (1900-2000) (WCD 2000)

According to the World Bank, countries represented by the Organization for Economic Co-operation and Development (OECD) have already developed 70% of their economically feasible dam potentials, while developing countries are only using 30% of their potentials. Strikingly, less than 10% of the potential has been exploited in Africa (World Bank 2009). Since developed countries have built dams on most of their rivers, they now mainly focus on managing and improving the efficiency of existing dams. But for developing countries, dam construction is considered a promising development opportunity. Therefore, the future of the large dam construction worldwide largely depends on rate of development activities in these countries.

By the end of 20th Century, more than 45,000 large dams had been built around the world (WCD 2000). Figure 2.2 shows the worldwide distribution of large dams. Five regions, East Asia, South Asia, North America, Europe, and Southern African have the highest density of large dams. Figure 2.3 illustrates the historical trend of dam construction for different regions, highlights the great increase in dam construction in Asia, North America, and Europe in the second half of the 20th century.

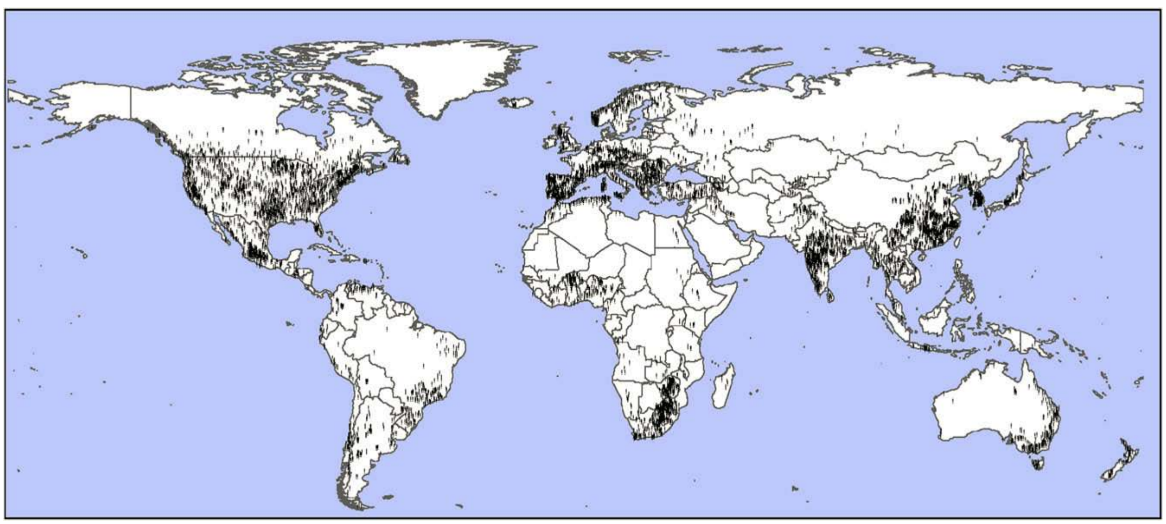
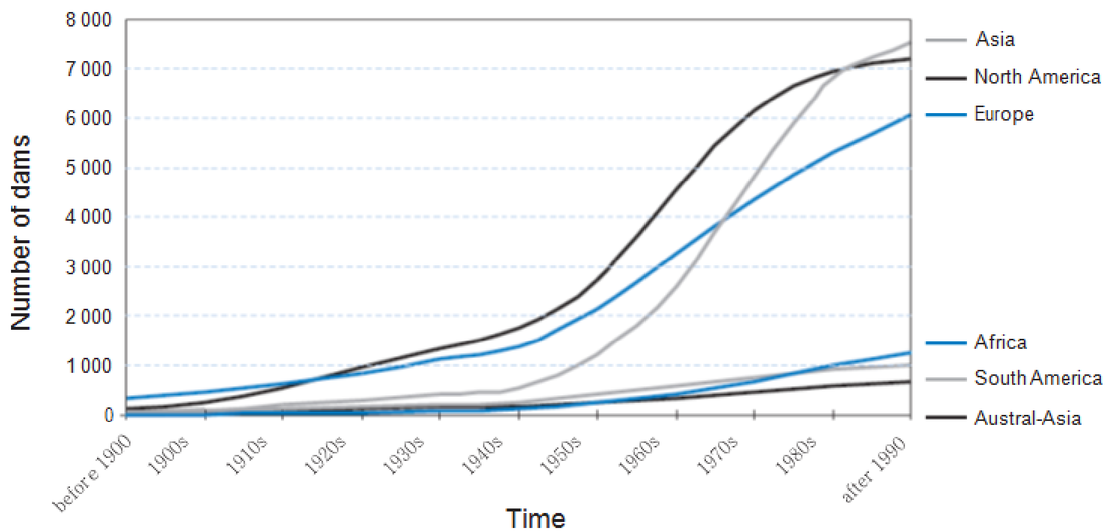


Figure 2.2 Distribution of large dams in the world (Tullos, Tilt et al. 2009)



Source: ICOLD, 1998. Note: Information excludes the time-trend of dams in China

Figure 2.3 Dams constructed over time by region (1900-2000) (WCD 2000)

Asia has not only the most existing dams compared to all other regions, but is also currently experiencing the highest construction rates. China and India, the two most populous countries in the World, are building most of these new large dams. Rapid economic development in these two countries not only demands more energy and water supply, but also provides the financial resources for major construction projects, such as the building of large dams (Liu and Diamond 2005; Bawa, Koh et al. 2010). The top five countries with most of the dams currently under construction are all in Asia: India, with 700-900 new dams under construction; China, with 280 dams; Turkey, with 209 dams; South Korea, with 132 dams; and Japan, with 90 dams (WCD 2000).

The United States has built the greatest number of large dams in North America, about 8,000. However, by the end of the 20th Century, a new trend was evident as old and poorly functioning dams were decommissioned across the United States. Nearly 15 years ago, the top official at the U.S. Bureau of Reclamation, which had been responsible for building massive dams throughout the American West, declared that the "era of big dams is over" (Longman 2008). In 1998, the speed of decommissioning exceeded that of construction for the first time (WCD 2000). Decommissioning old dams has many benefits for the restoration of riparian systems. However, some studies have shown that the removal of old dams may also cause negative impacts on associated ecosystems as they are forced to readapt to new hydraulic regimes (Bednarek 2001; Poff and Hart 2002) .

Currently, there are about 6,000 large dams in Europe. The pattern of construction of dams and reservoirs in Europe can be illustrated using the United Kingdom and Spain as examples. In the UK, the number of large dams grew rapidly during the 19th Century, from fewer than 10 to 175, a rate of 1.7 per year. By 1950, the rate had almost doubled. After 1950, construction took place at a rate of 5.4 dams per year before dropping to zero by the late 1990s. Today, the UK has a total of 486 dams. In contrast, Spain saw the number of reservoirs grow at the rate exceeding 4 per year between 1900 and 1950, before almost doubling and reaching 741 facilities by 1975. By 1990, this figure had more than doubled again (19.5 per year), and today there are 1,172 large dams in Spain, the most in Europe (European Environmental Agency 2010). With suitable sites becoming fewer and environmental concerns becoming greater, the total number of dams in Europe is now growing very slowly.

2.1.2 Multiple functions of large dams

Irrigation

Large dams have made significant contributions to rapid increases in yields associated with modern agriculture. About one fifth of the world's agricultural land is irrigated, and irrigated agriculture accounts for about 40% of the world's agricultural production. Half of the world's large dams were built exclusively or primarily for irrigation, and an estimated 30 to 40% of the 268 million hectares of irrigated lands worldwide rely on dams (WCD 2000).

The heights of large dams can range from 15 to several hundred meters. But generally, dams used for irrigation are relatively low compared to those constructed for flood control and hydropower. In North China, where precipitation is often inadequate for irrigation, and the flow of rivers is generally low, many dams have been built to meet the water needs of cropland (Nickum 1998).

Water supply

According to research on water supply security, there is a clear positive correlation between the density of dams and security level (Vorosmarty, McIntyre et al. 2010). Many reservoirs were built to provide a reliable supply of water to meet rapidly growing urban and industrial needs, especially in drought-prone regions where natural groundwater sources and existing lakes or rivers were considered inadequate to meet all needs. Globally, about 12% of all large dams are designated as water supply dams, and about 60% of these are in North America and Europe (WCD 2000). Most metropolitan areas must rely heavily on reservoirs for water supply, such as Beijing, where the water supply depends on the Miyun and Guanting Reservoirs north of the city (Government of Beijing 1981).

Electricity generation

Hydropower provides about 19% of the world's electricity production, and in some countries, it is the most important power source (WCD 2000). Therefore, dams for hydropower are constructed globally as an important development approach. In addition to the ambitions of many different governments, the World Bank also promotes large hydropower dams by providing a large number of loans, especially to developing countries (World Bank 2009).

Hydropower is considered to be cleaner than electricity generated by burning fossil fuels. It has almost zero CO_2 emission (if the CO_2 emitted by deteriorating organic matter at the bottom of the reservoirs is not considered), and once completed, no additional inputs are needed other than the maintenance of the power station. In the view of hydraulic engineers, some deep valleys with rapid elevation drops are particularly suitable for building large dams.

The electricity generated from hydropower dams is most often fed into national grids, which benefits people in the whole country. However, local people commonly bear most of the negative impacts from dam construction and the operation of the power station (Magee 2006). This uneven cost-benefit distribution is one of the main equity issues related to large dams.

Flood control

Worldwide, flooding has caused more deaths than any other natural disasters (WCD 2000). In those countries with monsoonal climates, flood control during the rainy season becomes even more imperative. Generally, flood control projects include not only dams and reservoirs, but also levees, all of which significantly change natural flow regimes.

However, dams constructed for flood control can sometimes make the situation even worse. For some rivers with high sand concentrations, like the Yellow River in China, dams often cause serious sedimentation problems, which lift the riverbed and reduce the water-holding capacity of the original watercourses (Xu 1998; Yang, Zhang et al. 2008). The case study part in this chapter will show the failure of Sanmenxia Dam on the Yellow River, which is a good illustration of how a flood control dam can exacerbate flooding disasters.

Navigation

Only a small number of large dams have been constructed specifically for the purpose of navigation. But for some, the need to improve transportation conditions was an important consideration in the decision-making process. One of the most obvious examples is the Three Gorges Dam in China, which was advocated eagerly by provinces on the upper reaches of the Yangtze River, like Chongqing and Sichuan Province. After the dam was finished, the river's water level rose by 175 meters, allowing 10,000-ton ships to reach Chongqing, which has substantially improved the transportation condition of this major city surrounded by mountains (Jackson and Sleigh 2000).

2.1.3 Environmental impacts of large dams

This section briefly discusses the environmental effects of large dams, including direct impacts on riparian fauna and flora, and indirect impacts on regional ecosystems and climate change. These important impacts were fully addressed by colleagues associated with this overall project, while my research focused on the social impacts of large dams. Hence, the summary that follows is presented to provide an environmental context for my work.

Inundated area

Inundation of the reservoir area is the most obvious direct impact a dam will have on the environment. Most large dams are located in valleys, which often have relatively high biodiversity. Thus, dam construction inundates critical habitats for many plant and wildlife species. Some large dams have a height of more than 100 meters, such as the cascade dams on the Upper-Mekong River, which have the potential to drive many endemic species to local extinction (Brown, Tullos et al. 2009; Burke, Jorde et al. 2009).

Reservoir inundation could also cause a change in land use patterns. After impoundment, local people may be forced to move up the hillsides and clear new farmland where forests may have been before the construction of the dam. This change in land use also might aggravate soil erosion, further threatening biodiversity (Fu and He 2003; Yuan and He 2004).

Altered flow regime

Dam construction is considered one of the most significant alternations to natural hydrologic systems by many researchers (Poff, Allan et al. 1997; Tullos, Tilt et al. 2009).

The flow regime of a river is determined by several factors, including the magnitude of discharges, the frequency of a given flow condition, duration, timing, and rate of change (Poff, Allan et al. 1997). The evolution of a river ecosystem is a process of adapting to the flow regime over several thousands of years. However, dam construction causes rapid changes in natural flow regimes in several aspects that will significantly impact river ecosystems.

Flood control dams reduce the variation in the magnitude of flows. Such dams store water during high flow seasons, and discharge water during low flow seasons. According to Poff and colleagues (1997), while the stabilization in the magnitude of flow reduces the chance of destructive floods and benefits humans, it also impairs the ecological benefits that high and low flows provide for the river ecosystem. For example, high flows have the ability to transport large amounts of sediment and nutrients, and also prevent the invasion of species that cannot adapt to the natural regime. Low flows could provide recruitment opportunities for native plants on floodplains, which are otherwise frequently inundated. Dam construction reduces the frequency of high and low flows, and is, therefore probably harmful to many endemic species.

Sedimentation

Sedimentation is not only a technical problem for the dam itself, but it also has noticeable environmental consequences. For many large dams, serious sedimentation shortens the service life and long-term sustainability of the facility (Tullos 2009). This situation is more obvious in some rivers with high sediment concentrations, such as the Yellow River in China (Xu 1998). The Chinese government built Sanmenxia Dam on the Yellow River in 1960. But only two years later, a serious sediment problem occurred that blocked tributary water, damaged hundreds of thousands hectares of farmland and forced more than 400,000 people to migrate to other places. After that, the dam lost almost all of its proposed functions. Sanmenxia Dam will be discussed in greater detail in the Chinese dam case study part of this chapter.

Dams capturing sediment moving downstream can also cause the erosion of downstream channels and tributary head-cutting. Estuaries and deltas need sediments from upstream to offset the erosion by waves and tides. Dam construction not only captures the sediment, but also reduces the amount of water flowing downstream because of evaporation and water consumption by agriculture and/or industry. Therefore, seawater might encroach and erode estuary areas. This effect is well illustrated by problems with Aswan Dam and the Nile Delta in Egypt (Din 1977).

Greenhouse gases emission

Hydropower has been considered a clean energy source with lower greenhouse gas emission rates than electricity generated by fossil fuels. However, studies show that decomposing organic matter in reservoirs emits a large amount of greenhouse gases. This problem is more severe in shallow reservoirs in tropical regions (Galy-Lacaux, Delmas et al. 1999). However, since natural lakes and wetlands also emit greenhouse gases, whether the contribution of reservoirs to global climate change is significant remains controversial.

Migrant species

Many aquatic species in rivers have specific migratory patterns during their life cycles. During different life stages, such as spawning, juveniles, and sexual maturation, many species shift to different reaches of a river. Dams can block migratory paths, and reduce the populations of many species, possibly driving some species to extinction. Some large dams have established fish bypasses (ladders) as a means for mitigating the negative effects on migratory species, but the percentage of large dams with such structures is very low, and ladders only aid the movement of certain species. Also, these structures sometimes do not work effectively, since the migration of different species requires various navigational cues, such as strong currents (WCD 2000).

2.1.4 Social impacts of large dams

Large dams significantly impact humans worldwide (Figure 2.4). Social impacts brought by dam construction generally occur in three broad categories: economic impacts; cultural impacts; and impacts on standard of living, such as education, healthcare, and infrastructure. The next chapter will narrow the scope to the specific study area, and analyze the impacts on local communities using more detailed information and a stringent analytical framework.

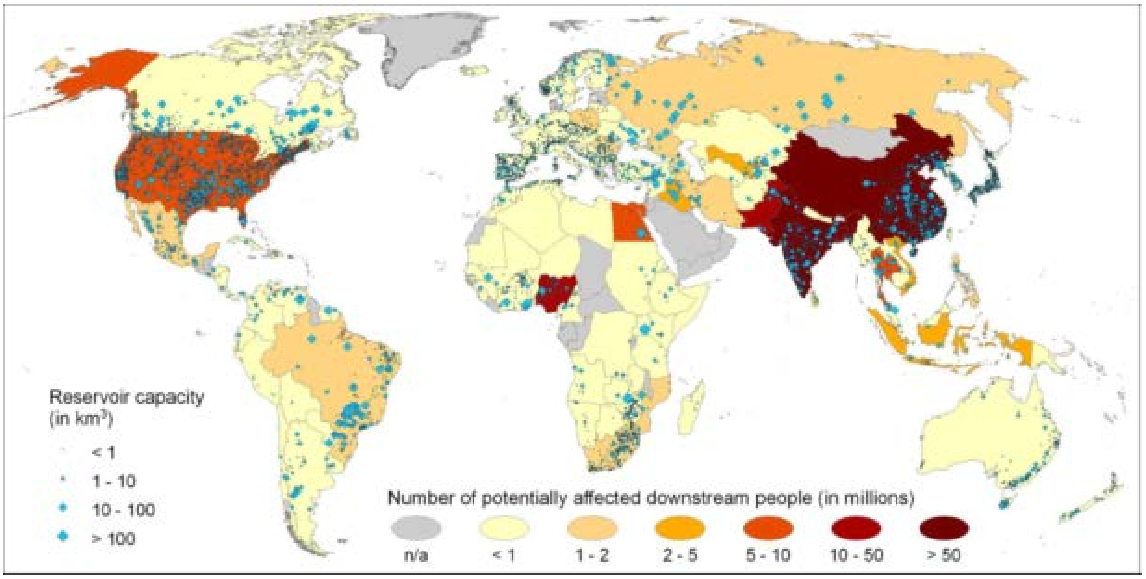


Figure 2.4 People affected by dams worldwide (Richter, Postel et al. 2010)

Impacts on agriculture

Large dam projects have multiple negative impacts on agriculture at different scales. The most direct and significant impact dams have on agriculture is the inundation of farmland. The conditions of the land along riverbanks are generally ideal for labor-intensive agriculture: relatively flat, easy access to irrigation water, and fertile. In my field research area, Yunnan China, most of the highly productive paddy fields are along riversides. But since these fields are close to the river and at approximately the same elevation, most of them will be submerged by reservoirs once the dams are completed.

As a consequence of farmland inundation, new farmland needs to be cleared to compensate for the losses incurred by local farmers. These newly cleared lands, however, are in most cases inferior, since previously they were not arable. Problems relevant to newly cleared farmland include higher or lower temperatures, which may be inappropriate for the growth of certain crops; lower productivity, because it takes raw land several years before it can produce high yields; difficulties in irrigation, since the distance from the river is often much greater than before, and major investments in irrigation equipment are required to obtain the same amount of water as before; and some newly cleared lands have steeper slopes than before, which increases soil erosion. In addition, their relatively poorer conditions also force farmers to use more synthetic fertilizers, which can increase pollution pressures on water bodies and ecosystems.

Impacts on local livelihood

Large dam projects submerge large areas of farmland, cause thousands of people to be relocated, and therefore have substantial impacts on local livelihoods. According to the

WCD (WCD 2000), 40-80 million people were relocated worldwide between 1950 and 2000 because of large dam construction.

The direct impacts of large dams on local people include the loss in houses, farmlands, forests and other resources that determine a farmer's material wealth. To offset the losses, relocated people are sometimes given new houses and newly cleared farmland, while in other cases, their material wealth losses are addressed through monetary compensation programs. If only material wealth loss is considered, relocated people in many cases are fairly compensated, or in some cases even over compensated.

However, dam projects and associated relocation programs also have various indirect impacts on local people. First, many relocation schemes fail to consider the possible negative effects that might arise from moving to a new and different environment. People rely on specific skills to make a living, but the effectiveness of these skills can be impaired when moved to a totally new environment. For example, according to one of my interviewees, one relocation program in Yunnan, China moved people living in alpine communities to a subtropical area, where the different climate prevented farmers from growing most of the crops they used to grow in their original villages. Therefore, even though they were given enough farmland, the transition to growing new crops proved to be a tough process for these people. Second, the social network supporting the community is probably disrupted in the process of relocation. For example, in a totally new environment, people might need to develop a new network for buying materials and selling products. Third, the inundation of a person's hometown can lead to significant psychological problems. Professor HE Daming, Asian International Rivers Centre, told me during his interview that in some communities, which had existed along the Lancang

River for thousands of years, people developed severe psychological disorders when their village suddenly disappeared beneath the dam reservoir.

Impacts on social inequity

The relocation of people due to dam construction not only impacts a farmer's wealth, but it also initiates a process of wealth reallocation. This may broaden the gap in relative wealth at different scales during relocation, which may lead to social inequity problems.

At the household level, relocation often drives people to find new and diverse employment opportunities, instead of continuing agricultural activities similar to those they did in their original village. Some villagers may be relocated to urban areas to work in factories or companies, while others may open their own small businesses. The result of this change in occupations is that some people end up being better off and some others become worse off. This new diversity widens the gap in wealth status among households, which may lead to social problems in the community.

The wealth status of entire villages also changes differentially because of different compensation policies and the different opportunities that arise from a specific dam project. Hence, compensation policies can vary substantially over time and in different regions. For instance, compensation standards in my study area quadrupled in 2006 in response to new regulations, which caused large discrepancies in compensation between communities moved before and after this date. The opportunities available to relocated people also vary greatly. For example, some villages are moved close to an urban area with a convenient transportation system, which can stimulate the local economy. In contrast, other villages are moved to relatively isolated areas with limited access to services and very poor living conditions.

At an even larger scale, such as the county or province level, the distribution of costs and benefits associated with the dam project may also be uneven. Regions close to a dam project likely will suffer most severely from its environmental and social impacts, but may not benefit greatly from the dam. For example, China's Three Gorges Dam controls flooding in downstream provinces thousands of kilometers away, and generates electricity, which is fed into national grid, but only a small portion of these benefits reach local people in the dam-affected areas (Jackson and Sleigh 2000). A more detailed analysis of social inequities related to dam construction will be covered in Chapter 3.

Impacts on culture

The impacts of dam construction on local culture can occur in multiple ways. First, the reservoir formed by the dam could inundate historical heritage sites along the river, since many ancient civilizations originated in river basins and left abundant historical structures. Second, dams are generally built in mountainous areas, which in many cases are the homes of ethnic minority groups with very diverse cultures. The relocation of these groups may disrupt their traditional lifestyles, causing the loss of many unique cultural traditions and intangible features of their heritages.

The Aswan Dam in Egypt flooded the original sites of many historical monuments, including Abu Simbel, Philae, Kalabsha, and Amada. The UNESCO and the Egyptian government moved many of these structures to higher ground above the reservoir to mitigate the loss of these historical resources (Hassan 2007). China's Three Gorges Dam also affected a large area rich with historical heritage. The most famous one is the "Moyashike", a place where huge Chinese calligraphy was carved along a cliff dozens of meters above the Yangtze River. The Chinese government moved whole pieces of rock about 50 meters up the cliff so that this spectacular scenery remained visible for long distances after the reservoir filled (Childs-Johnson and E. Sullivan 1996).

The relocation of ethnic minority groups sometimes forces them to change lifestyles, therefore losing their traditions. Some ethnic groups are merged into another ethnic group's culture, and have to adapt to the new environment by changing language and/or abandoning some of their old ways of living. In my research area, many ethnic minorities no longer speak their own language after moving into areas dominated by Han, and often they end up lacking appropriate space to celebrate some of their traditional festivals, therefore gradually abandoning these cultural events.

2.1.5 Debates around large dams

Debates about large dams have intensified in recent decades, and they generally fall into three types of concerns: economic feasibility, environmental sustainability, and social equity. This section briefly summarizes the different points of views commonly expressed about these concerns.

Economic feasibility

There are many proponents of dam construction, who mainly hold the opinion that building dams will generate opportunities for economic and social development, both at local and national levels. Their arguments include:

1. Dam construction projects will generate employment opportunities for local people, and stimulate local economies because new hotels and restaurants will need to be opened for construction workers.
2. The infrastructure that must be constructed before the dam project begins, such as roads and bridges will enhance the ability of local communities to access other regions, and sell their products across a larger market area.
3. After the dams come into operation, the reservoirs could provide irrigation water for farmland, stimulate a beneficial fishery, and attract tourists to the region because of their ‘lake-like’ sceneries and recreational opportunities.
4. The navigation conditions for upstream regions will be improved, therefore facilitating trade and commerce activities.
5. Hydropower dams generate cheaper and cleaner electricity than those produced by fossil fuel combustion. This will reduce the need to build coal-fired power plants and have a smaller ecological footprint for each unit of electricity produced.

However, the opponents to large dams argue that many dams actually fail to achieve their original economic goals. Many may not even recover the cost of their construction, nor the secondary costs to the environment and local communities. Their major arguments are as follows:

1. Many large dam projects overrun their budgets significantly, due to underestimating the technical difficulties, the compensation costs associated with the relocation processes, and changes in external conditions, such as the costs of labor and/or construction materials. Therefore, some large dams that are

considered economically feasible actually end up failing to recover their total costs.

2. All large dams, regardless of their original purposes, have a problem of shortfall in designed goals to a certain extent. According to WCD's report (2000), most of the irrigation dams and water supply dams fail to achieve their designed goals, while hydropower dams are more likely to fulfill their targets.
3. Most large dam projects do not consider the externalized social and environmental costs in determining their total costs; therefore, the cost/benefit calculations for these projects are problematic. For example, large dams could harm a downstream fishery, but this financial loss is seldom incorporated into the actual cost of the dams during the decision-making process, especially when the downstream area is in a different political region.
4. There exist many alternatives to large dams, which may have much smaller economic, social, and environmental costs. Water-saving agricultural techniques have a great potential to reduce agricultural water demand. For example, micro-irrigation methods, such as sprinkler and drip systems, have already proved their ability to save water. Renewable energies, including biomass, wind, solar, geothermal, and ocean tidal, only constitute about 1.5% of the electricity generation around the world. If the use of renewable energy were increased greatly, the construction of hydropower dams might decline substantially.

Environmental sustainability

Some opponents to dam construction argue that building large dams is an environmentally unsustainable solution for generating electricity, flood control, and irrigation for the following reasons:

1. The lifespan of a large dam is limited. Because of problems like sedimentation, most dams lose part or all their functions after about a hundred years. However, the impacts on the environment are irreversible and perpetual. Therefore, the short-term benefits of the large dams do not offset their long-term negative impacts.
2. Large dams alter the conditions of river systems so dramatically that many species cannot adapt appropriately, and therefore are likely to go extinct. According to various studies, dam construction is among the most harmful human-caused reasons for biodiversity loss.
3. The impacts of dam construction on the environment could act at different spatial scales, and therefore are very difficult to assess. Many studies focus only on the local impacts, but dams may also affect the regional climate and geological conditions, such as triggering earthquakes, and could even contribute to global climate changes because of increased greenhouse gas emissions.

The proponents of dam construction do not necessarily deny these negative impacts on the environment, but often argue that they are exaggerated. They note that ecosystems have the ability to adapt to the changes, and that there are many technological approaches that can be applied to mitigate the negative impacts. In sum, they argue that there is still an overall advantage to society to building large dams, as their positive benefits outweigh the negative impacts.

Social inequity

Opponents of dams argue that the people suffering the most from dam construction are primarily local minorities and indigenous people, and that most of the benefits arising from dams do not reach these people. But proponents argue that better compensation policies that take upstream-downstream benefits and costs into consideration would resolve these social inequity problems. Taking these issues into consideration, the following principles should always be considered during the decision-making process:

1. It is critical to make sure that all stakeholders involved in and impacted by a dam construction project participate in the decision-making process. Central and local governments, local communities, companies, scholars, and non-government organizations (NGOs) should have opportunities to express their concerns and opinions before the start of a dam project.
2. The entire decision-making process should be transparent to all stakeholders and even to society as a whole. For some projects that have national level influences, such as Aswan Dam in Egypt and the Three Gorges Dam in China, it is important to help the larger society understand the positive and negative impacts of the projects, and the trade-offs that might be necessary.
3. The rights of the indigenous people and ethnic minority groups should be given particular attention and protected. Statistics show that the percentage of ethnic minorities among all people affected by the dam projects is generally much higher than the percentage of the minorities in the whole population. These minorities

generally lag in social and economic development, and are therefore more vulnerable to any changes brought about by dams. Thus, their interests should be considered during the decision-making process even though they may lack the ability to formally defend their own rights.

2.2 Large dams in China

2.2.1 The history of China's dam construction

China has a long history of building dams and levees for flood control and irrigation. The earliest dam remains found so far indicate it was built about 2,600 years ago, and some of the dams built more than 2,000 years ago are still functioning. These hydrologic projects contributed greatly to building a prosperous agricultural society in ancient China. But most of these ancient dams were relatively low, not meeting today's height definition for a large dam (> 15 m).

According to the WCD (2000), before 1950, there were 5,196 large dams worldwide, but only 22 were in China. However, the speed of dam construction in China increased so rapidly during the second half of the 20th Century that after 1982, China was building more dams than all other countries combined. The construction rate slowed during the 1990s, when there were 1,100-1,700 large dams under construction every year worldwide. Likewise, there were only 250-320 large dams under construction each year in China, but this still represented 20-25% of the world's annual total. Another significant trend began in 1995, when India's building rate exceeded China's for the first time. The history of modern dam construction in China (i.e., post-1950) can be further examined by considering four separate time periods that reflect differing building rates (Pan and He 2000).

The first period was from 1950 to 1957, when large dam construction was just beginning in China. Strategic plans during this period focused on managing several hazardous rivers, including the Huai, Hai, and Huang. The heights of most dams constructed during this period were from 50 to 100 m, and their main purpose was to control major floods that were occurring in these river basins. Some of the famous dams built during this period include Guanting Dam (46 m) in Beijing, Foziling Dam (74.4 m) in Anhui Province, and most importantly, Sanmenxia Dam (106 m) in Henan Province, which will be presented as case study later in this chapter.

The second time period, 1958 to 1966, featured the nation-wide, large-scale construction of infrastructure, including large dams. Different levels of political districts actively participated in this effort, and the number of large dams in China increased dramatically. Some very large dams were constructed in this period, such as Liujiaxia Dam (147 m) in Gansu Province.

The third period was from 1967 to 1986. Because of the influence of political events, such as the Cultural Revolution, the rate of dam building was noticeably reduced. However, some of important dams were constructed during this period, such as Gezhouba Dam on the Yangtze River in Hubei Province, which played an important role in the later construction of Three Gorges Dam. During this period the quality and technology associated with building dams also advanced substantially.

The fourth period extended from 1987 to the present. China's successful economic development during this period not only provided financial support for large-scale infrastructure projects, but it also generated a huge demand for electricity, which has been a major stimulus for increasing hydropower projects nation-wide. After long debates, the building of two of the world's largest dams, Xiaolangdi Dam in Henan Province and the Three Gorges Dam in Hubei Province was initiated during this period. These will be discussed in greater detail in the case study section of this chapter.

The administration of reservoirs in China depends on their water-holding capacities (Pan and He 2000): reservoirs with capacities over 100 million m^3 are administrated by provincial or higher level agencies; those with capacities between 10 and 100 million m^3 are administrated by prefecture level agencies; those with 1 to 10 million m^3 are administrated at county level; those from 100 thousand to 1 million m^3 are administrated at town level; and, reservoirs under 100 thousand m^3 are administrated at village level. Hydroelectric plants have different administrative systems and will not be discussed here.

2.2.2 The thirteen hydropower bases in China

In the 1980s, the Chinese government designed a long-term development plan for hydraulic projects, most of them focused on hydropower. The Ministry of Water Resources identified 13 hydropower bases in different river basins across China (Figure 2.5) (China Hydropower Engineering Web 2011). Hydropower was considered a cleaner and cheaper energy source than fossil fuels, and this ministry proposed increasing the proportion of hydropower in the electricity structure of China, as coal-burning power plants currently contribute about 80% of the nation's total electricity. This long-term hydraulic project plan covered almost all the large river basins in China (Figure 2.5), and its implementation has been intensified due to the growing demand for energy as a result of rapid urbanization and economic development. Later sections of this thesis will provide case studies of some important dams, including the Three Gorges Dam, Xiaolangdi key water control project, and dams in Yunnan Province, where this study

Figure 2.5 Thirteen hydropower bases in China (China Hydropower Engineering Web 2011)

was conducted.

Each of these 13 hydropower bases has important characteristics that are discussed below (China Hydropower Engineering Web 2011). The numbers correspond to those provided in Figure 2.5.

1. The Jinsha River is another name for the upper reach of the Yangtze River, and is also one of the three parallel rivers in Yunnan Province. It has a large flow magnitude and drop in elevation, and therefore is potentially the largest source of hydropower in China. The feasible, installed capacity of this river alone is 63,830 MW, and there are dams either proposed or under construction on its middle and lower reaches; the upper reach of the Jinsha River has not yet been exploited.

2. The Yalong River is located in western Sichuan Province, and is the largest tributary of the Jinsha River. Its middle and lower reaches run through deep valleys and have a significant elevation drop. The first hydropower station on the Yalong River, the Ertan hydropower station, had an installed capacity of 3,300 MW and was the largest hydropower station built during the 20th Century in China.

3. The Dadu River is a secondary tributary of the Yangtze River, but it has tremendous hydropower potential. Its elevation drop is more than 1,800 m, with a feasible, installed capacity of 23,480 MW. Because the estimated extent of submerged farmland and villages is much less than that for other large dams in China, the Dadu River is considered to be very economically feasible for hydropower development.

4. The Wu River is another large tributary of the Yangtze River, with an installed capacity of 6,875 MW. Since land around the river has abundant deposits of coal and

many minerals, hydropower development is hoped to leverage the exploitation of multiple resources in the area.

5. The Upper-Yangtze River refers to the reach downstream of the Jinsha River, from Yibing to Yichang. The elevation drop in this reach is only 220 m, much less than that in the Jinsha River, but the magnitude of its flow is much larger. The Three Gorges Dam is on this reach, and four other dams are proposed along this reach. Additional dams also are proposed for smaller tributaries of the Upper-Yangtze River.

6. The Nanpan and Hongshui Rivers are the upper tributaries of the third largest river in China, the Pearl River. They are close to the most developed region in China, the Pearl River Delta, where Hong Kang, Guangzhou, and Shenzhen are located. Therefore, electricity generated from these two rivers could be fed into the Guangdong Province grid to further stimulate economic growth in these major urban areas.

7. The Lancang River is another of the three parallel rivers in Yunnan Province, which is also the name of the upper reach of the Mekong River. Six dams were proposed for the upper reach of Lancang River, and another eight for the lower reach. The total installed capacity for the mainstream of the Lancang River is 21,370 MW. Dams on this river are discussed in detail in the case study part of this chapter.

8. There are 16 dams designed on of the Upper-Yellow River, with total, installed capacity of 14,155 MW. These dams are located in gorges in northwest China that have low population densities and less productive farmlands. Therefore, the economic impacts of these dams on local people are comparatively low.

9. The Middle-Yellow River runs through the longest stretch of gorges on this river. Since this reach is the source of the largest amount of sand along the river, dams built here would not only generate electricity, but also would control siltation in downstream dams, such as Sanmenxia and Xiaolangdi. Its estimated installed capacity is 6,092 MW.

10. There is a series of dams planned for rivers in western Hunan Province, which have great hydropower potentials, including the Yuan, Zi, and Li Rivers. It is proposed to build cascade dams on each of these three major rivers, with total installed capacity of 6,613 MW. Beside hydropower, they also will have the ability to control flooding in cooperation with dams on the mainstream of the Yangtze River.

11. The mountainous areas in the southeast provinces of Fujian, Zhejiang, and Jiangxi contain tremendous hydropower potential, with an estimated total installed capacity of 16,800 MW.

12. The northeast China hydropower base includes five major rivers, namely the Heilong, Mudan, Songhua, Yalu, and Nen. The total installed capacity is estimated to be 11,316 MW.

13. The Nu River is the third of the three parallel rivers in Yunnan Province. Its proposed installed capacity is 21,320 MW. However, because of the protests arising from various NGOs as well as the Ministry of Environment Protection, no dams have been constructed to date on this river. This will be discussed in the case study part of this chapter.

2.2.3 Relocation impacts caused by dam construction

The total number of relocated people as a result of dam construction in China is reported to be 10.2 million according to official statistics, but this number is very controversial, and is much lower than some independent estimates. According to the study of Wang and colleagues (2007), by 2006 there were 22.8 million people relocated because of dams. This study also divided the history of dam-caused relocations into three periods, which are summarized below.

First period (1950-1957): There were about 300,000 dam-caused relocations during this period. Because it was right after the Chinese Revolution and the government controlled large amounts of land, relocation programs were relatively easy to conduct.

Second period (1958-1977): The number of relocated people increased rapidly to 4.91 million. However, due to social instability, particularly the Cultural Revolution, relocation policies were often neglected and relocated people suffered for a long time from low compensation and unreasonable living conditions.

Third period (1978-present): Most large dams in China were built during this period, which caused the most relocated people in China's history: 22.8 million by 2006. Besides the need to relocate such a dramatically large population, rapidly changing socioeconomic conditions added more complexity to the relocation process.

According to the study of Tang (2009), there are four major types of dam-caused relocations in China. The following paragraphs summarized the main points in this study.

Type 1: Agricultural-oriented relocation. This type of relocation is suitable for less developed regions, where there are few industries and population densities are relatively low. The government generally clears new farmland and provides new buildings and infrastructure for the relocated people, who usually continue to support their livelihoods through agricultural activities as they did before relocation.

Type 2: Urban and suburban area relocation. This type of relocation is suitable for industrialized regions, where there are more job opportunities, particularly in manufacture and service industries. Relocated people are not given farmland, but can work in factories or find other jobs in urban areas.

Type 3: Whole community relocation. In this type of relocation, a community is moved as a whole unit, and their political structures are maintained in the new location. The communities are relocated to either agricultural areas or urban areas.

Type 4: This type involves different combinations of types 1 and 2 that depend on different household situations. The relocation policy could be very flexible in this type of relocation, and affected people are either relocated to a far place, or just move a short distance.

The compensation policy for relocated people has also evolved along with the development of China's society. Before the 1990s, China was still under an extreme central planning system, and dam-affected people were required to sacrifice their own interests for the benefit of the country; therefore they received very low compensations for being forced to move. Then in 1991, the Central Government enacted legislation to regulate compensation policies in large hydraulic project affected areas. But at that time, the compensation standards were still very low. In 2006, the Central Government updated this legislation and substantially raised compensation levels by more than threefold, and also began to emphasize the importance of maintaining sustainable livelihoods for relocated people. But the new standards are still considered to underestimate or incompletely compensate the real losses of affected people.

Problems related to dam-relocated people are sensitive in China, and the investigation of these problems is commonly restricted. This partially arises from the government's concern that a large number of dissatisfied relocated people could cause social instability, and because of the corruption that often goes on during the relocation process. For example, in 2010, XIE Chaoping, the author of *Daqianxi* (Great Migration) was arrested in Beijing and attracted public attention when he uncovered the miserable lives of relocated people from Sanmenxia Dam area and the corruption associated with the relocation program, both of which harmed the interests of local officials (South China Weekends 2010). But the active roles of the press and various NGOs in drawing public attention to the plight of relocated people have been a very important force for improving the relocation process and compensation policies in China.

2.3 Case studies of large dams in China

This section provides a series of case studies on representative large dams in China, including the Three Gorges Dam, Xiaolangdi key water-control project, and cascade dams on the Nu, Lancang, and Jinsha Rivers. The first two dams were built on the two largest rivers in China, the Yangtze and the Yellow, respectively. The other three cases are all in Yunnan Province, which has the most hydropower potential among all provinces in China. This section complements the general analysis of China's large dam issue in last section with solid examples by discussing in detail the physical, social, and environmental features of these dams.

2.3.1 The Three Gorges Dam

Seventy years of decision-making

The Three Gorges Dam was among the most contentious dams in China's hydraulic project development history. The original idea of building a large dam on the Yangtze River before it runs into plains of Central China was proposed in 1919 by Sun Yat-sen, and in 1932 the government of Republic of China conducted the first investigation to identify potential sites for such a dam. However, at that time it was not economically viable or technologically feasible for the Chinese Government to build such a dam. In 1944, John Lucian Sovage, a dam expert from the US Bureau of Reclamation, investigated the Three Gorges area, and wrote the first scientific proposal for constructing the dam. In this proposal, the electricity generated by the dam surpassed the total demands of all seven provinces around the Three Gorges. China and the US began to consider a collaborative effort to build the dam, but this plan was terminated in 1947 due to the Chinese Civil War (Xinhua News Agency 2003).

After the founding of the People's Republic of China in 1949, the dam proposal was again brought into serious discussion, when MAO Zedong showed special interest in constructing the dam to harness the Yangtze River. Mao and many hydraulic engineers investigated the Upper-Yangtze many times; and discussed optimal locations for the dam and its expected cost, lifespan, and possible difficulties that might be encountered during its construction and operation. However, the budget proposed by hydraulic engineers to Mao was still too large for the fragile national economy. Even so, Mao's desire to build this dam played an important political role in later decision-making processes (Childs-Johnson and E. Sullivan 1996; Xinhua News Agency 2003).

In 1984 the Yangtze River Basin Committee proposed a plan to the Central Government, with a dam height of 150 m. However, the City of Chongqing was dissatisfied with this plan because the backwater of the reservoir would not reach Chongqing. Hence, the final dam height was changed to 185 m, with the water level rise of 175 m being equal to the elevation of the Chaotianmen Port in Chongqing, which would greatly improve the transportation conditions and commerce for this megacity. In 1992, after many years of debates and discussions, and being more confident in its economic abilities, the Chinese Central Government finally made the decision to build the dam (Xinhua News Agency 2003).

Construction commenced in 1994, with the whole project divided into three stages. The first stage lasted from 1994 to 1997, and included preparing projects to divert the Yangtze River's flow, and designing a temporary ship lock along the eastern bank. The second stage (1998 to 2003) involved building the dam and installing generators on the east side, and completing a permanent ship lock. The third stage, 2003 to 2009, involved finishing the dam and installing generators on the west side. After the completion of the project, the reservoir behind Three Gorges Dam currently is 600 km long covering a total area of 10, 000 km^2 (Xinhua News Agency 2003; Stone 2008).

Multiple functions

Three Gorges Dam is a megaproject with multiple purposes. The first purpose is to generate electricity. Due to the huge reservoir capacity, it now has the ability to generate the greatest amount of electricity among all dams worldwide. The installed capacity is 18,200 MW, and the electricity from Three Gorges Dam is transported to 10 provinces, including Shanghai thousands of kilometers away (Jackson and Sleigh 2001; Xinhua News Agency 2003; Stone 2008).

The second purpose is flood control. The downstream area of the Yangtze River has been vulnerable to flooding for thousands of years, which has been intensified by deforestation in its upstream areas. The Yangtze's downstream plain is the most populated and developed region in China, and three large floods during the 20th Century, 1931, 1954, and 1998, caused thousands of deaths and countless losses in capital. In 1992, right before the final decision was made to construct the dam, some experts stated the important function of flood control as follows: "If we don't consider the flood control of the Three Gorges Dam, then its costs will exceed the benefits; however, if we take the benefit of flood control into account, then the benefits of the dam will exceed the costs" (Xinhua News Agency 2003). This statement illustrates the significance of the dam's flood control function. It was reported that the Three Gorges Dam reservoir has a flood storage capacity of 22.15 billion m^3, and could alone protect downstream areas from 100-year return-period floods. Furthermore, in collaboration with other flood control projects, the dam also would significantly reduce damages arising from 1,000-year floods (Xinhua News Agency 2003; Wu, Huang et al. 2004).

The third purpose is for navigation. Flow in the upstream reaches of the Yangtze used to be rapid and narrow, but after dam construction, it became placid and wide. The water is also much deeper than before, which allows larger ships to reach the upstream cities. For example, the Port of Chongqing can now accommodate large cargo ships in the 10,000-ton class connecting commerce to downstream locations. This improvement in water transportation has significantly stimulated economic development in this megacity (Xinhua News Agency 2003).

Social and environmental consequences

The Three Gorges Dam is not only the world's largest hydraulic project, but it also has caused the greatest number of relocated people. In 1985, it was estimated that the dam-formed reservoir would submerge the homes and surroundings for 726,000 people, and if population growth was considered, the number would reach to 1,132,000 by 2008. In reality, however, official documents have reported that after the completion of the relocation program in 2010, a total of 1,397,000 people have been relocated, including about 190,000 in other provinces. The dam directly affected 20 counties in Chongqing City and Hubei Province; but many more counties and provinces were involved in the relocation project. As in the original plan, 25,000 people in affected counties in Hubei were relocated to other unaffected counties in the same province; 20,000 people in affected counties in Chongqing were relocated to other unaffected counties also in Chongqing, but 70,000 people were relocated to other provinces, specifically, Sichuan, 9,000; Jiangsu, Zhejiang, Shandong, Hubei, and Guangdong, 7,000 each; Shanghai and Fujian, 5,500 each; and Anhui, Jiangxi, and Hunan, 5,000 each. The actual numbers were generally much higher than those cited in the original plan; for example, Anhui Province actually accepted 8,094 residents from Chongqing rather than 5,000 as stated in the plan (Jackson and Sleigh 2000; Li, Waley et al. 2001; Xinhua News Agency 2003).

The relocation program was given high priority in the whole Three Gorges project even before dam construction started. As the former Premier LI Peng said, "The relocation program is the critical factor in the success of the Three Gorges Dam project". In the document enacted by then Central Government in August 1993, “The Three Gorges Project Development-oriented Resettlement Regulations”, it was said that the relocation strategy should be “development-oriented resettlement”, by which the relocated people could maintain or even improve their original standards of living, and the government should create favorable conditions for the long-term development of their livelihoods. Another Central Government document in 1999 stated that the destination districts should provide regions with favorable natural and economic conditions to the relocated people. Therefore, the social impacts of the Three Gorges dam extend far beyond the reservoir area (Xinhua News Agency 2003).

After resettling in new places, relocated people began their long and sometimes difficult adaption to a new environment. Lack of farmland and other resources made the lives of some relocated people extremely difficult, and it was also hard for many to merge into the local society with the original residents. For example, a local woman marrying a relocated young man in Suqian, Anhui Province became top news in their town, since relocated people were discriminated against to certain extent by local people and this kind of marriage was very uncommon (People's Daily Online 2010). After taking into consideration the social costs of the 1.4 million relocated people, the overall value of the Three Gorges Dam becomes even harder to judge.

The environmental impacts of the Three Gorges Dam are also substantial. The dam altered the Yangtze River’s flow regime significantly, which extensively influenced water quality (Muller, Berg et al. 2008), terrestrial and aquatic biodiversity (Wu, Huang et al. 2004), and fisheries (Chen 2002). Records showed that after the construction of the dam, the concentration of nitrate almost doubled downstream, and the concentration of many heavy metal ions, such as Pb, Cu, Cd, and Cr also significantly increased. These changes in water quality could threaten the health of downstream ecosystems. Water level in the reservoir increased by 175 m and isolated more than 100 mountain tops and ridges, turning them into land bridge islands. This fragmentation of habitats could greatly reduce the number of species. The dam has even larger impacts on aquatic biodiversity, such as the blocking of migratory pathways and fragmenting of aquatic habitats, which are particularly detrimental to many species, some of which are endangered. The fishery on the Yangtze River also suffers from the dam. Annual commercial harvest data show that after 2003-2005, which was the period of impoundment, the commercial harvest of four carp species and the number of drift-sampled carp eggs and larvae decreased dramatically.

2.3.2 Xiaolangdi key water-control project

A failure precedent: Sanmenxia Dam

The Yellow River is the most hazardous river in China, and it is also a river with the world's largest concentration of sand. Due to serious ecological degradation and soil erosion in its middle reach, there is 1.35 billion tons of sand deposited in the river every year during the flood season. In the lower reach where the river course becomes flat and the flow speed decreases, about a quarter of this sand accumulates along the riverbed, lifting it by 10 cm each year. After thousands of years of sedimentation, the riverbed of the lower reach is now on average 5 m higher than the surrounding land, and a 1,400 km long levee has been built and maintained to hold the water. Hence, flood control of the Yellow River has long been a key concern of the Chinese Government (Ministry of Water Resources 2009).

To resolve the sediment accumulation and flood problems the Chinese Government decided to build a large dam in the gorge areas of the Yellow River in the 1950s. Experts from the Soviet Union were invited to help design the dam. Those experts were experienced in large hydraulic projects in the Soviet Union, but had never worked on a river with such a high sand concentration. They finally chose Sanmenxia Gorge as the dam site. However, this proposal was strongly opposed by some Chinese experts who were familiar with the characteristics of the Yellow River, particularly HUANG Wanli, who was a professor in Tsinghua University and well renowned for his knowledge about the management of the Yellow River. HUANG argued that building a dam at Sanmenxia would block the sand from moving downstream and cause serious floods on the upstream plain area. Unfortunately, at that time it was difficult to oppose experts from the Soviet Union, so the proposal was approved and HUANG suffered political persecution for more than 20 years (Tan and Liu 2003; Tianjin E-North netnews 2003).

Sanmenxia Dam was complete in 1960. Unfortunately, only one-year later HUANG's prediction became true when 1.5 billion tons of sand blocked the Yellow River, lifting the riverbed of the Wei River, the Yellow River's largest tributary, by 40 meters. A large area of highly productive farmland on the Wei River plain was inundated, and almost half a million local people were forced to move to Gansu Province hundreds of kilometers away. Even though Sanmenxia Dam was overhauled several times, it continued to cause serious problems for the next 40 years. The failure of this dam was the result of suppressing different opinions during the decision-making process and the lack of consideration of how to reduce sediment accumulation. Having learned from these mistakes, the Chinese Government during the 1990s began planning for another large dam, Xiaolangdi Dam about 130 km downstream from Sanmenxia Dam, which would fulfill the unachieved goals of this earlier dam (Tan and Liu 2003; Tianjin E-North netnews 2003).

The historical missions of Xiaolangdi Dam

Xiaolangdi key water-control project is located 40 km north to Luoyang City, Henan Province, and 130 km downstream of Sanmenxia Dam. It is at the last gorge mouth of the middle Yellow River, and controls an area of 69,420, 000 km^2 of river basin, which is about 92% of the entire Yellow River basin. The multiple purposes of Xiaolangdi Dam include flood control, sediment reduction, water supply, irrigation, and hydropower (Ministry of Water Resources 2009).

After the failure of Sanmenxia Dam, Xiaolangdi Dam was given high expectations to solve the serious problems related to the Yellow River. During the rainy season, the downstream levee becomes very fragile, and because of the continuing accumulation of sand on the riverbed, the levee needs to be strengthened and heightened year after year. From the 1970s on, a new problem emerged when heavy water consumption in the Yellow River watershed began causing water shortages downstream during the dry season. Therefore, four goals were set for Xiaolangdi Dam: 1) during the rainy seasons the levee would not break; 2) during the dry seasons the water course would not dry up; 3) water contamination would be kept at a low level; and 4) sand would not continue to accumulate on the downstream water course, and thus the height of the waterbed would not increase (Henan Xinhua News Agency 1997; Ministry of Water Resources 2009).

In April 1991 the National People's Council approved the Xiaolangdi project. Dam construction started in September 1991, and was complete at the end of 2001. The top of the dam is 281 m above sea level, and the maximum water level is 275 m above sea level. The total capacity of the dam reservoir is 12.65 billion m^3, which includes 7.55 billion m^3 for storing sand and other 5.1 billion m^3 for regulating water flow and generating electricity. The World Bank provided a loan of one billion US dollars for this project, as well as technical and management support (China.org.cn 2008; Ministry of Water Resources 2009).

After the completion of the dam, Xiaolangdi began to play an important role in river management. First, the massive reservoir could store water during the rainy seasons, thus reducing the risk of floods in the downstream areas. Before the Xiaolangdi Dam was built, the existing levee and reservoirs on the Yellow River could only provide protection from 60-year return-period floods, but now downstream areas are safe from 1,000-year floods (Liu 2004; Ministry of Water Resources 2009).

Second, the reservoir stores water during the rainy season, and discharges it during the dry season to mitigate water consumption pressures downstream, particularly during drought years. In contrast to earlier times, the Yellow River has never dried up since the completion of the dam. Hence, a large agricultural area benefits significantly from the water supply function of the Xiaolangdi project (Liu 2004; Ministry of Water Resources 2009).

Third, learning from lessons from the Sanmenxia Dam, the Xiaolangdi Dam took the sand accumulation problem into consideration. About 60% of the reservoir's capacity was designed to store sand coming from upstream, and it is estimated that the height of the downstream riverbed will not increase for at least 20 years. In the long term, the dam also would control water speed slowing the washing-out of sand along the downstream riverbed, and with collaborative efforts in upstream areas to restore vegetation and reduce soil erosion, sand accumulation and depletion downstream could reach a balance (Ministry of Water Resources 2009).

Fourth, Xiaolangdi Dam also has an electricity generation function, with an installed capacity of 1,800 MW, which could effectively mitigate the electricity supply pressure in Henan Province, where it is located (Liu 2004; Ministry of Water Resources 2009).

Overall, Xiaolangdi Dam has achieved most of its goals and contributed significantly in managing the Yellow River. The sand accumulation problem has been reduced to a large extent, and the Yellow River is becoming more and more stable. The World Bank has praised this project, regarding it as a successful model for other projects it is supporting in developing countries (China.org.cn 2008).

Despite various achievements of the Xiaolangdi Dam, it also has had substantial social and environmental impacts. For example, 201,400 people were relocated, including 159,400 in Henan Province and 42,000 in Shanxi Province. At the maximum water level of 275 m, 277.8 km^2 of land in eight counties were submerged or indirectly affected, inundating 13,000 ha of farmland and 3,960 ha forests and orchards. Furthermore, 174 villages and 787 factories needed to be relocated, and 297 historical sites were submerged (Ministry of Water Resources 2009).

According to the requirements of the World Bank for environmental protection, the Xiaolangdi project also developed different methods to minimize its impacts on the environment. However, it still changed the landscape across a large area, and the negative effects caused by the project likely will not be known for years to come (Ministry of Water Resources 2009).

2.3.3 The Nu River

Undetermined fate of a pristine river

The Nu River originates in the Qinghai-Tibet Plateau, running through Yunnan Province in southwest China, and then Myanmar on its way to the Indian Ocean. Non-governmental organizations opposing the construction of dams on the Nu River have argued that it is the last large, pristine river in China. Debates about whether to build dams on the Nu River have gone on for eight years, and the future of this unique river is still undetermined.

The possible exploitation of the Nu River for hydroelectricity was first incorporated into the national hydropower development plan in the 1980s. In 1999, the National Development and Reform Commission decided to start the procedure for constructing a series of dams on the Nu River. After public bidding, two institutes, the Beijing Investigation and Design Institute and the East China Investigation and Design Institute, were identified as being responsible for the design and planning of the cascade dam project. After four years of investigation and discussion, they presented a proposal to build 13 cascade dams, with the total installed capacity of 21,320 MW, which was 1.215 times of the capacity of the Three Gorges Dam, and would represent 20% of China's total hydroelectricity production after completion. Until that time no one had doubted that the cascade dams would be built soon on this river (Dai 2004).

However, dramatic changes happened just two weeks later, when two environmental organizations, Green Watershed and Green Earth Volunteers, launched a campaign against the dam project on the Nu River which attracted public attention. WANG Yongchen, founder of the Green Earth Volunteers, convinced 62 influential people, including scientists, writers, journalists, and environmentalists, to sign a declaration to protect the natural status of the Nu River. Then, many media services began to publish articles about the proposed dams, with most of them being against the project. These NGOs also organized international conferences, and even drew the attention of UNESCO, which recognized their petition and showed "concern" about the Nu River dam project. Finally, Chinese Premier WEN Jiabao called for the suspension of all the dam projects on the Nu River and requested a more detailed environmental and social impacts assessment (Cao and Zhang 2004).

In the years following this 2003 landmarked action, proponents and opponents of dam construction on the Nu River have continued their seesaw battle. In 2005 a group of famous scholars who supported the project visited the region, and blamed the environmental organizations for being "biased" and "extremists." Some institutes also conducted the environmental impact assessments, which acknowledged some negative effects the project would have on the ecosystem and indigenous culture, but overall supported the dam project. Both sides have continued submitting petitions to the Central Government. The most recent petition was written by four geologists in February 2011, who warned that the Nu River runs along on a fragile geological zone, and that the dam project could trigger various geological disasters, including large earthquakes. Official agencies announced in March 2011 that the project was still under a "feasibility study" and that a decision could not be made until its completion (Lv 2011; Reuters Beijing 2011; Wang 2011).

Opinions from both sides

Opponents of the dam include Chinese NGOs, and some journalists and scientists. Their major arguments are summarized below.

1. The Nu River is the only undammed large river in China, and it should be left as a natural river for future generations. The title "The last virgin river in China" attracted a lot of public attention, and aroused national debate about whether to build dams on the river or not. In addition to its uniqueness as China's "only virgin river", the Nu is also marked by high biodiversity and is identified as part of the World Natural Heritage by UNESCO. The dam project might cause irreversible impacts on the Nu gorge's ecosystems and pristine scenery.
2. The Nu River runs across a region with very high ethnic and cultural diversity, and dam construction would require relocating thousands of these indigenous people, which would damage their unique customs and cultures.
3. Some experiences with dam-caused relocation programs in Yunnan Province showed that they significantly lowered the standards of living of the relocated people. Therefore, it is socially unfair for local people to sacrifice their livelihoods while hydroelectric companies reap huge benefits from the project.

The proponents of the dams care more about local development, and they think the dam project will provide golden opportunities. Those people include local government officials, managers of state-owned hydroelectricity companies, and some scientists. Their major points are also summarized below.

1. The feeling that the Nu is still a pristine river is an illusion of people who have never been there. In reality, because of population growth and extreme poverty, local people have already destroyed the primary forest below the elevation of 2,000 m. Therefore, dam construction would only cause inundation of these already ecologically destroyed areas and would not have substantial impacts on primary ecosystems above that elevation. Actually, dams might even benefit the ecosystem, since the electricity generated could reduce the mass consumption of fuel wood and save remaining intact forests.
2. Hydroelectric projects could bring prime development opportunities to this remote area. Nujiang Prefecture, where most of the cascade dams would be built, is among the poorest regions in China. In 2002, this prefecture had a total fiscal revenue of only 105 million yuan (~US$ 16.4 million), which was much less than 1% of that in a rich prefecture in East China. The cascade dam project could generate an annual profit of 36 billion yuan (~US$ 5.6 billion), and, even though only a small portion would be retained locally, this would result in at least a ten-fold increase in the local revenue. This is why the local government is among the most active advocators of the dam project.
3. It is undeniable that the dam project will have significant impacts on the river species, particularly some migratory fishes. But the environmental impact

assessment showed that among the 48 indigenous fish species, only one would likely be driven to extinction. Hence, the value of one species cannot be compared with the development opportunities for millions of people.

4. Population density in the proposed project area is relatively low compared to other hydraulic project areas, such as the Three Gorges Dam area. Even though the installed capacity is larger than Three Gorges Dam, the Nu River's dams would require the relocation of only 48,979 people, which is less than 5% percent of the people relocated in the Three Gorges Dam project. Therefore, the social impacts of the dam project are also relatively low.

The meaning of the Nu River debate

After being hotly debated for eight years, the future of the Nu River is still undecided. However, no matter the result, the debate does have significant implication for China's dam construction history. It was the first time in modern China that civil society's opinions influenced the Central Government's decision-making process regarding infrastructure construction. It also represented a great leap in understanding the roles of different stakeholders in dam construction.

Central planning schemes have profound influences on infrastructure construction in China. Historically, the Central Government or its ministries were responsible for the entire process associated with such projects, including design, planning, construction, and assessment. Therefore, when NGOs and civil society caused dramatic changes in that process, and halted an already-decided project for eight years, many government officials were unfamiliar with this new phenomenon. Hence, the Nu River campaign was a signal that the forces of civil society in China are emerging and growing, and will play more and more important roles in the future development of China's infrastructure.

Even though the Nu River debate did not draw as much attention as the Three Gorges Dam had, it still has its own significance in China's dam construction history. It was in the Nu River debate that all the stakeholders in dam construction began to comprehensively consider the impacts the dam could bring in different respects. Previously, when planning to build a dam, economic costs and profits were the determinant factors, and environmental and social impacts were largely ignored. Particularly, the public was only informed how much profit a dam project had generated, but had never been told about the negative effects on environment or local people. But during the Nu River debate, all the positive and negative impacts of cascade dams were openly discussed via websites, newspapers, and TV shows. All stakeholders, including government officials, scientists, local people, NGOs, and hydroelectric companies, had opportunities to give their opinions and also consider opinions from other stakeholders. This debate enriched the knowledge of all stakeholders about dam impacts, and will profoundly influence the decision-making process for dam construction in China in the future.

2.3.4 The Lancang River

A successful hydropower development model

The Upper-Mekong River, which is called the Lancang River in China, is one of Yunnan's three parallel rivers. It flows from the Tibetan Plateau, goes through Yunnan Province for 1,247 km, and runs through Myanmar, Laos, Thailand, Cambodia, and

Vietnam before empting into South China Sea. Running through deep valleys, the Mekong River has an elevation drop of over 800 m in Yunnan Province, which is ideal for building dams in the view of hydrologic engineers. In the 1980s, Yunnan Province invited national renowned hydropower experts to investigate and design the Lancang cascading hydropower exploitation plan. These experts designed 14 cascade dams on the reach of the Lancang River in Yunnan Province, with eight dams on the middle and lower reaches of the river. From upstream to downstream, these eight dams are: Gongguoqiao, Xiaowan, Manwan, Dachaoshan, Nuozhadu, Jinghong, Ganlanba and Mengsong (Figure 2.6) (Han 2006).

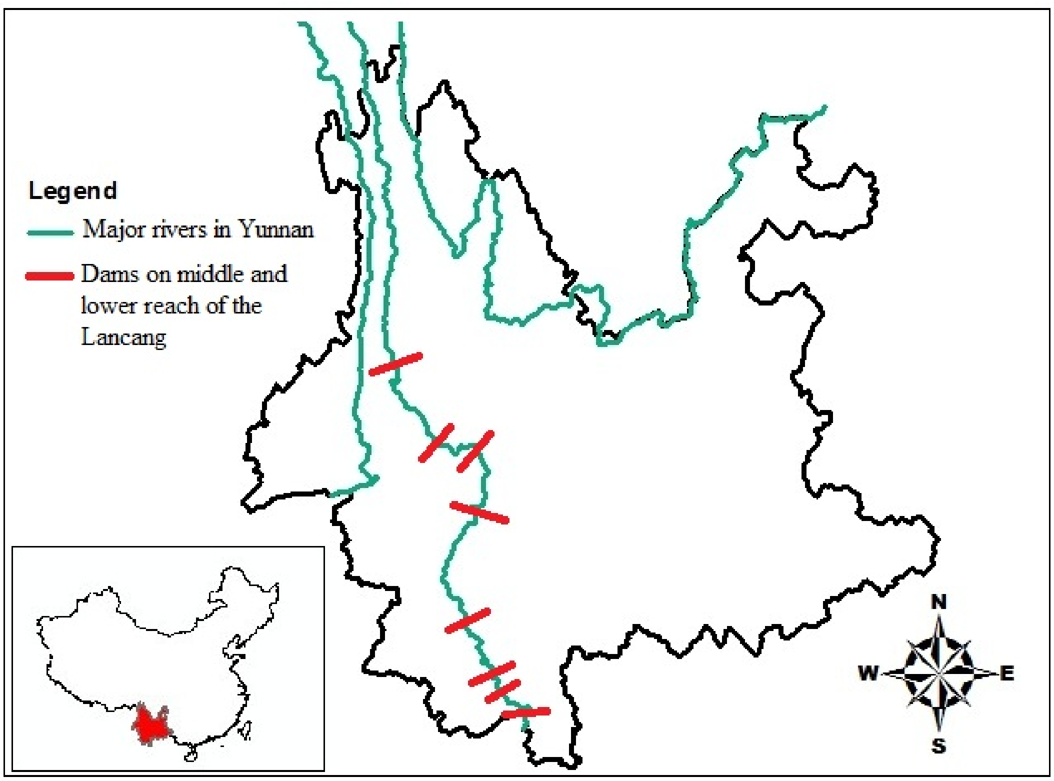


Figure 2.6 Cascading dams on the Lancang River

The development process of the Lancang cascade dams is a good illustration of the Chinese hydropower model, which is “watershed, cascade, rolling, comprehensive.” “Watershed” means a watershed should have a whole and consistent exploitation plan, instead of separate plans for different reaches; “cascade” means for each large river, there should be a series dams being built to take advantage of the entire river’s hydropower potential; “rolling” is the strategy to use a small amount of capital to build the first of the cascade dams, then use the profit from the first dam to build the second one, then the third, and so on; “comprehensive” has two basic meanings, the first is that all the dams should regulate the flow under a comprehensive plan for the whole river, and the second is to build dams not only to generate electricity, but also as means for enhancing irrigation, water supply, navigation, and tourism (Han 2006; Duan 2009).

The first dam built on the mainstream of the Lancang River was Manwan Dam. It was completed in 1995, with an installed capacity of 1,250 MW. Manwan is the first dam in Yunnan Province that takes part in the “Transport western electricity to the east” strategy. Part of the electricity from it is transported to highly-developed Guangdong Province to meet its massive energy demand. The second stage of the Manwan project was completed in May 2007, adding another 300 MW installed capacity to the hydropower station.

Dachaoshan was the second dam built on the Lancang River, which was completed in 2003, with an installed capacity of 1,350 MW. Its financing and management was a revolution in China’s large hydropower dam construction history, which for the first time introduced the modern enterprise system into the hydropower sector.

The third dam, Xiaowan, is 70 km upstream of Manwan Dam. It was completed in 2009, with the installed capacity of 4,200 MW. It is one of two key water-control dams in the cascade dam system, having the ability to regulate flow for all the downstream dams in a long term. The height of the dam is 300 m, forming a reservoir of 14,560 million m^3.

Nuozhadu Dam is the largest on the Lancang River, and it is the other key water-control dam, regulating flow for three dams downstream of it, Jinghong, Ganlanba, and Mengsong. Nuozhadu Dam is still under construction, and the planned installed capacity is 5,850 MW. According to the official website, the dam is planned to be completed in 2017 (Xinhua News Agency 2002).

Jinghong Dam was completed in 2009, with an installed capacity of 1,500 MW. According to an agreement between China and Thailand in 2001, a Thai company was to hold 70% of the company's shares, and all the electricity generated from plant was to be sold to Thailand. However, to accelerate the implementation of the "transport western electricity to the east" strategy in China, it was finally decided that a Chinese company would hold all of the shares and that the electricity from Jinghong would be sent to Guangdong Province.

The other three dams, Gongguoqiao, Ganlanba, and Mengsong, are either under construction or being designed. These dams are much smaller than the other dams, and they will not have the ability to regulate flow. The designed installed capacities for each of them are: Gongguoqiao, 750 MW; Ganlanba, 250 MW; and Mengsong, 600 MW (Xinhua News Agency 2002; Duan 2009).

Environmental and social consequences

Cascading dams on the Upper-Mekong River will dramatically change the profile of the river, and alter its natural flow significantly (Figure 2.7). It is also clear that Xiaowan and Nuozhadu are much larger dams than the others, and these two dams actually have the ability to regulate the flow of their downstream dams. Such a significant change in the landscape will undoubtedly have impacts on the environment and local human communities.

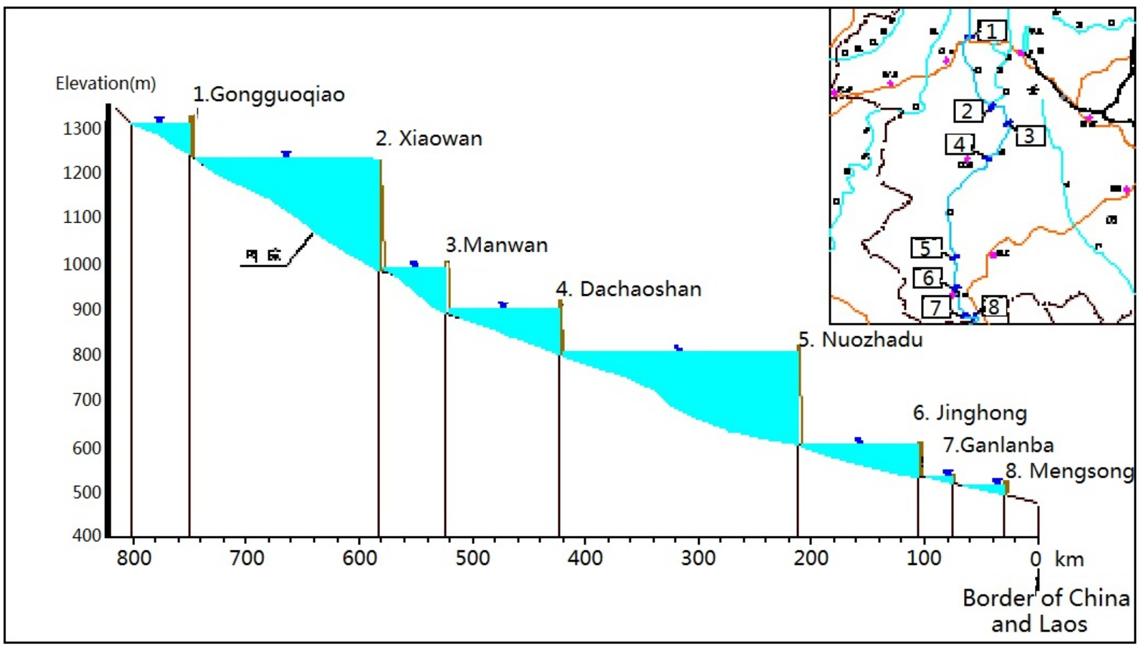


Figure 2.7 Vertical profile of the Lancang River after dam construction

The first environmental impact dams have is on local agriculture. Only 7% of land in Yunnan is arable, and most of the arable land is along riversides. The newly formed reservoirs will submerge a large area of productive farmland and local villages will be forced to move. The people so relocated would cause secondary environmental impacts, such as the clearing of new land for agriculture and increasing deforestation and soil erosion in that area. The newly cleared farmland is generally less fertile than the original land, and therefore it will require more fertilizer, being more costly and possibly promoting more pollution of water bodies. The second impact is on fish and fishery in the Lancang River. The lower reach of the Mekong River, which is downstream to the Lancang River, is one of the largest freshwater fishing grounds in the World. It is estimated that freshwater fishes constitute 80% of the animal protein consumption in Cambodia. During the wet season a large area in Cambodia is inundated by the Mekong River, which provides an opportunity for many fish species to spawn. Regulating the flow of the Lancang River will reduce the magnitude and frequency of floods downstream and substantially reduce fish populations. Migratory fish cannot go to upstream due to the fragmentation of the watercourse, which might cause the extinction of some species. In addition, the cascade dams also aggravate sedimentation in the Lancang River. Evidence shows that the rate of soil erosion along the Lancang River has increasing in recent years, which could significantly shorten the lifespan of the dams.

Social impacts of the cascade dams include changes in local livelihoods, social inequity problems, cultural diversity loss, and international conflicts over water use. Local farmers suffer wealth loss in both material and non-material forms, such as submerged farmland and houses, being unable to use certain skills, and social capital loss. Relocation could also cause social inequities at different scales, from household to regional levels. The Lancang region is one of the most cultural diverse areas in China, with more than 20 ethnic groups (Dore and Yu 2004). A mass relocation program could cause significant cultural impacts and loss in traditional customs. The Mekong River is called “the Danube River in the East”, going through seven countries. Building dams on its upstream reaches likely would heighten the conflicts between upstream and downstream residents. Chapter 3 will discuss the social impacts of the Lancang cascade dams in greater detail.

2.3.5 The Jinsha River

The Jinsha River is the Upper Yangtze River, with a watershed of 473,200 km^2, which is about 26% of the total Yangtze watershed. The upper reach of the Jinsha River is from Yushu to Shigu, a length of 958 km, and an elevation drop of 1,677 m; the middle reach is from Shigu to Panzhihua, which is 1,326 km in length with an elevation drop of 1,570 m; and the lower reach is from Panzhihua to Yibin, which is 782 km and has a 729 m elevation drop. The Jinsha River has the hydroelectric potential of 112,400 MW, which is about 16.7% of China's hydroelectric potential. Most of the river runs through deep and narrow gorges, geologically suitable for building large dams (China Three Gorges Corporation 2008; Li 2009).

The planning of hydroelectric projects on the Jinsha River dates back to the 1950s. In the 1990s, according to the national hydroelectric planning strategy, 14 dams were proposed along the river. Two of these dams were to be on the upper reach, Rimian and Tuoding; eight dams were proposed for the middle reach, Hutiaoxia, Liangjiaren, Liyuan, Ahai, Jinanqiao, Longkaikou, Ludila, and Guanyinyan; and four dams were identified for the lower reach, Wudongde, Baihetan, Xiluodu, and Xiangjiaba. The State Development and Reform Commission dictated the order of their construction: dams on lower reach were to be built first, followed by dams on the middle reach, and last those on the upper reach (Li 2009).

In 2002, the China Three Gorges Corporation, a state-owned company, obtained the right to build the four dams on the lower reach. The Xiluodu Dam project commenced in December 2005, and Xiangjiaba began in December the following year. The other two lower reach dams, Wudongde and Baihetan, are presently going through feasibility studies and environmental impact assessments. The proposed total installed capacity of the four dams is twice as large as that of the Three Gorges Dam (Li 2009).

At the end of 2005, a new state-owned company, the Yunnan Jinsha River Hydropower Corporation, was founded, with the goal of building the eight middle reach dams. According to the "Jinsha middle reach hydropower planning report" in 2003, the total installed capacity of these dams will be 20,580 MW. The shareholders in the Corporation are actually several big electricity companies in China: Huadian Corporation, Huaneng Corporation, Datang Corporation, Hanneng Corporation, and Yunnan Investment Corporation. Each of these companies is in charge of one or more dams; for example, Huadian is responsible for building Ludila Dam, and Huaneng is responsible for Longkaikou Dam. The fact that different companies manage different dams on the middle reach of the Jinsha River might make flow regulation more complex and politicized. Actually, flow regulation of the entire Yangtze River lacks a comprehensive management strategy, which impairs the functioning of its dams for flood control and supplying water. For example, when the Yangtze watershed suffers from drought, downstream areas need more water for irrigation and urban consumption, but in many cases the upstream dams hold the water to generate electricity, which aggravates drought problems downstream. When there is heavy precipitation in the watershed, the upstream dams generally discharge their stored water to release pressure on the dams, which makes the situation of the already flooded downstream areas even worse (Li 2009; South China Weekends 2010).

Similar to the situation involving the Nu River, there are heated debates about the dams on the Jinsha River. Because of the massive profits arising from the production of hydroelectricity, hydropower companies and local governments eagerly push the dam construction process forward. But the Ministry of Environmental Protection and environmental NGOs also try their best to prevent some of the construction. But unlike the Nu River situation, where no dams have been built to date, there are several dams already under construction along the Jinsha River. The fragmentation of the Jinsha River also has extensive social and environmental impacts. Unfortunately, there appear to be fewer published studies addressing the potential impacts of dams on the Jinsha River compared to other case studies presented in this section (Li 2009; South China Weekends 2010).

CHAPTER 3 A FRAMEWORK FOR SOCIAL IMPACT ANALYSIS: A CASE STUDY OF DAMS ON THE UPPER-MEKONG RIVER, CHINA

3.1. Background information[1]

Large hydrological project construction is often accompanied by impacts on the environment and local communities (WCD 2000; Tullos, Tilt et al. 2009). Driven by population growth, energy demand increases, and social changes in China, the conflicts between hydropower exploitation, environment protection, and social development have become increasingly intense (McNally, Magee et al. 2009). Large dam construction has been highly controversial for decades and the debate over it has become even more heated during recent years (Égré and Senécal 2003; Tilt, Braun et al. 2009). The construction of a large dam often will inundate thousands hectares of farmland and cause dozens of indigenous villages to be relocated (Sadler, Verocai et al. 2000). It also could distribute the costs and benefits unequally and unfairly, causing the widening of wealth gaps (Tullos, Tilt et al. 2009). At the same time, some dam projects bring development opportunities to the local communities (Fuggle, Smith et al. 2000). Therefore, analyzing and assessing both the negative and positive social impacts on local communities are critical in the decision-making processes involving the construction of dams and the designing of associated compensation policies.

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[1] N.B., Some background information presented in this chapter has been mentioned in the preceding chapters and Appendix I. This is because Chapter 3 is serving as a first draft of a scientific journal article that will be revised and submitted soon after the completion of this thesis.

Social impact analysis should take different dimensions of impacts into consideration (Freudenburg 1986; Vanclay 2003), and several papers have been published using such analyses to assess the impacts of large hydrologic projects (Sadler, Verocai et al. 2000; Tilt, Braun et al. 2009). In this study, I intended to provide a social impact assessment framework that has more straightforward implications for improving the development of compensation policies. First, I classify the wealth of affected people into three dimensions, and then comprehensively compare the loss and compensation in each dimension, and finally assess the influences on arising gaps in wealth. For compensation policies, my basic hypothesis is that the more villagers and decision-makers agree on the degree of losses and compensations in all dimensions of wealth, the more reasonable the compensation policies will be, and the less dissatisfaction affected villagers will have. I selected three dams built on the Upper-Mekong River in 1995, 2003, and 2009, and conducted interviews and surveys in 10 villages affected by these dams. Official statistics and government documents were also collected for the analysis.

This research was conducted in Yunnan Province, which is located in the southeast corner of China, bordering with Vietnam, Myanmar, and Laos. It is one of the most mountainous provinces in China, with 94% of land consisting of mountains and plateaus. Elevations in Yunnan range from 76 to 6740 m above sea level. Because of this dramatic drop in elevation and abundant rivers in the province, Yunnan has great hydrologic potential: the Nu, Jinsha, and Lancang Rivers are each among the top six rivers for hydrologic potential in China. Driven by the rapid increase in China's energy demand due to economic development, dozens of large hydrologic projects have been built, or are under construction or being planned for rivers in Yunnan. At the same time, Yunnan has the highest biodiversity and cultural diversity among all provinces in China (Dore and Yu 2004). It is identified as one of the 25 biodiversity hotspots in the world, and is also the home for 25 ethnic groups, including 14 who live exclusively in Yunnan. Therefore, protecting biological and cultural diversity in Yunnan from large-scale hydrologic exploitation is a major concern of conservationists in and out of China.

The Upper-Mekong River, which is called the Lancang River in China, is one of the three parallel rivers in Yunnan. It flows from the Tibetan Plateau, goes through Yunnan for 1,247 km, and runs into Myanmar, Laos, Thailand, Cambodia, and Vietnam before emptying into South China Sea. Running through deep valleys, the Mekong River has an elevation drop of over 800 meters in Yunnan Province, which is ideal for building dams in the view of hydrologic engineers. The Lancang cascading hydrologic exploitation plan is a national-level hydrologic plan to take advantage of this steep elevation drop by building a series of eight dams in Yunnan. Among these, the Manwan, Xiaowan, Dachaoshan, and Jinghong are already in full operation. The other four are either under construction or being designed.

3.2 Research sites

Among the cascading dams along the Upper-Mekong River, I selected three dams and their affected areas as research sites. Manwan Dam was the first dam on the Upper-Mekong mainstream which was finished in 1995. Dachaoshan Dam was completed in 2003, and the third dam, Xiaowan, began operation in 2009.

Local communities affected by the construction of dams can be divided into two types. First, the raised water level causes inundation of farmland, houses, commercial forests, and other properties. But local people still live in the same villages, or just move a short distance from their original villages. In this thesis, I call those in this type 'near-relocated villages'. Second, the impacts of the reservoir on the human habitat areas might be so great that the original villages are no longer usable, and the communities have to be relocated to faraway places. I call this type 'far-relocated villages'. In the field research, interviews and semi-structured surveys were conducted in 10 villages, which were selected as representatives for both types of affected communities in each of the three dam influenced areas (Figure 3.1 and Table 3.1).

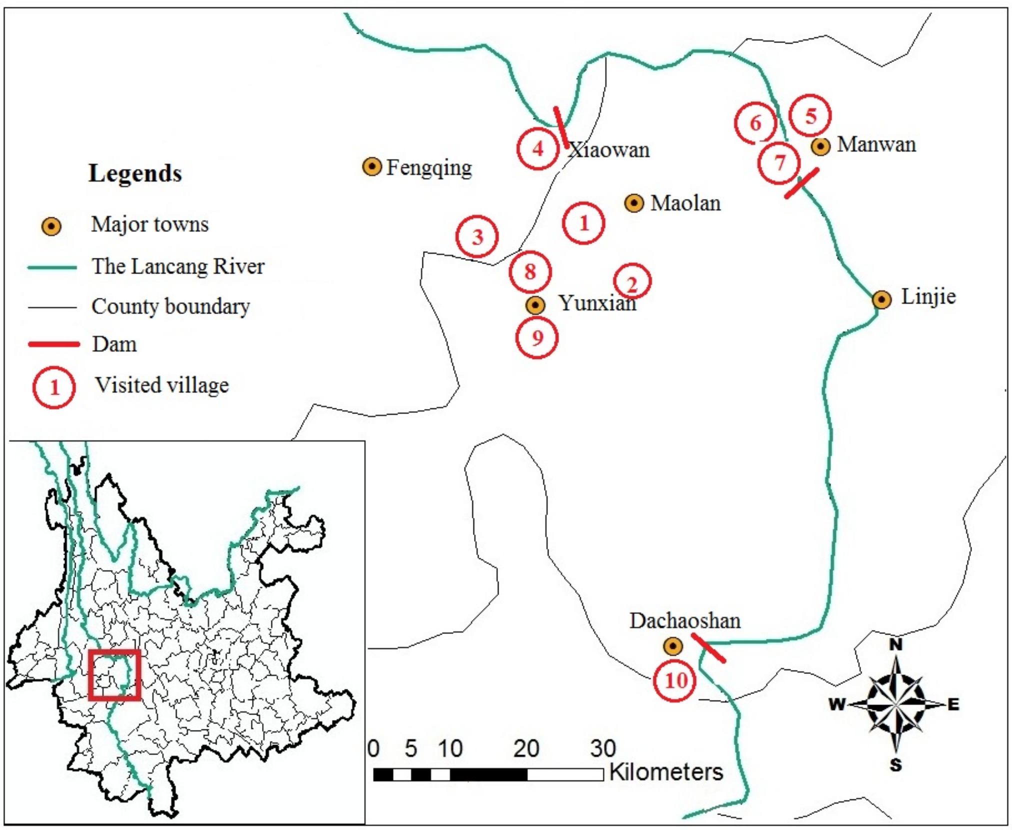

Figure 3.1 Ten visited villages in six categories

Table 3.1 Ten visited villages in six categories

Dam and Relocation Type	Villages
Manwan near-relocated	Yuluo (5) , Yakoutian (6), and Dapingzhang (7)
Manwan far-relocated	Hewan (8) and Tianxin (9)
Dachaoshan near-relocated	Longtan new village(10)
Dachaoshan far-relocated	Wayaoqing (1) and Hongdouqing (2)
Xiaowan near-relocated	Xiaowan village (4)
Xiaowan far-relocated	Daxing village (3)

*The numbers in this table are consistent with those in Figure 3.1

3.2.1 Case study 1: Manwan Dam

Manwan Dam was the first large dam built on the mainstream of the Upper-Mekong River, completed in 1995 with installed generating capacity of 1,250 MW. The total submerged farmland was 6,225 mu (1 mu = 1/15 ha), including 3,630 mu of paddy field, and 2,595 mu dry field. According to official data, there were 3,208 people in reservoir areas who were relocated. However, according to various studies, the actual number of migrants was much larger than the official data, since landslides and other dam-caused problems forced more people to eventually move. To assess the impacts of the Manwan Dam, I conducted interviews and surveys in three near-relocated villages, and two far-relocated villages (Figure 3.1 and Table 3.1).

Near-relocated villages of Manwan: Yuluo, Yakoutian and Dapingzhang

Yuluo village is beside the reservoir of Manwan Dam, and although it was impacted substantially by dam construction, its residents received remarkably low compensation. In 1993, one year before the Manwan reservoir began to fill, the first group of people moved to a village called Zhehou. However, the situation there was so poor that the rest of the villagers refused to move there. They stayed in the original village until 1999, when landslides caused by the reservoir were so threatening that they had to move to a higher location on the other side of the river, which is the current location of Yuluo village. When the villagers moved, their houses were compensated according to area, and they were responsible for building new houses for themselves. They did not receive compensation for lost farmland, but the government cleared new land for them around the new village.

The area of farmland per household decreased notably after moving, and the quality of the soil was worse than before. The lack of irrigation water also forced villagers to switch from growing rice to growing wheat or corn, which do not require intensive irrigation.

The transportation condition of Yuluo village was terrible, with only one muddy road to a nearby town, and it was impassible during the rainy season when boats became the only reliable means of transportation. Poor transportation conditions made access to healthcare and education difficult. The closest elementary school was 12 km away, which took one day to walk back and forth. Hence, children had to lodge overnight at their school. The nearest hospital was in a town that took four hours to reach. Drinking water was also hard to get in the village.

Even worse, the new village was vulnerable to landslides, which caused the walls of some houses to crack. These tough conditions combined to make the average income of the villagers extremely low. Subsequently, most young people chose to go to cities to work in factories, returning home only during the farming season.

Yuluo village was in the poorest condition among all the villages I visited during this study. It is a representative of relocated communities that suffered from the low compensation policy that existed during the early 1990s. Because the living conditions were so harsh, the villagers had requested a “second move” to a new place more suitable for human habitation.

Yakoutian village is one km upstream of Yuluo village. By the time I visited, there were only nine households left in this village, the others having moved to a newly built village about 60 km away. The situation in Yakoutian village was almost the same as that in Yuluo. The area of farmland was dramatically reduced, and there was not adequate water to irrigate the paddy fields. The village was far from hospitals and schools, and the transportation condition was very poor. Drinking water was difficult to get.

Dapingzhang village was the third near-relocated village I visited in the Manwan reservoir area. Because the original village was close to the dam, it was almost totally inundated by the newly formed reservoir. There were three opportunities for the villagers to move to a faraway, newly built village, in 1987, 1995, and 2000, but still some villagers preferred to live in this area. The location of their village had to be moved several times because of landslides and other hazards. Each household received 6,000 yuan (1 yuan = US$ 0.153) to rebuild their house.

Villagers in Dapingzhang grew crops on their remaining dry fields and newly cleared fields. However, there was no irrigation water, and the soil condition was poorer than before. Transportation services for the village declined, since there had been a national highway (No. 214 highway) parallel to the river, but it was submerged by water after the dam was constructed.

Far-relocated villages of Manwan: Hewan and Tianxin

Hewan village was built for the far-relocated people from the Manwan area, and 26 households, including 107 people, moved there in 2005. Each person received 6,800 yuan for house compensation, and 0.5 mu paddy field and 1.5 mu dry field in Hewan village. Relocated villagers were responsible for building their own new houses, and even though they had the freedom to design most of the new house, they had to follow the standards of constructing a "two story building with white walls and red roof." The red tiles for the roof were purchased by the government. The "red roof and white walls" style was chosen as a symbol of "harmonious rural society".

Compared with the earlier location, the soil quality of new paddy field was almost the same and irrigation water was sufficient; however, the quality of the dry field was much poorer. Another disadvantage of the new agricultural condition was that the climate at the new location was warmer than that of their previous villages. This had a negative impact on the growth of rice.

Most villagers agreed that the application of herbicides significantly reduced the time invested in the field. Furthermore, in the past they had mainly used farmyard manure, but now they had to use a lot of synthetic fertilizers.

The government was not able to clear enough farmland for all the villagers, so they compensated them by providing money: 13,000 yuan per mu (US$ 30,469 per ha) for the shortfalls. Agricultural incomes were insufficient at both locations, forcing villagers to go to cities to work in factories for several months a year.

Since the new location was closer to the county town, transportation, healthcare, and education conditions were better than before. But some villagers noted that drinking water was insufficient at times, since the relocation process caused an increase in population, but the water sources remained the same.

Also in 2005, 33 households, about 130 people, moved from Manwan Dam-affected areas to another distant village, Tianxin. At that time, only a certain proportion of the villagers were allowed to move to Tianxin, and others stayed in the old village. The farmlands of relocated villagers were given to those who chose to stay.

Each of the relocated villagers received 7,000 yuan for his or her house, in addition to 0.5 mu paddy field, and 1.5 mu dry field. Villagers said that after moving, the standards of living for relocated people and people who stayed were almost the same.

New farmland was considered in better condition than their former land. After the construction of Manwan Dam, the old farmland became too stony to grow crops, but the new farmland in Tianxin did not have this problem. The government required some of the villagers to grow tobacco, but this would not greatly impact these villagers because they could interplant corn in among the tobacco. If the villagers grew Chinese sorghum, they received half bag of fertilizers per mu. However, in the past many people grew tea, for which Tianxin village is unsuitable.

Transportation, education, and healthcare are better than before. Beginning in 2005, electricity fees for villagers in Tianxin were waived for 10 years. Thus, in many respects, the relocation from Manwan to Tianxin was beneficial.

3.2.2 Case study 2: Dachaoshan Dam

Dachaoshan Dam, the second dam built on mainstream of the Upper-Mekong after Manwan, was finished in 2003. According to official data, the area of submerged paddy field was 1,562 mu, and submerged dry field was 4,762 mu; 6,363 people were relocated by 2001. Two villages, Wayaoqing and Hongdouqing, which were far-relocated from original locations, were investigated. And one village, Longtan new village, which was near-relocated, was investigated (Figure 3.1 and Table 3.1).

Near-relocated villages of Dachaoshan: Longtan new village

Longtan new village is downstream of Dachaoshan Dam and thus was not submerged by the reservoir. However, most of the land of the original village was used as construction sites or factory buildings. So the whole village moved upward on the mountainside in 2000. Compensation was 5,000 yuan per mu (US$ 11,719 per ha) for paddy field, and 2,000 yuan per mu (US$ 4,687.5 per ha) for dry field. New land was cleared to become paddy field, and 20% of the compensation was required to invest in an irrigation project. However, as the villagers said, only 5% of the compensation had been received by the time I interviewed farmers in this community.

The irrigation project included a small reservoir on the hilltop, with ditch systems connecting to paddy fields. Water in the river was pumped up to the reservoir, and then flowed to ditches through the fields. However, the water supply was not able to meet the demand of paddy field, so most of the paddy field was used as dry field.

However, healthcare, education, and transportation were improved over earlier conditions. Taking drinking water as an example, in the past villagers needed to carry water from wells. Now the “three set-up project” (set up electricity, water, and a road for villagers) made running water available for villagers.

Far-relocated villages of Dachaoshan: Wayaoqing and Hongdouqing

Wayaoqing village is located 10 km north to the county town of Yun County. It has a population of 230 people, moved from the Dachaoshan Dam-affected area about 50 km away in December, 2000. The houses in their original villages were either abandoned or submerged by water, and most of their paddy field was inundated. Most of the dry land was on higher hillsides and thus was unaffected. The property rights for unaffected paddy field, dry field, and forests were given to the government, and then these lands were re-allocated to people who chose to be near-relocated.

The houses in Wayaoqing were designed and built by the government in a uniform style. A new house with a kitchen and bathroom was valued at 54,000 yuan. Houses and the crops in the original villages were also evaluated. If a household’s original house and crops were worth more than 54,000 yuan, the government compensated the surplus value. If the original house and crops were less, the households did not need to pay the shortfall. The new houses were built with bricks and concrete, and were generally in better condition than the former houses.

In the original villages, each villager had about 0.8 mu paddy field on average, and he could cultivate as much dry field as his ability allowed. In Wayaoqing, the government cleared new land and assigned it to villagers. Each person received 0.1 mu land for growing vegetables, 0.7 mu paddy land, and the area of dry field ranged from 2 to 8 mu. In the past, their paddy fields were so productive that they hardly needed to use fertilizers and still could have high yields. They now have to use fertilizers intensively to maintain high yields. However, after moving to the new location, they learned more advanced agricultural techniques, and have easier access to the markets to get hybrid species and fertilizers, hence, they achieve much higher yields than before. One disadvantage now is that the irrigation system relies on a reservoir, which only discharges water after April 20. Hence, rice can not be grown before that date. Previously, there were ditches around their paddy fields and they could irrigate the land whenever it was needed.

When asked about whether healthcare and education conditions were improved, the interviewees did not reach an agreement. But most of them thought that the quality of education was better, despite the fact that schools were farther away than before.

Residents in Hongdouqing village moved from the Dachaoshan Dam-affected area at almost the same time as people in Wayaoqing. They had the same house compensation policy as in Wayaoqing, but the allocation was different: each ten houses drew lotteries to decide who got which house. In addition, each household received 500 yuan to cover moving expenses.

Before moving, villagers were promised to receive 0.7 mu paddy field per person. However, they actually only received 0.24 mu per person. What made the situation worse was the irrigation condition. Houdouqing used the same reservoir for irrigation as Wayaoqing, but the distance between Hongdouqing and the water source was too far to guarantee a reliable water supply. In fact the reservoir water was only available during the first two years, and afterwards the villagers had to use paddy field as dry field because of the lack of water. This noticeably reduced their agricultural incomes. Even their drinking water quality was hard to guarantee, which evoked many complaints among the villagers. The current dry fields also had lower quality than former fields. The current fields are sandy soil, which loses water easily, whereas the former fields were clay soil that could retain water for several days after a rain.

Because of the use of herbicides, time invested in agricultural activities was shortened. To make up for the loss in paddy field, some villagers grew pecan and red lac to increase income. Lack of arable land caused an excess in the labor force, and a large portion of villagers went to cities to seek jobs in factories.

Hongdouqing is located by a main road and close to the county town, thus transportation is much better than previous villages located along the riverbank. Healthcare and education conditions are also improved because of easier access to hospitals and schools in the county town.

The 88 households in Hongdouqing consist of four ethnic groups: Han, Yi, Bulang, and Dai. Most of them now speak Mandarin Chinese instead of their ethnic language, but this change is mainly because of the need to communicate, not the relocation. However, some ethnic-featured activities were affected by the relocation. For instance, many traditional festivals of Dai people have activities that require spacious ground, but after relocation, they could not find space for such activities.

3.2.3 Case study 3: Xiaowan dam

Xiaowan Dam was in full operation in 2009, and more than 30,000 people were relocated, but this figure needs to be validated. I conducted surveys and interviews in one far-relocated village, Daxing, and one near-relocated village, Xiaowan (Figure 3.1 and Table 3.1).

Near-relocated villages of Xiaowan: Xiaowan village

In 2004, 44 households living in reservoir or construction areas moved up the hillside, to reside in Xiaowan village. Most of the villagers' original houses were not submerged by water, but were taken by construction activities. The houses in Xiaowan were built in 2003, and valued at 100,000 yuan each. Their old houses were compensated for 200 yuan per m^2, and 125 yuan per m^2 for kitchens. They were compensated for 12,000 yuan per mu (US$ 28,125 per ha) for paddy field, and 6,000 yuan per mu (US$ 14,063 per ha) for dry field. New farmland was not provided until 2009, therefore, between 2004 and 2009 they had no farmland. Furthermore, the new farmland is still raw and unsuitable for cultivation, and there is also an inadequate supply of irrigation water.

However, many construction workers began coming to Xiaowan in 2004, which has stimulated the local economy. Many villagers quit their agricultural activities and opened small businesses, such as shops, hotels, or restaurants. Other villagers found jobs in the dam project as construction workers. This change in lifestyle also changed income levels and consumption structures. In the past, villagers ate rice and vegetables they had grown themselves, and made money by selling chicken, eggs, pigs, and cows. They now generated more money than before by working on the dam project or running small businesses, but they also had to spend more money for food.

Their new houses were built all in the same style, and had sanitation and running water systems. Although the quality of the houses had been improved, the yards were too small to raise cattle or poultry as they had done before.

Dam construction also developed the local infrastructure, such as road networks and hospitals. But the large number of immigrants also caused the local crime rate to rise. Minorities complained that they no longer had a place to hold traditional festivals, such as Torch Festival where they stick torches in the fields.

Far-relocated villages of Xiaowan: Daxing village

Villagers in Daxing village moved there in 2009. They have almost the same compensation policy as in Xiaowan village for their houses: the government built uniform style houses and valued each of them at 100,000 yuan. Villagers were compensated for their old houses at 200 yuan per m^2, and 125 yuan per m^2 for kitchens.

The farmland compensation policy is unclear for Daxing, because a local policeman stopped our interview. According to one government document, each villager was given 1.0 mu paddy field, 1.0 mu dry field, 1.0 mu forest, and 0.05 mu vegetable field. However, villagers in Daxing were very unsatisfied with the compensation, since the farmland they received was either too small or too infertile. They were unable to support their families by solely growing crops, so most of the villagers had to find jobs in factories or construction sites. The government subsidizes villagers to grow tobacco, but it takes several years before the tobacco becomes profitable.

Information control in Daxing village is so strict that anyone from outside is not allowed to interview the villagers without the local government's permission. However, if an interviewer does get permission, he or she still cannot select interviewees randomly, but will be led to certain households to conduct the interviews. These households generally were told what to say by government officials, thus the authenticity of the interviews would be questionable.

3.3 Wealth and standard of living analysis

Dam construction causes wealth loss of villagers. The government compensates for loss of wealth to different extents, and the projects themselves could also bring opportunities to enhance the villagers' wealth. In this section I divide wealth into three different dimensions. If we want to judge the overall impacts of dam construction on the wellbeing of communities, we need to compare the loss and the compensation in each dimension. This comparison should be helpful to decision makers by helping them to better understand the impacts, and to develop more comprehensive and fair compensation policies.

3.3.1 Definition of three types of wealth

Wealth is a multi-dimensional attribute (Coleman 1994). I identified three classes of wealth based on the work of Mulder and colleagues (2009):

1. Material wealth: Includes farmland, houses, livestock, cash crops, forests, etc. This class of wealth can be measured in monetary units.
2. Embodied wealth: Wealth that is implicitly carried by a person. In this chapter I focus primarily on various skills that could be used to make a living (e.g., agricultural skills, fishery and ferry skills, and business skills.)

3. Relational wealth: Includes a person's social network, language, customs, and traditional festivals (i.e., social infrastructure). I also added transportation conditions, healthcare, and education resources to this class, as examples of physical infrastructure that benefits individuals, but is not possessed by them.

3.3.2 Loss in three types of wealth

Material wealth loss is easy to measure monetarily, and is in many cases considered the only loss for the relocated people. Farmland and houses inundated, or expropriated for construction sites, are the most significant losses in material wealth for most farmers. In some cases, part of the villagers' farmland, forest, or grassland is not affected by the reservoir, but since they are relocated faraway, they have to abandon these lands.

Embodied wealth, such as agricultural skills, once mastered, is unlikely to be forgotten. However, the environment determines the effectiveness of embodied wealth. If a farmer has grown rice for decades, but he is relocated to another place and given land that is only suitable to growing wheat, he will suffer a loss in his rice growing skills. In a worse case, if he loses all his land and has to find a job in a city, he loses all his embodied wealth in agricultural skills.

Relational wealth is also difficult to measure, but it does have significant meaning for the wellbeing of people. A person may have developed an economic network for selling his products and buying input materials after living in a place for many years. People have relatives and friends that socially support one another, as well as their cultural identity, featured by languages, traditional festivals, and customs. Relocation might have impacts on these economic/social/cultural networks to a great extent. Loss in relational wealth might also mean it becomes more difficult to access education and healthcare resources (i.e., physical infrastructure).

3.3.3 Compensation, subsidies, and opportunities in three types of wealth

Most relocated people received a “fair compensation” only in terms of material wealth. They might be given new houses in better conditions than their previous ones, and if new farmland is smaller than their former farmland, they may receive monetary subsidies.

There is generally no explicit compensation for embodied wealth. However, the new environment could provide them opportunities to gain more embodied wealth, sometimes even more than their previous level. For example, the construction of a dam convenes thousands of workers, who increase the demands for goods and services and form a prosperous local market. Many local people might quit agricultural activities and open restaurants or shops. Even though these local people abandon agricultural production and possibly lose such skills, they gain commercial skills that could lead to making more money and improving their standards of living. This could be a positive impact of dam construction on local communities.

Relational wealth is hard to quantitatively analyze, and decision makers generally totally ignore it in designing compensation programs. Nevertheless, relocation could also bring opportunities to generate new network wealth. Construction of infrastructure may make people better able to build a larger social network, and to have better access to education and healthcare resources.

3.3.4 Comparison of loss and compensation

In this section, I compare wealth losses and compensations in three dimensions, material, embodied, and relational wealth, based on study results from 10 relocated villages associated with the construction of Manwan, Dachaoshan, or Xiaowan Dam.

Case study in Manwan Dam

Near-relocated villagers in Manwan-affected areas suffered great material loss, but received insufficient compensation (Table 3.2). Their houses were compensated either by area, or a lump-sum of 6,000 yuan. The compensation might be able to cover the cost of building an old style house, however, due to social development, no one builds such houses any more, and a new brick-timber house costs much more than the amount provided. Another big problem was that after dam construction, the frequency of landslides increased and seriously threatened the houses and the lives of residents. Therefore, the value of the houses should be devaluated to a large extent because of the enhanced level of insecurity. The area of their farmland was also dramatically reduced. In addition, the lack of irrigation water made growing rice impossible, and growing alternative crops decreased agricultural incomes.

In terms of embodied wealth, there was no explicit compensation, but new opportunities were provided by the dam project for the villagers (Table 3.2). Near-relocated villagers in the Manwan area used to grow rice on paddy field and corn and wheat on dry field. After they lost their paddy field, farmers could only grow wheat or corn, thus their rice-growing skills were inactivated. But the formation of the reservoir boosted fishery and ferry businesses, particularly in the short period after the completion of the dam. Some villagers quit agriculture, bought boats and provided ferry services for visitors. But the prosperity of the ferry business lasted for only a short period of time. Eventually, most of the workers left Manwan, and only a small group of technicians remained to maintain the power plant. Hence, income from ferry businesses shrank, and income from agriculture also decreased because of the reduction in farmland. Therefore, the compensation in embodied wealth was much less than the loss in a long term.

Relational losses for the relocated Manwan villagers were also significant, but there was very little compensation (Table 3.2). Transportation conditions worsened after dam construction, because some roads were inundated after impoundment. Consequently, access to education and healthcare services also declined. The average distance to the elementary schools was about 10 km, and there were no paved roads. It took villagers in Yuluo village four hours to get to the closest rural clinic, since they had to take a boat first and then a bus. Drinking water was also difficult to get in Manwan-affected villages.

Far-relocated people from Manwan-affected areas lost their houses and all of their farmland, forests, and other properties (Table 3.2). The compensation policies were different over time and area. People moved in Hewan village were compensated for 6,800 yuan per person for houses, and those moved in Tianxin village received 7,000 yuan per person. Other villagers moved in Dula received 42,000 yuan per household, and those in Xiaowangpu received 68,000 yuan per household. Generally, each person was assigned 0.5 mu paddy field and 1.5 mu dry field. The forests within 10 meters of their original houses were also compensated. In general, the compensation for material wealth was reasonable.

Embodied wealth of far-relocated Manwan-affected people was slightly influenced (Table 3.2). They grew the same crops as before: rice, wheat, and corn. In some villages such as

Tianxin, the local government required villagers to grow a certain percentage of tobacco and compensated them with fertilizers. They use more fertilizers and herbicides than before, which increased costs, but also saved their time in agricultural activities and increased yields. Only a small percentage of farmers quit growing tea after moving to their new village due to the unsuitable climate. Some villagers worked in fields during farming seasons and went to a city to work in factories during the rest of the year, but this was not necessarily caused by dam construction.

For some new villages close to the county town, relational wealth was actually over-compensated by the new opportunities (Table 3.2). Next to main roads, the transportation condition was much improved compared to their previous villages. The county town could also provide a higher quality of education and healthcare for the villagers. For some villages, the electricity fee was waived for 10 years after they moved. Living close to the town also provided better access to information and job opportunities, and actually some villagers began sideline businesses after moving, such as opening small shops.

Table 3.2 Case study in Manwan Dam

	Near-relocated, Manwan		**Far-relocated, Manwan**	
Wealth type	**Loss**	**Compensation**	**Loss**	**Compensation**
Material	Houses; all farmland; New houses in landslide-prone area	6,000 yuan per house; new cleared farmland with low quality	Houses; all farmland; Forests	Various amount of money for houses, but enough to build new ones; Sufficient new farmland; Monetary compensation for forests

Embodied	Cannot grow rice;	Short term opportunity to do fishery and ferry; No compensation in long term.	No big impacts; Small percentage of people quitted growing tea;	No compensation
Relational	Worse transportation; Worse education and healthcare conditions; Hard to get drinking water	No compensation	No significant loss	Better transportation; Better education and healthcare; Easier access to information and job opportunities;
Overall	Compensation in all the three wealth types are much lower than the losses, therefore the villagers are considered to be seriously impacted.		Fair-compensated in material wealth, over-compensated in relational wealth, therefore the overall conditions are improved.	

Case study in Dachaoshan Dam

The near-relocated village in the Dachaoshan-affected area is located downstream from the dam. Therefore, houses there were not submerged by the reservoir. The villagers' major material loss was their farmland (Table 3.3), which was taken for construction sites or factory buildings. Compensation had been promised at 5,000 yuan per mu (US$ 11,719 per ha) for paddy field, and 2,000 yuan per mu (US$ 4,688 per ha) for dry field, but actually only 5% of the money was given to the villagers by the time of the interviews. Compensation came several years later than the actual confiscation of land, which caused villagers to experience tough lives during these years. They were given new farmland; however, the soil quality of the new land was much lower than their previous land. Higher elevation, lower temperatures, and lack of irrigation water combined to make the agricultural conditions even worse. Thus, compensation for material wealth was far below the level of loss.

Their embodied wealth was almost unchanged, since they did not move, and they still grew the same types of crops (Table 3.3). But some villagers did quit growing rice because of lack of irrigation water.

When it comes to relational wealth, farmers were actually better off with respect to transportation, healthcare, electricity, and access to drinking water (Table 3.3). Recently, the government began the "three set-up project", which built physical infrastructure for electricity, roads, and running water for rural people in many parts of China. Even though this project was not the direct compensation from dam construction, the dam-affected areas did have priority for such projects, partly because such infrastructure was also necessary for dam construction.

Houses were nearly justly compensated for far-relocated villagers influenced by Dachaoshan Dam. They were given houses built by the government in the same style and evaluated at 54,000 yuan. If their original houses were more than 54,000 yuan, they would receive monetary compensation for the shortfall; if less, they did not need to pay the difference. But the farmland was not always compensated fairly. Some villagers got paddy fields the same size as their previous ones, even though the quality was lower. Other villagers were given much smaller paddy fields, despite the promise that they would receive the same size as their previous fields. Their new fields were generally uncultivated land, and the government cleared it for the relocated people. These lands required new irrigation systems that were not as reliable as the previous system.

In terms of embodied wealth, some villagers had to quit growing rice, because of inadequate irrigation water (Table 3.3). But most villagers thought that after moving to the new villages, they began to use more advanced agricultural practices including more productive crop species. In contrast, the near-relocated villagers did not change their agricultural techniques during that time period, and were still using relatively primitive approaches and low-yielding species. The government did intend to provide opportunities to enhance the relocated people's embodied wealth. For example, one compensation policy waived the business tax for 20 years for Hongdouqing, a far-relocated village from Dachaoshan, to encourage villagers to develop small businesses. However, very few villagers have received benefits from this policy since they rarely started such enterprises.

Relational wealth was improved since moving, according to most villagers' responses during the interviews (Table 3.3). By moving out of the deep valleys near the river, the transportation condition of their new villages was much better than in their original villages. In addition, the county town provided better healthcare and education opportunities. However, some minority groups lacked spacious places to celebrate some of their traditional festivals, which should be considered as a relational wealth loss.

Table 3.3 Case study in Dachaoshan dam

	Near-relocated, Dachaoshan		Far-relocated, Dachaoshan	
Wealth type	**Loss**	**Compensation**	**Loss**	**Compensation**
Material	Farmland taken as construction sites;	Inadequate compensation for farmland; Given new cleared land with much lower quality	Houses; all farmland	Given better houses; enough new cleared farmland, with a little lower quality
Embodied	No significant loss; Some villagers quitted growing rice.	No compensation	No significant loss	Appling new techniques in agriculture; Waive tax for small businesses
Relational	No significant loss	Better transportation; Better education and healthcare; Easier access to electricity and drinking water	No significant loss; Some minorities don't have space for traditional festivals	Closer to city, better transportation and easier access to education and healthcare resources.
Overall	Much lower compensation than loss in material wealth, but better off in relational wealth. The overall impact is hard to determine, since it's difficult to compare between material wealth and relational wealth.		Fair-compensated in material wealth, better compensated in embodied wealth and relational wealth, therefore the villagers are considered to be better off.	

Case study in Xiaowan Dam

Near-relocated villagers from the Xiaowan Dam area were compensated for 200 yuan per m^2 for their original houses, but needed to pay 100,000 yuan for new houses built by the government in a uniform style. These houses were built with bricks and concrete, with well-designed sanitation systems. But the yards were very narrow compared to those in the original villages. Farmland was well compensated, with 12,000 yuan per mu (US$ 28,125 per ha) for paddy field, and 6,000 yuan per mu for dry field. They were also given new farmland in 2009, but the land was still raw and thus needed several years before being suitable for cultivation.

The villagers moved in 2003, but from 2004 to 2009, many people returned to the Xiaowan area to work on the dam project. Therefore, even though the villagers did not own farmland during 2004-2009, they maintained their lifestyles by opening shops, restaurants, and many other businesses that provided services for people constructing the dam. These villagers lost their embodied wealth in terms of agricultural activities, but dam construction activities provided them opportunities to obtain new embodied wealth, such as business skills (Table 3.4). Hence, when the Xiaowan construction site was prosperous, they did make more money than they had growing crops. The pending threat to their livelihoods was that most of the workers will leave the area after the full completion of the project, and the market will predictably shrink. At such time many small businesses will likely close and the villagers will make much less money than now, and their embodied wealth will suffer greatly.

Relational wealth has been improved significantly since construction began (Table 3.4). Many roads were built, which made transportation to this remote village much more convenient. Healthcare is also much better than before, since the project also brought hospitals and clinics. Other aspects, like education and access to electricity and water, have not changed much. In addition, some villagers blamed the current higher crime rate on the immigrate population.

Far-relocated people in the Xiaowan Dam-impacted area were given much better houses than relocated people in other dam areas (Table 3.4). Their original houses were compensated by area. Each person was given 1.0 mu paddy field, 1.0 mu dry field, 1.0 mu forest, and 0.05 mu for growing vegetables. It is difficult to determine whether they have received fair compensation for material wealth, because even though they got the best houses, they had the strongest dissatisfaction among all the relocated people. Unfortunately, people without the government's permission were not allowed to conduct interviews in Daxing village, so I got very limited information at this study site.

Embodied wealth of the villagers was greatly impacted, because the compensated farmland was unable to grow crops (Table 3.4). The government subsidized villagers to grow tobacco, but it required a relatively long time to bring this crop to market. Because arable land was reduced dramatically, many people had to go to other places to work in factories.

Transportation and healthcare conditions were improved (Table 3.4). The new built village was on the side of a major road, and there was a clinic in the village, which was not available in their previous village. Other aspects of change in relational wealth were hard to determine, also because of the lack of information.

Table 3.4 Case study in Xiaowan Dam

	Near-relocated, Xiaowan		**Far-relocated, Xiaowan**	
Wealth type	**Loss**	**Compensation**	**Loss**	**Compensation**
Material	Houses; all farmland	Given better houses; Fairly-compensated for lost farmland Given very little new farmland	Houses; all farmland	Given better houses; Fairly-compensated for lost farmland Given very little new farmland
Embodied	Cannot grow any crops; In long term might not be able to run small businesses	Opportunities to run small businesses and make more money	Can't grow any crops	No compensation; few opportunities to obtain other embodied wealth
Relational	No significant loss; Some minorities do not have space for traditional festivals	Better transportation; Better education and healthcare; Much easier to communicate with outside	Lack of information	Better transportation; Better education and healthcare;
Overall	The material wealth compensation is lower than the loss, but they got much higher compensation in embodied and relational wealth. Therefore in short term the standard of living of the villagers is much better off. In a long term they might lose more embodied wealth.		Compensations for material and embodied wealth are much lower than the losses; The loss in relational wealth is unclear. The overall impact is hard to determine.	

3.4 Gap of wealth analysis

Dam construction causes relocation, which has substantial influences on social equity. This section will briefly analyze the impacts on social inequity and its implications.

Relocation of people is also a process of reallocation of wealth. It could narrow the gap of wealth in some cases or widen the gap in other cases. One of the most noticeable effects of narrowing the gap of wealth was in the case of housing conditions. In their original villages, people had the freedom to build houses in their preferred style. Therefore, houses in the original villages varied in area, materials, design, and monetary value. However, after relocation, the differences between housing conditions diminished. In the far-relocated villages of Hongdouqing and Wayaoqing in the Dachaoshan Dam-impacted area, houses were designed and constructed by the local government with exactly the same area and style. Therefore, the value of each house was also the same. Hence, villagers there had almost the same housing conditions, which narrowed inequity in terms of housing. In Hewan village, which was built for far-relocated people impacted by the Manwan Dam, villagers were responsible for building their own houses, but the new houses had to follow certain regulations: they had to be two-story buildings with white walls and red tiles on the roof. This policy also reduced the gap in living conditions.

However, in more general situations, dam construction widened the gap of wealth, at both the household and community levels.

At the household level, before construction of the dam, people living along the river were mostly subsistence agriculturalists. Staple crops included rice, wheat, corn, and beans, which composed 90% of their yields, and their primary income source was food production.

After being relocated, some villagers experienced large changes in their income structures. Food production decreased to a level that could only meet their own consumption at best. Most of the villagers had to seek other income sources, such as from fishing, transportation services, or working in factories. Fu and He (2003) divided the relocated people into four categories according to their income sources:

1. Families who bought fishing boats (they might at the same time do agricultural activities)
2. Families who bought transportation boats (they might at the same time do agricultural activities)
3. Families who had members going to other places and working in factories or at construction sites
4. Families whose income still came mostly from agriculture

The diversification of income sources widened the gap of wealth. Before dam construction, each person had approximately the same area of farmland based on Chinese land law, and agricultural income was their major income source; therefore, a wealth gap was not noticeable. However, relocation and the opportunities brought by dam construction diversified income sources, and differences in income between households became significant.

Fishing and transportation services generally are more profitable than agricultural activities. But they are also vulnerable to changes in the socioeconomic environment.

After 2001, more strict regulations for environment protection were adopted in the Manwan reservoir area, and the fishing industry in the reservoir was seriously impacted. It was reported that the non-agricultural income diminished greatly after the new regulations were applied.

Increase in the wealth gap also happened at the community level, that is, between villages in different relocation categories. Taking Xiaowan Dam as an example, the two relocated villages, Xiaowan and Daxing, now have different economic statuses. Xiaowan is a near-relocated village, which is close to the dam construction site. Construction workers and engineers came to that village and made it a prosperous place crowded with restaurants, hotels, shops, and food markets. Hence, the income of local people increased significantly because of business activities. On the other hand, Daxing is a far-relocated village, which was built right before the relocation. There is inadequate farmland for the villagers to grow enough food, nor can they develop a prosperous local market. Hence, the standard of living of villagers was lowered, and some of villagers had to find jobs in factories hundreds of kilometers away to supplement their income. Therefore, the construction of Xiaowan Dam actually widened the wealth gap between Xiaowan and Daxing. Similar situations also existed in villages affected by the other two dams investigated in this study. But the results could be the opposite. For example, for villages affected by Manwan Dam, conditions were almost the same at first with respect to economic status, because of the reliance on subsistence agriculture with each household having the same area of farmland that had nearly the same quality. However, after the dam was built, far-relocated people received newly built houses and enough farmland, while the near-relocated villagers had much less farmland with poorer quality. Therefore, the standard of living for near-relocated villagers was much lower than those who moved to a newly built village.

Relocation also impacts gaps of embodied wealth and relational wealth. First, people who were relocated to villages close to a county town could have better access to new techniques and information, and therefore they would be more likely to apply new techniques in their agricultural activities. Different villages affected by Dachaoshan Dam were obvious contrasts. Farmers who moved to Wayaoqing and Hongdouqing, both within 10 km to the county town, apply more advanced agricultural techniques, and therefore had higher yields than those people who were near-relocated and basically had to grow crops at the same locations. Second, dam construction brought different opportunities to different villages. Depending on construction demands, roads were built in various places. For those villages close to the roads, their relational wealth increased because of a better transportation network. High-quality schools and hospitals were easier to access, and they also had more chances to succeed in small businesses. Some villages did not have newly built roads, thus their transportation and other conditions, such as education and healthcare, likely stayed at the same levels. Other villages were even worse off in that the dam reservoir submerged existing roads to their villages, worsened transportation conditions for their residents. Deteriorated transportation also caused limited access to education and healthcare resources.

Overall, the construction of dams widened the gap of wealth both among people in the same village and among different villages. At first, villages along the Upper-Mekong River were primarily homogeneous, rural communities living on subsistence agriculture. Dam construction diversified the income sources of some villagers, provided opportunities to villages unevenly, and various compensation policies also generated gaps of wealth between different villages in one or more dimension.

3.5 Insider-outsider analysis and its implication for decision-making

In this section, “insider” refers to local villagers who are affected by dam construction, while “outsider” refers to decision-makers in dam construction and the compensation process. My basic hypothesis is that the more insiders and outsiders agree on the degrees of loss and opportunities in three dimensions of wealth, the more reasonable the compensation policies would be, and the less dissatisfaction affected villagers would have. I will test this hypothesis by further examining the villages visited during this study along the Upper-Mekong River.

The opinions of insiders were collected by interviewing affected people in the 10 study villages (far- and near-relocated villages at three dam sites), and those of outsiders were gleaned from government documents related to relocation and compensation. The outsiders’ comprehension of the villagers’ loss could determine the compensation, as well as some other subsidy policies. I compared the degree of dissatisfaction and the degree of agreement insiders and outsiders reached for the loss, and explored the relationship between them (The State Council of China 1991; The State Council of China 2006).

The perceptions for loss in material wealth are close for insiders and outsiders. Both of them agree that houses and farmland are the most important properties that were lost during dam construction. Therefore, various governmental policies were implemented to compensate villagers either by providing new properties, such as building new houses and/or clearing new farmlands, or money. Fair compensation for material wealth is the minimum requirement for an overall fair compensation policy, because it is the easiest to perceive and meet. Material wealth is quantitative and relatively easy to measure, thus if the compensation for it is unfair, villagers would know it immediately and be unhappy and disgruntled. In many government documents the government promised that the compensation policy would as least maintain the standard of living of relocated people. However, by addressing "at least maintain", in most cases they only focused on material wealth, and compensated villagers with properties and money at least equal to their previous situation.

As for embodied wealth, farmers might not be able to use one or more of their skills due to environmental differences between their old and new location, but the government generally is not able to totally understand such loss. For example, sometimes the climate in the new area is different from that in the original area, which makes it unsuitable for growing the same crops. But compensation policies do not take this loss into consideration, and instead merely compensate with the same area of farmland. However, the government sometimes does generate opportunities for relocated villagers to develop new skills, thus enhance their embodied wealth. For example, the government might waive the business tax for relocated people for several years to encourage them to run small businesses.

When it comes to relational wealth, the government might build some basic physical infrastructure in the new villages to compensate the villagers' loss in this type of wealth. For example, some migrant villagers have newly built clinics and schools, and some even have sanitation systems, which are rare in much of rural China. Road construction, which actually improved the transportation conditions of relocated people, is in most cases required for dam construction instead of being an intentional compensation policy for local people. In addition, some villages were moved to places closer to a county town, where the transportation, healthcare, and education conditions are better, and this could also be regarded as compensating for losses in relational wealth, or an opportunity for them to expand their relational wealth.

Manwan Dam was completed in 1995, and at that time the compensation for relocation was very low in China. The compensation for these villages was based on a government document enacted in 1991, *Statute of Land Compensation and People Relocation in Large Hydraulic Project Construction.* According to this document, farmland was to be compensated 3 to 4 times the average value of the yields over the last three years. If the land was used for irrigation or flood control projects, the compensation should be lower than the above rate. This was a very low compensation standard, and one that would not cover losses incurred by local people, even in material wealth. For example, near-relocated villagers in the Manwan affected area received unfair compensation for their material wealth during that period, which made the living conditions for local people extremely difficult and caused vehement complaints from villagers.

Completed in 1999, the Dachaoshan Dam project raised the compensation standards much higher than those associated with Manwan Dam. New houses were built with brick and timber, and the loss of land and forests was also fairly compensated. There were also compensations for embodied and relational wealth losses. The government began to realize losses occurring in these two types of wealth, and emphasized that: "when considering the allocation of education, healthcare and infrastructure funding, the government should give the counties who have relocated people high priority to help them recover the standard of living"; and "When constructing buildings in the affected area, the operating institutions should provide job positions to the affected people. The local government should also provide job opportunities to relocated people by invests and construction." Therefore, people in far-relocated Dachaoshan villages thought that there were no major changes in their standards of living before and after the dam construction, even though they expressed concerns about irrigation limitations in their new villages.

Xiaowan Dam was in full operation in 2009. Compared to villagers affected by Manwan and Dachaoshan dams, people in the Xiaowan area got much higher compensation in terms of material wealth. The government once more raised the compensation standard for material wealth: farmland compensation was now to equal 16 times the average yields over the last three years, and if the compensation was unable to maintain the standards of living of the affected residents, the compensation could be adjusted to a higher level. Far-relocated villagers from Xiaowan Dam thought that they were much better off in housing. However, the compensation for their embodied and relational wealth was not put into effect, and villagers who had abandoned their agricultural activities had difficulties finding new jobs. This ineffective implementation of policy also caused widespread dissatisfaction.

After analysis, I conclude that the government's increasing awareness of multi-dimensional wealth loss by villagers was the major reason for the different degrees of satisfaction in the three dam areas. In early 1990s, the government asked the people to "sacrifice their own rights to support the nation's construction." The dominant idea at that time was to put nation's interest above individuals'. Therefore, compensation standards were very low in all the dimensions. In late 1990s, the government began to realize the importance of individual rights, and intended to provide fair compensation, at least in material wealth. After 2000, more dimensions of the wealth loss were taken into consideration in the compensation policies, such as creating job opportunities, and enhancing education and healthcare resources for the affected people. The results of my interviews show that the more the dimensions of wealth loss are perceived by the government, the more reasonable and fair the compensation policies are, and the less dissatisfaction affected people will have.

3.6 Conclusion and discussion

First, the division of three dimensions of wealth specified the losses and compensations of relocated people, and made the comparison of losses and compensations more reasonable and comprehensive, thus helping to better understand the social impacts of dam construction.

Houses and farmlands are the major material losses. While houses are always compensated, farmlands are in many cases either smaller or in poorer quality than before. These shortfalls in farmlands are generally given monetary compensation, but the problem is that any loss in farmland is also accompanied by a loss in embodied wealth. If a household's farmland is not large enough to generate yields necessary for the subsistence of the family, or there is a surplus workforce, monetary compensation is probably not helpful in building sustainable income sources. Therefore, compensation for embodied wealth becomes necessary; for example, by recruiting local people as dam construction workers, providing subsidies or tax exemptions for small businesses to encourage some farmers to shift to other lines of work, or offering trainings and education for relocated people to improve their employment competitiveness.

In most cases, far-relocated people have higher standards of living than near-relocated people after the dam construction. There are several reasons for this phenomenon. First, the Upper-Mekong River runs through very steep and deep valleys, and arable land along its sides is very limited and generally confined to small, relatively flat parcels scattered along its course. After impoundment of the reservoir, a large percentage of the farmland is submerged, and relocated people had to clear new pieces of land, which took more time to cultivate and were generally less productive than their original land. In addition, most near-relocated villages also have problems such as less farmland, lack of irrigation water, and rocky soil. The deteriorated agricultural conditions reduced the incomes of villagers. Second, compared to near-relocated villages, far-relocated villages received more compensation for both houses and farmland. Their houses were newly built with better designs and materials, and their average area of farmland per person was also in most cases larger than far-relocated villagers. Third, the new villages that were built for far-relocated people are often along main roads or close to the county town, which improve access to better transportation, education, and healthcare services. In addition, they also have easier access to new techniques and information, and are more likely to succeed in small businesses and in building effective social networks.

There are some exceptions to the finding that near-relocated villages have better conditions than far-relocated villages. For example, the local market in Xiaowan village has burgeoned rapidly since 2004, when the Xiaowan Dam project commenced and thousands of workers came to the construction site. Concurrently, the income of local people increased by running small businesses that provided goods and services to the migrant workers. However, this prosperity is not likely to last for long. After the project is complete, most of the workers will leave, and the local market will shrink dramatically. This temporary boom-bust actually happened in the Manwan area in the 1990s, when the dam was under construction. But after the period of prosperity, people had to face much tougher lives due to insufficient or low quality farmland.

Compensations for relocated people are mostly focused on material wealth. However, dam construction could bring opportunities to enhance embodied wealth and relational wealth. The assessment of the impacts must consider these opportunities as implicit positive impacts of dam construction.

Second, the insider-outsider analysis provided a theoretical framework for understanding the differences between the perceptions of relocated people and government agencies of the losses and compensations. When villagers suffered from multidimensional wealth losses, it is probable that, even if the government sufficiently compensated for the dimension it perceived (i.e., material wealth), the villagers would remain unsatisfied because the two other important dimensions of wealth loss were ignored.

The government and affected people reached agreements on material wealth losses most easily. But compensation for material wealth still needs to consider a few potential complications. First, compensating at the current property values cannot guarantee the same standards of living over time. Economic development and inflation factors also need to be taken into consideration. Second, along with time, the compensation for material wealth increases because of policy adjustments and improvements in civil rights.

Third, the time scale for compensation should be emphasized. Dam construction has permanent impacts on relocated people, but compensation programs generally last for only a few years. It is important to design compensation policies to help villagers build sustainable livelihood.

The government also realizes the embodied wealth loss of villagers, and therefore has designed various compensation policies to address it. However, few of these policies have been implemented as expected. Only the policy that construction sites should give high priority to affected people to provide them job opportunities has been enacted to date. A 20-year tax exemption for some villages did not prove effective, since most people in these villages wished to continue their agricultural practices, and lacked the necessary skills to run small businesses. Providing training for relocated people to improve their competiveness was featured in Central Government documents, but such training programs had not been implemented in any of the villages I visited during this study. Thus the effective implementation of such programs is an imperative for policy makers.

Relational wealth compensations are more likely to be byproducts of dam construction. If roads for the dam project happened to go through a village, the village's transportation services, as well as other conditions would be improved. But there are very few intended compensations for relational wealth loss.

Third, dam construction has impacts on gaps in wealth at different levels. The division of three dimensions of wealth can also be applied in a social inequity analysis. In material wealth, various policies compensated different villages with different amounts and qualities of properties. In some villages the income sources were diversified, therefore the income gap increased. In embodied wealth, the opportunities brought by the dam project and relocation were uneven. Some villages are close to the county town and therefore might have better access to new techniques and information. People in some village also abandoned agriculture and opened small businesses due to the socioeconomic changes caused by the project. Similarly, relational wealth, such as the conditions for transportation, education, and healthcare also could be improved or worsen accordingly.

In further research on the social impact analysis of large dam projects, researchers might work to design a more scientific and reasonable division of wealth. For example, the definition and elements of embodied and relational wealth need to be further specified.

Another weakness of this analysis is that it does not adequately address cultural impacts, which are also important aspects of social structure. However, compared to wealth, cultural changes are much more complicated and difficult to quantify. It could be a great improvement if a future analysis framework incorporated cultural changes into the social impacts properly.

Material wealth is the easiest to be quantified, and methods in fields such as statistics and economics could be used to analyze the impacts on this wealth class. Abundant macroeconomic data and official statistics are available at different temporal and spatial scales, and techniques in econometrics could also be applied in a material wealth analysis.

More updated knowledge in sociology and other social sciences should be incorporated into the framework, particularly for the analysis of embodied and relational wealth. When applying this framework in different regions, geographic differences and socioeconomic backgrounds should be taken into consideration and necessary adjustments should be made to better fit the analysis to the specific situations.

CHAPTER 4 SUMMARY AND CONCLUSIONS

This chapter summarizes the findings and conclusions of the first three chapters, particularly facts about large dams in China and elsewhere in Chapter 2, and the social impact analysis in Chapter 3. It also discusses the limitations of the thesis research, including limitations in literature review and empirical study. The final part offers suggestions and recommendations for future research on large dam issues.

4.1. Summary of key findings and recommendations

4.1.1. Debates, trends, and the future of large dams

This thesis included a review of large dam construction worldwide and at China's national level (Chapter 2). While the worldwide review mostly discussed the general characteristics of dam construction, the Chinese review focused on the particular features of large dam construction in China.

The worldwide review first discussed the history, distribution, and the trends of large dams. Even though the history of dams is as long as that of human civilization, the overwhelming majority of dams were built after 1900, with the peak in construction occurring between 1970 and 1975. Five regions that have the highest dam density are East Asia, South Asia, North America, Europe, and Southern Africa. The distribution of dams is uneven between developed and developing countries: the former have already developed more than 70% of their economically feasible dam potentials, while the latter have only developed about 30%. Hence, most of the dams currently under construction or being planned are in developing countries, and therefore, the trend of future dam construction worldwide mainly depends on the pace of economic development in these countries.

The major purposes for dam construction include irrigation, water supply, flood control, electricity generation, and navigation. Some of the objectives are well achieved, which are the cases for most hydropower dams. But many dams intended for irrigation or water supply have fallen short in meeting their original goals. Dams for flood control could be a double-edged sword: they could regulate natural flow and reduce the magnitudes of floods, but also could cause unintended consequences, such as sedimentation of riverbeds, and making flood disasters even more pronounced. Some dams are built to raise the water level to improve navigation conditions, but this may come at considerable environmental and social costs.

General environmental impacts of large dams include inundating terrestrial ecosystems, altering natural river flow regimes, blocking routes for migratory species, increasing sedimentation, and enhancing greenhouse gas emissions. Most of the changes to natural systems are irreversible, therefore it is necessary to conduct reasonable environmental impacts assessment before the construction process is approved, and to identify proper mitigation measures that should be applied in the project.

There are different types of social impacts of large dams that occur at different levels, including those on agriculture, local livelihood, social inequity, and culture. Compared with environmental impacts, social impacts are harder to identify and assess, and therefore are easier to be overlooked during the decision-making process. However, a comprehensive understanding of social impacts is essential to the fair distribution of benefits and costs over all stakeholders. Therefore, incorporating a social impact assessment into the decision-making process is as important as applying an environmental impact assessment before dams are constructed.

Debates around large dams generally fall into three categories: economic feasibility, environmental sustainability, and the social equity issues. Large infrastructure projects like dams provide direct and indirect economic benefits, and have been used for a long time as an important means to stimulate economic development. But there are also externalized costs of dams, which make the benefit-cost analysis problematic. The environmental impacts of dams are difficult to deny, but the debates are in most cases on whether opponents of dams exaggerate those impacts. Social equity debates focus on one key issue: whether the groups who suffer the most from dams also benefit the most, or get fairly compensated for their losses.

In China there were very few large dams before 1950. However, during the second half of 20th Century China built about half of all the large dams constructed worldwide. Most dams built between 1950 and 1966 were aimed at irrigation and managing hazardous rivers. In contrast, most dams built after about 1980 primarily focused on generating electricity, due to the rapid increase in energy demand as China modernized. Currently, electricity generation is the single most important driver for dam construction in China. The Ministry of Water Resources identified 13 hydropower bases in different river basins in China, which cover almost all the river reaches that have technically feasible hydropower potential. The early construction projects did not account much for social impacts, but there has been a steady progression of policy and inclusion of stakeholders ever since.

The last part of this review provided five case studies, which represented the most important or controversial dam projects in China. The Three Gorges Dam is by far the largest hydraulic project in the world, and it was finally build after a 70-year-long debate. With multiple functions to control floods, improve navigation, and generate electricity, it has also caused substantial environmental and social impacts in the reservoir-affected area. The Xiaolangdi key water-control project is the most critical facility on the Yellow River to manage flow and mitigate sedimentation. Since the Yellow River is a seriously degraded river system, Xiaolangdi Dam is generally successful in harnessing this unpredictable river. The cascading dams on three rivers in Southwest China, the Nu, Lancang, and Jinsha were discussed last. Dams on these rivers are all intended for electricity generation, and use the same model of cascading development, which means planning a series of dams on one river, and using the profits from earlier complete dams to finance the building of the rest. This cascading model could be an economically efficient means for developing entire river systems, but the social and environmental impacts are also extended to entire watersheds.

4.1.2 Understanding the social impacts and compensation policy

The cascading dam projects on the Mekong River will not only dramatically change the profile of the river, but also will have significant impacts on local communities. This study identified three classes of wealth for the affected people, namely material wealth, embodied wealth, and relational wealth, and comprehensively compared the loss and compensation in each dimension of wealth. An empirical study in the research area showed that the division of three dimensions of wealth can help researchers and policy makers better understand the multilevel social impacts on relocated people (Chapter 3).

Dam construction has direct impacts on material wealth, primarily by submerging houses and farmlands. Material wealth is easy to understand, and therefore its loss is most often equitably compensated, or even over-compensated. But embodied wealth and relational wealth are generally affected in indirect manners, and thus they are more difficult to recognize by policy makers. Hence, most unfair compensation practices arise from ignoring either embodied wealth or relational wealth. However, the impact is not always negative, as some dam projects bring concurrent opportunities for villagers to enhance these two types of wealth, such as by providing more job opportunities or improved infrastructures.

This study also applied a three-dimensional wealth framework to examine the impacts of dams on gaps in wealth at the household and community levels. At the household level, providing uniform house styles in compensation programs narrowed the differences in living conditions between villagers, but the relocation process often created diversity in their occupations and income sources, which could widen the gap of wealth between households. At community level, different communities received different levels of compensation because the policy varied between different regions and time periods. Therefore, the wealth inequity between different villages has been generally widened. As byproduct effects, dam projects brought different development opportunities to different individuals and communities. For example, some villages were moved closer to larger urban areas, and others had better transportation conditions. All these effects brought inequities in wealth and opportunities to these originally homogeneous rural regions.

In the third part of the social impact analysis, an insider-outsider analysis was conducted to better understand differences in the perceptions of wealth loss between local villagers and policy makers. The analysis resulted in a proposed hypothesis that the more the insiders and outsiders agree on the degrees of losses and opportunities in the three dimensions of wealth, the more reasonable the compensation policies would be, and the less dissatisfaction affected villagers would have. According to the case study, as the government's perception of wealth loss evolved over time, the compensation policy also became more and more reasonable from the insiders' perspective. In the 1980s, the government required villagers to sacrifice their personal interests for the nation's betterment, and provided extremely low compensations for relocated people. In the 1990s, the government only recognized material wealth loss, and made relatively fair compensation for it, but did not account much for the other types of losses. After 2000, the government began recognizing the importance of embodied and relational wealth, and tried to compensate for their loss by providing job opportunities and improving infrastructure in addition to material wealth compensation. The subsequent improvement in perceptions and increased satisfaction by relocated people supported the hypothesis of this study.

Recommendations for more reasonable compensation policies were also identified based on the analysis of the three dimensions of wealth, issues of social inequity, and the insider-outsider comparison. This study showed that it is critical to systematically assess the three dimensions of wealth loss caused by dam construction, and that in order to improve the accuracy of the assessment, a transparent decision-making process is necessary. Then, to achieve the goal of fair compensation, the government needs to compare which dimensions of wealth loss are covered and fairly compensated by the policy, and compare them with the actual wealth loss in each dimension as perceived by villagers. The ideal compensation policy should compensate fairly in all three dimensions. The compensation policy should also take social inequity effects into consideration, and make sure to avoid uneven impacts on different individuals or communities that would widen the inequity gap between them.

4.2 Limitations of this research

4.2.1 Literature review

The review of large dam construction worldwide and at China's national level (Chapter 2) provided a general overview of the issues involved and set a historical context for the empirical study which was conducted in the specific research area (Chapter 3). Although this review likely will be of interest to others studying the impacts of dams in China and elsewhere, the author believes that there are several aspects of it that could be improved in the future.

First, Chapter 2 and Appendix 1 were based on an extensive literature review, therefore the supporting data were cited from a very broad range of sources. The diversity of these sources allowed this study to cover most of the major large dam problems, but at the same time it revealed inconsistencies between different studies. The most important references used in this study are listed in Appendix 1, A Review of Key Studies on Large Dams. On this list are reports from the World Commission on Dams, Chinese Water Resources Ministry, and other independent organizations; a special issue on large dams published in the *Journal of Environmental Management*; a Ph.D. dissertation; a major book on large dams; and other various sources. Although insightful and helpful to those concerned about large dams, three significant inconsistencies are evident among these sources. 1) These sources were published at different times, and hence the data presented and used in the analyses were based on different time periods and lacked knowledge from more recent studies. This may be critical in addressing fast-changing ecological and social impacts. To minimize the disadvantage of different publication dates, most of the references used this study were published after 2000. 2) The statistical criteria varied between different sources, so the data for the same region might be different according to the analyses used. 3) The authors of these studies held different values, being either proponents or opponents for large dams, which likely biased their presentations. Given the hot debate over dam construction, it is not easy to find an objective framework when putting these opinions together.

Second, large dam problems are complex, interdisciplinary, and diverse. In order to provide a comprehensive picture of these problems, Chapter 2 covered a very wide range of topics in general, but for brevity had to tradeoff a lack of details for each topic. Large dams have multiple purposes, including irrigation, water supply, hydropower, and flood control, and each purpose has multiple impacts on a complex of economic, social, and environmental factors. In addition, a specific dam project always has its own unique geographic features. Addressing all these factors in a single chapter means that each topic could only be generally and concisely discussed.

Third, in the review and case studies of large dams in China, official statistics and peer-reviewed research papers are scarce and difficult to find, therefore this study cited data and reports from the websites of NGOs and governmental agencies. Hence, this information lacked peer-review by the scientific community and may be reflecting the values of the organization or agencies with respect to dam construction.

I believe that the lack of sufficient, reliable data weakened the analysis and conclusions of this study to a certain extent. Information related to large dams has been treated as confidential for a long time in China, and even the locations of many dams are generally inaccurate on published maps. Some data are officially announced, such as the area of submerged farmland and number of relocated people. However, the trueness of these data is questionable, because the estimates from independent organizations are in many cases much larger than those officially announced. When it comes to dams on international rivers, such as the Mekong River, those data become even more politically sensitive, since they may influence negotiations between neighboring countries. What this study did was to select the most credible data from the accessible pool of information currently available.

4.2.2 Empirical study

My original research presented an empirical study of the impacts of dam-related relocations on the different dimensions of individual and community wealth and evaluated the effectiveness of compensation policies, which allowed a much deeper analysis and discussion of the issues involved. Although the analysis provides unique insights into the socioeconomic impacts of cascading dams on the Upper-Mekong River on local communities, I acknowledge that there are also limitations to this research.

First, the research area for this study has high biological, geographic, and cultural diversity, and because of limited time and resources, it was impossible to fully address the complexity of the social impacts of large dams across the region. The Upper-Mekong Region of Yunnan Province, China is one of the world’s 25 biological hotspots, and is the most ethnically diverse and geographically varied region in China. Hence, it was not possible to fully understand the various social factors that are influenced by large dams based on one-month of on-site research. This study selected 10 villages as representatives for far- and near-relocated communities associated with three dam-impacted areas. However, the differentiation of communities is likely much more complicated, as the region is so heterogeneous that two villages 10 km apart could be dramatically different with respect to their socioeconomic status and natural environmental conditions. Hence, gaining a comprehensive understanding of dam impacts and society-environment interactions in this region would require a more detailed, systematic, and costly investigation.

Second, this study lacks a quantitative analysis of the socioeconomic data, such as regression analyses on the income changes and material wealth losses of dam-affected people. When designing the study questionnaires, I intended to ask interviewees about their income changes and losses in monetary units after the dam construction. However, the interview process showed that local farmers either did not know their accurate incomes, which were mainly from selling agricultural products, or evaded directly answering specific financial questions about their incomes and losses. So in most cases I asked them to give estimates, but the values they provided varied across a large range. Therefore, this study was only able to provide qualitative and semi-quantitative analyses about income changes and losses. It would be ideal to apply an econometric analysis if a more accurate and complete socioeconomic dataset was available.

Third, the sample size of the interviews did not reach the planned number. When designing the investigation, I planned to conduct about 100 interviews in a dozen villages.

In reality, even though the research team managed to investigate 10 far- or near-relocated villages at three dam-affected sites, I was only able to conduct 44 valid interviews. This was mainly because of the strict restrictions on investigating dam-related issues in the study area. All the interviews of local people had to be done with the permission of the local propaganda department and with one of their representatives present, which likely influenced the randomness and credibility of the interviews.

4.3 Suggestions for future research

Large dam construction is not merely an engineering problem, but is rather at the center of resource exploitation, environmental protection, and social development. The complexity of this problem demands that resolving it will require interdisciplinary knowledge and collaboration. Figure 4.1 illustrates the interactions among the three components of large dam construction. Owing to the inter-relationships between these components, failing to address any of them likely will result in the eventual failure of the project. While it is critical to coordinate the demands arising from all three components, it is also important that experts in different fields study each component in detail. The following suggestions are provided for improving the understanding of each component.

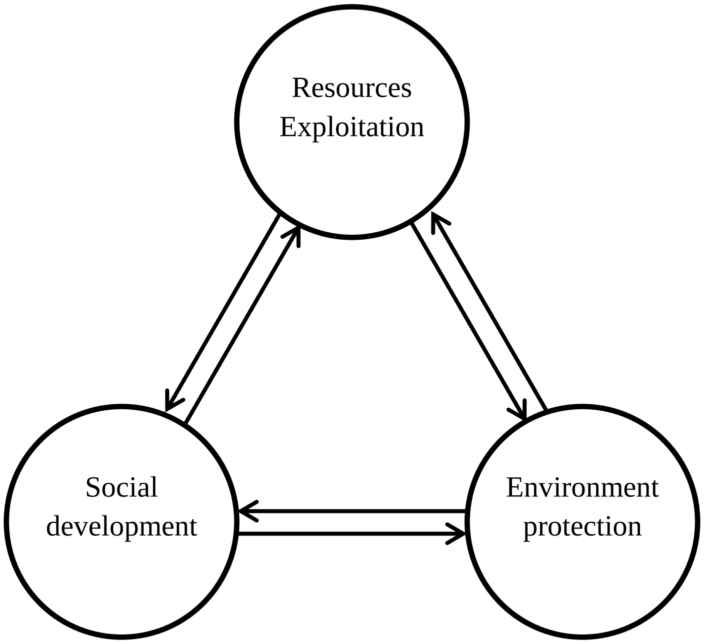

Figure 4.1 Economic feasibility, environmental sustainability, and social equity

Economic feasibility is at the center of resource exploitation. When planning to build a dam, resource potential, technological capacity, finance, and market are all among the factors that need to be evaluated. Beside these considerations, it will be helpful to research the financial and physical performances of dams, such as the possibilities for overrunning estimated budgets and/or failing to meet planned objectives. The World Commission on Dams' (2000) report did interesting statistical analyses of the physical and financial performances of dams around the world. However, it might be more persuasive to make thorough inquiries into the reasons behind the high or low performances of dams with different purposes, such as why most of irrigation dams fail to meet their original goals, while most hydropower dams not only recover their costs, but also surpass their original objectives. Another possible research topic involving economic feasibility would be to compare the profit rate of large dams with other alternatives. For example, comparing hydropower plants with solar or wind power plants, or comparing the economic effects of irrigation dams with new, innovative water saving technologies. Such comparisons will help developing economies decide if they should build large dams or pursue other options.

Environmental sustainability is another goal that large dam projects should strive to achieve. Much research has focused on the environmental impacts of large dams, including studies on immediate changes in terrestrial and aquatic ecosystems, geological features, and water quality following the construction of large dams. Future research on environmental sustainability problems should also focus on long-term impacts, such as greenhouse gas emission rates, regional climate changes, and relationships between reservoir size and the frequency of earthquakes. Since a substantial percentage of freshwater on the planet is held in large dam reservoirs, these long-term impacts to the global environmental sustainability should not be neglected.

Social equity was not emphasized in dam projects until the recent decade. Even though large dams have been used as an important means for social development, the distribution of benefits and costs are not equitable in most cases. The following suggestions are potential directions that future research on the perspective of social equity should advance. First, this thesis proposed a framework for better understanding the social impacts of large dams, where wealth was divided into three categories. Future researchers may work on designing a more scientific and reasonable division of wealth. For example, the definition and examples of embodied and relational wealth need to be further specified. Second, a global decision-making framework is necessary to fully understand the social impacts, and the World Commission on Dams has made great contributions in building such a framework. However, large dam problems vary significantly between different regions, therefore geographic and socioeconomic differences should be taken into consideration and necessary adjustments should be made to the framework to better fit specific situations. Finally, certain universal standards need to be developed to ensure basic social equity during and after the dam building process. For example, all the stakeholders need to be fully informed, the decision-making process should be participatory, and the compensation policy design needs to be transparent.

REFERENCES

Bawa, K. S., L. P. Koh, et al. (2010). "China, India, and the Environment." Science **327**(5972): 1457-1459.

Bednarek, A. T. (2001). "Undamming Rivers: A Review of the Ecological Impacts of Dam Removal." Environmental Management **27**(6): 803-814.

Brown, P. H., D. Tullos, et al. (2009). "Modeling the costs and benefits of dam construction from a multidisciplinary perspective." Journal of Environmental Management **90**(Supplement 3): S303-S311.

Burke, M., K. Jorde, et al. (2009). "Application of a hierarchical framework for assessing environmental impacts of dam operation: Changes in streamflow, bed mobility and recruitment of riparian trees in a western North American river." Journal of Environmental Management **90**(Supplement 3): S224-S236.

Cao, H. and P. Zhang (2004). Civil society's force behind the suspension of Nu River Project. Economy (in Chinese).

Chen, C.-T. A. (2002). The impact of dams on fisheries: Case of the Three Gorges Dam. Challenges of a Changing Earth**:** 97-99.

Childs-Johnson and L. R. E. Sullivan (1996). "The Three Gorges Dam and the Fate of China's Southern Heritage." ORIENTATIONS **VOL 27**: 55-61.

China Hydropower Engineering Web. (2011). from http://www.slsdgc.com.cn/show.php?contentid=7743.

China Three Gorges Corporation. (2008). "Special Issue on Jinsha River Hydropower Development." from http://www.ctgpc.com.cn/jsjsdkf/special_news.php.

China.org.cn. (2008). "The Xiaolangdi Key Water-control Project on the Yellow River." from http://www.china.com.cn/aboutchina/data/zmslgc/2008-05/08/content_15122872.htm.

Coleman, J. S. (1994). Foundations of social theory, Belknap Press of Harvard University Press.

Dai, L. (2004). The Nu River Dam Debate: Debate on What? . Outlook Weekly (in Chinese).

Deji, C. (1999). "Engineering geological problems in the Three Gorges Project on the Yangtze, China." Engineering Geology **51**(3): 183-193.

Din, S. H. S. e. (1977). "Effect of the Aswan High Dam on the Nile Flood and on the Estuarine and Coastal Circulation Pattern Along the Mediterranean Egyptian Coast." Limnology and Oceanography **22**(2): 194-207.

Dore, J. and X. Yu (2004). Yunnan Hydropower Expansion: Update on China's energy industry reforms&the Nu, Lancang&Jinsha hydropower dams.

Duan, X. (2009). "Experiences and Recommendations for Hydropower Development on Lancang River." from http://www.wcb.yn.gov.cn/slsd/ztyj/3857.html.

Égré, D. and P. Senécal (2003). "Social impact assessments of large dams throughout the world: lessons learned over two decades." Impact Assessment and Project Appraisal **21**: 215-224.

European Environmental Agency. (2010). "Reservoirs and dams." from http://www.eea.europa.eu/themes/water/european-waters/reservoirs-and-dams.

Freudenburg, W. R. (1986). "Social impact assessment." Annual Review of Sociology **12**: 451-478.

Fu, B. and Y. He (2003). "The effect on the emigration's income and reservoir area ecology in caused by farmland change in reservoir area of M anwan Hydropower Station." Territory & Natural Resources Study.

Fuggle, R., T. W. Smith, et al. (2000). Large Dams in Water and Energy Resource Development in The People's Republic of China (PRC). Cape Town: country review paper prepared as an input to the World Commission on Dams.

Galy-Lacaux, C., R. Delmas, et al. (1999). "Long-term greenhouse gas emissions from hydroelectric reservoirs in tropical forest regions." Global Biogeochem. Cycles **13**(2): 503-517.

Government of Beijing. (1981). "Beijing Government Document [1981] No. 124." from http://210.73.64.113/Govfile/front/content/11981124_0.html.

Han, D. (2006). "Expedite the Hydropower Development on Lancang River." from http://www.chinapower.com.cn/article/1043/art1043147.asp.

Hassan, F. (2007). "The Aswan High Dam and the International Rescue Nubia Campaign." African Archaeological Review **24**(3): 73-94.

Henan Xinhua News Agency. (1997). "Xiaolangdi Project Will Not Become The Second Sanmenxia Dam." from http://www.ha.xinhuanet.com/xhzt/2006-10/24/content_8336708.htm.

Jackson, S. and A. Sleigh (2000). "Resettlement for China's Three Gorges Dam: socio-economic impact and institutional tensions." Communist and Post-Communist Studies **33**(2): 223-241.

Jackson, S. and A. C. Sleigh (2001). "The Political Economy and Socio-Economic Impact of China's Three Gorges Dam." Asian Studies Review **25**(1): 57-72.

Kerr, R. A. and R. Stone (2009). "A Human Trigger for the Great Quake of Sichuan?" Science **323**(5912): 322.

Li, H., P. Waley, et al. (2001). "Reservoir resettlement in China: past experience and the Three Gorges Dam." Geographical Journal **167**(3): 195-212.

Li, W. (2009). Halt of Two Hydropower Dams on Jinsha River reflects the Dilemma of Hydropower Development in China. Life Week (in Chinese).

Liu, F. (2004). "The indispensable role of the Xiaolangdi key water-control project." China Water Resources News.

Liu, J. and J. Diamond (2005). "China's environment in a globalizing world." Nature **435**(7046): 1179-1186.

Longman, J. (2008). "Dams are rejected in America as too destructive. Yet they are still promoted in Latin America. Why?", from http://www.thedailybeast.com/newsweek/2008/09/12/generating-conflict.html.

Lv, M. (2011). "New Opponents against Nu River Hydropower." from http://www.infzm.com/content/55856.

Magee, D. L. (2006). New energy geographics: Powershed politics and hydropower decision making in Yunnan, China. PhD, University of Washington.

McNally, A., D. Magee, et al. (2009). "Hydropower and sustainability: Resilience and vulnerability in China's powersheds." Journal of Environmental Management **90**(Supplement 3): S286-S293.

Mertha, A. C. (2005). "China's “Soft” Centralization: Shifting Tiao/Kuai Authority Relations." The China Quarterly **184**: 791-810.

Ministry of Water Resources. (2009). "Yellow River Water&Hydropower Development Corporation, Ministry of Water Resources." from http://www.xiaolangdi.com.cn/xiaolangdi/.
Mulder, M. B., S. Bowles, et al. (2009). "Intergenerational Wealth Transmission and the Dynamics of Inequality in Small-Scale Societies." Science **326**(5953): 682-688.
Muller, B., M. Berg, et al. (2008). "How polluted is the Yangtze river? Water quality downstream from the Three Gorges Dam." Sci Total Environ **402**(2-3): 232-247.
Nickum, J. E. (1998). "Is China Living on the Water Margin?" The China Quarterly(156): 880-898.
Oi, J. C. (1992). "Fiscal Reform and the Economic Foundations of Local State Corporatism in China." World Politics: A Quarterly Journal of International Relations **45**(1): 99-126.
Oi, J. C. (1999). Rural China takes off: institutional foundations of economic reform, University of California Press.
Pan, J. and J. He (2000). Large dams in China: A fifty-year review, China WaterPower Press.
Pandey, A. P. and R. K. Chadha (2003). "Surface loading and triggered earthquakes in the Koyna-Warna region, western India." Physics of The Earth and Planetary Interiors **139**(3-4): 207-223.
People's Daily Online. (2010). "Three Gorges Dam relocated people married local girl." from http://energy.people.com.cn/GB/12773812.html.
Poff, N. L., J. D. Allan, et al. (1997). "The natural flow regime." Bioscience **47**(11): 769-784.
Poff, N. L. and D. D. Hart (2002). "How Dams Vary and Why It Matters for the Emerging Science of Dam Removal." Bioscience **52**(8): 659-668.
Reuters Beijing. (2011). "Nu River Plan is still Under Feasibility Analysis." from http://cn.reuters.com/article/macroeconomicsNews/idCNnCN165548920110308.
Richter, B. D., S. Postel, et al. (2010). "Lost in development's shadow: The downstream human consequences of dams." Water Alternatives **3**(2): 14-42.
Sadler, B., I. Verocai, et al. (2000). Environmental and Social Impact Assessment for Large Scale Dams, WCD Thematic Review V.2 prepared as an input to the World Commission on Dams. WCD. Cape Town.
Shah, Z. and M. Kumar (2008). "In the Midst of the Large Dam Controversy: Objectives, Criteria for Assessing Large Water Storages in the Developing World." Water Resources Management **22**(12): 1799-1824.
South China Weekends. (2010). "Punishment caused by a report." from http://www.infzm.com/content/49610.
South China Weekends. (2010). "Two Hydropower Dam Projects Resume One Year after Rejection." from http://www.infzm.com/content/50594.
Stone, R. (2008). "Three Gorges Dam: Into the Unknown." Science **321**(5889): 628-632.
Tan, Y. and H. Liu. (2003). "Sanmenxia Dam: the dangerous status of the former "first dam in China"." from http://www.people.com.cn/GB/huanbao/1072/2206736.html.
Tang, C. (2009). "Policies and practices in resettlement caused by dam construction in China." from http://www.chinawater.net.cn/Journal/slxb/20009z/14.html.

The State Council of China (1991). Statute of Land Compensation and People Relocation in Large Hydraulic Project Construction.
The State Council of China (2006). Statute of Land Compensation and People Relocation in Large Hydraulic Project Construction.
Tianjin E-North netnews. (2003). "A 50 year reflection on The Sanmenxia Dam." from http://news.enorth.com.cn/system/2003/12/03/000678411.shtml.
Tilt, B., Y. Braun, et al. (2009). "Social impacts of large dam projects: a comparison of international case studies and implications for best practice." J Environ Manage **90 Suppl 3**: S249-257.
Tilt, B., Y. Braun, et al. (2009). "Social impacts of large dam projects: A comparison of international case studies and implications for best practice." Journal of Environmental Management **90**(Supplement 3): S249-S257.
Tsui, K.-y. and Y. Wang (2004). "Between Separate Stoves and a Single Menu: Fiscal Decentralization in China." The China Quarterly **177**: 71-90.
Tullos, D. (2009). "Assessing the influence of environmental impact assessments on science and policy: An analysis of the Three Gorges Project." Journal of Environmental Management **90**(Supplement 3): S208-S223.
Tullos, D., B. Tilt, et al. (2009). "Introduction to the special issue: Understanding and linking the biophysical, socioeconomic and geopolitical effects of dams." Journal of Environmental Management **90**(Supplement 3): S203-S207.
Tullos, D., B. Tilt, et al. (2009). "Introduction to the special issue: understanding and linking the biophysical, socioeconomic and geopolitical effects of dams." J Environ Manage **90 Suppl 3**: S203-207.
Vanclay, F. (2003). "International principles for social impact assessment." Impact Assessment and Project Appraisal **21**: 5-11.
Vorosmarty, C. J., P. B. McIntyre, et al. (2010). "Global threats to human water security and river biodiversity (vol 467, pg 555, 2010)." Nature **468**(7321): 334-334.
Wang, C., A. Li, et al. (2007). "Management analysis of resettlement caused by dam construction in China and in the world." Express Water Resources&Hydropower Information **28**(4): 27-30.
Wang, Z. (2011). Wang Shucheng: No Rush on Nu River Hydropower Development. China Economic Weekly.
WCD (2000). Dams and Development: A New Framework for Decision-Making, World Commission on Dams.
Whiting, S. H. (2001). Power and Wealth in Rural China: The Political Economy of Institutional Change, Cambridge University Press.
World Bank (2009). Directions in Hydropower.
Wu, J., J. Huang, et al. (2004). "The Three Gorges Dam: an ecological perspective." Frontiers in Ecology and the Environment **2**(5): 241-248.
Xinhua News Agency. (2002). "The History of Lancang River Hydropower Development." from http://news.xinhuanet.com/fortune/2002-01/20/content_245846.htm.
Xinhua News Agency. (2003). "Background of the Three Gorges Project." from http://news.xinhuanet.com/ziliao/2003-05/30/content_894678.htm.

Xu, J. (1998). "Naturally and Anthropogenically Accelerated Sedimentation in the Lower Yellow River, China, over the Past 13,000 Years." Geografiska Annaler: Series A, Physical Geography **80**(1): 67-78.

Yang, T., Q. Zhang, et al. (2008). "A spatial assessment of hydrologic alteration caused by dam construction in the middle and lower Yellow River, China." Hydrological Processes **22**(18): 3829-3843.

Yuan, X. and D. He (2004). "Land Cover Remote Sensing Monitoring on Manwan Dam Immigrant Settlement." Journal of Mountain Science.

Zhang, M. and Y. Jin (2008). "Building damage in Dujiangyan during Wenchuan Earthquake." Earthquake Engineering and Engineering Vibration **7**(3): 263-269.

APPENDIX 1: A REVIEW OF KEY STUDIES ON LARGE DAMS

The positive and negative impacts of large dams have been the subject of major investigations and reviews over the past two decades. In this appendix, I examine some of these key reports in order to provide a context for my study. These literatures are selected from an extensive range, from the report of various organizations, such as the World Commission on Dams, to very specific research on certain rivers, such as the Mekong. They formed the knowledge base for my literature review in Chapter 2.

(1) *Dams and Development: A New Framework for Decision-Making*, a comprehensive report on the large dams around the world, was published by the World Commission on Dams (WCD) in 2000. There are ten chapters in this report, which are divided into two parts. The first part systematically analyzed the history, distribution, functions, performance, social and environmental impacts, and the decision-making process related to large dams; the second part proposed a policy framework for the development of water and energy resources, and suggested criteria and guidelines for future decision making.

In the first part, the report first explored the relationships between development and large dams. Large dams have played important roles in agriculture, economic, and social development. It was estimated that 30-40% of irrigated land around the world relies on dams; 19% of electricity worldwide is generated by hydropower dams; and in 63 countries, hydropower supplies more than 50% of the electricity. Water supply and flood control are also among the important dam functions. However, large dams cause serious environmental consequences, including physical transformation of rivers and impacts on riparian ecosystems. Meanwhile, they also have significant social impacts, such as people displacements and uneven benefit distributions.

To better understand and evaluate the costs and benefits from large dams, the report examined the technical, financial, and economic performances of the large dam cases in the WCD Knowledge Base. The report first found out that generally large dams have a tendency to schedule delays and cost overruns. After reviewing large dams with different purposes, the report further suggested that most irrigation dams have fallen short of their targets for delivering water, and have failed to recover their total costs; hydropower dams performed better than irrigation dams in terms of meeting their planned targets for electricity generation, and sometimes they even over-performed; water-supply dams typically failed to meet their objectives and performed poorly in cost recovery; and flood control dams have provided great benefits in this regard, but sedimentation problems caused by dams offset the benefits in many cases.

Then the report discussed extensively and systematically the social and environmental impacts large dams bring on ecosystems and local societies. Experiences and various studies show that: the inundated reservoir area would cause losses of forests and wildlife habitats; due to the rotting of vegetation the greenhouse gas emission would increase; the loss of aquatic biodiversity and fishery happened downstream; productive fringing wetland ecosystems might be create; and there are various cumulative impacts on water quality and natural flow regimes.

Large dams and society: As for the social impacts, the report identified four most markedly ones: 4-80 million people were displaced due to dam construction, and many of those were poorly resettled or unfairly compensated; because of the change in natural flow, the livelihood of downstream societies was seriously affected; indigenous peoples, tribal peoples, and ethnic minorities generally suffered disproportionately from the dam projects; and among affected communities gender gaps have widened and women suffer disproportionately during the process.

One of the goals of the WCD was to comprehensively compare and assess different options for providing energy and water services. Therefore, the report reviewed alternatives to large dams for providing irrigation, water supply, electricity, and flood control. It was suggested that Improving the performance and productivity on the supply-side, and enhancing the efficiency on the demand-side are basic principals in strategies to reduce the need for large dams.

At the end of the first part, the report reviewed current decision-making processes in both developed and developing countries, and explored the probable factors that promoted the decisions to build dams. Then, the report suggested that effective participation by all affected groups, transparency in the decision-making process, and comprehensive options assessment were the keys to guaranteeing a reasonable decision-making process. Furthermore, addressing social and environmental impacts ahead of the construction was also critical to mitigate the negative influences of dam projects. Legal frameworks and policy provisions are also necessary in major infrastructure projects like large dams.

In the second part, the report basically suggested a policy framework for the future develop of water and energy resources, in which large dam is only one of the options. The WCD first proposed a set of core values as a base for improving the develop process, namely equity, efficiency, participatory decision-making, sustainability, and accountability. Then, three important international covenants, The Universal Declaration of Human Rights (1947), the UN Declaration on the Right to Development (1986), and the Rio Declaration on Environment and Development (1992) were taken as the foundation for a rationale for sustainable development. Seven strategic priorities were identified: 1) gaining public acceptance; 2) developing comprehensive options assessment; 3) addressing existing dams; 4) sustaining rivers and livelihoods; 5) recognizing entitlements and shared benefits; 6) ensuring compliance; and 7) sharing rivers for peace, development, and security. Based on these priorities, detailed criteria and guidelines were provided for the convenience of implementation. Finally, the WCD gave an "Agenda for Change", where different groups and organizations are suggested to take different responsibilities for improving future decision making about large dams.

In short, the WCD report is not only a comprehensive review of the current status and a summary of various concerns about large dams around the world, but it is also a constructive handbook for future decision-making and policy implementation. Those features make it an important book that researchers and practitioners intending to resolve the large dam problems should not miss.

(2) *Large Dams in China: A 50 Year Review* is a comprehensive and circumspect report on the history, planning, current status, technological analysis, environmental assessment,

and the future of large dams in China. It was developed by leading hydrology scientists in China and was published in Chinese and English in 2000.

This book first provides a history of large dams in China that illustrates the evolution of the technologies used in dam construction over the past millennia, and how innovative technologies are applied to contemporary dam-building.

The second chapter is about the exploitation of hydropower in China. This chapter systematically lists the major rivers in China, as well as the hydropower potential of each. After theoretical calculations, it provides the percentage of the hydropower potential that has been exploited, and estimates increases in power that could be harvested by building new dams on various rivers.

From the third to the fifteenth chapter, the authors discuss the technologies used in different aspects of dam construction. Particularly, in Chapter 4, techniques that are used to mitigate environment impacts are introduced in a chronological order.

Chapters 16-18 are case studies of three of the most important dams in China: the Ertan, Xiaolangdi, and Three Gorges. These chapters primarily focus on the technologies applied in the construction of these dams.

Chapters 19 and 20, address the facilities associated with dam construction. The last chapter, Chapter 21, discusses future planning needs associated with the anticipated building of more large dams in China during the first decade of the 21st Century.

(3) Dr. Darrin Magee, currently an Assistant Professor at Hobart and Williams College, did his PhD research on large dam construction in Yunnan Province, China, (2006; *New*

Energy Geographies: Powershed Politics and Hydropower Decision Making in Yunnan, China). He coined the word "powershed" to illustrate the idea that hydropower production in Yunnan supports economic development in Guangdong Province. His dissertation has significant meaning in that the institutional and social changes during the period when dam projects were developing were properly integrated into the analysis of hydropower exploitation in southeast China.

Magee's dissertation first contributed empirical knowledge about dam construction on the Lancang and Nu Rivers. In the Lancang River case study, he discusses the history of the dam proposals and the role of the Mekong River Committee in the decision-making process. This was then followed by detailed descriptions of the cascade dams on the Mekong River, including the physical characteristics, functions, and institutions related to the construction and management of the dams. It is important to note that his work points out that the Huaneng Corporation applied four principles to hydropower development in Southwest China, namely "basin, cascade, rolling, and comprehensive", which have become the paradigm for the strategies used to exploit rivers in this region. The cooperation and contracts between China and Thailand in building some of the cascade dams were also mentioned. Physical details of the proposed dams were also listed in the dissertation.

The Nu River case study was different from the Lancang River case study in that none of the proposed dams had commenced construction by the time Magee conducted his research. Proponents of the dam construction included not only state-owned hydropower companies, but also local governments, which historically had to rely on subsidies from the Central Government to maintain infrastructure and promote development, but now anticipated that dam projects would bring economic opportunities to their regions. In contrast, opponents to dam construction vehemently argued that the power plants would cause the resettlement of numerous ethnic minority groups, and threaten biodiversity, fisheries, and agriculture in the area. In addition, debate about dams on the Nu River was much more open and pluralized than in the Lancang case. The opinions of civil society changed the process of decision-making, resulting in the call for suspension of the dam planning by Premier WEN Jiabao in 2004.

The second important contribution of Magee's dissertation research is that it explored and explained the institutional, legal, political, and economic factors involved in dam construction. Several 'supra-provincial' institutions played important roles in both the decision-making process and in determining the energy supply-consumption pattern. Watershed commissions were the first type of institution involved. Large-scale hydropower project development was not under the direct administration of the Minister of Water Resources in China. Instead, seven basin (i.e., watershed) commissions were in charge of water resources exploitation. Among these, the Yangtze River Water Resources Commission was the largest, and was responsible for developing hydropower projects for not only on the Yangtze River, but all rivers in Southwest China, including the Lancang and Nu. These water resources commissions were actually delegated authorities of the State Council responsible for approving or rejecting hydrological projects. The second type of the institution examined by Magee was hydropower companies, and the third type was grid companies.

China's hydroelectricity policies were reformed beginning in the 1990s. To meet the national goal of enterprise modernization and corporatization, the Ministry of Electric Power was changed to the State Power Corporation of China (SPCC). One of the goals in breaking up the ministry was to separate electricity generation from electricity distribution. In 2002, the assets of SPCC were reallocated to five generation companies (China Huaneng, China Datang, China Huadian, China Guodian, and China Power Investment), two grid companies (State Power Grid and Southern Power Grid), and four so-called auxiliary companies (China Power Engineering, China Hydro Consulting, Sinohydro Corporation, and China Gezhouba) (Figure A-1).

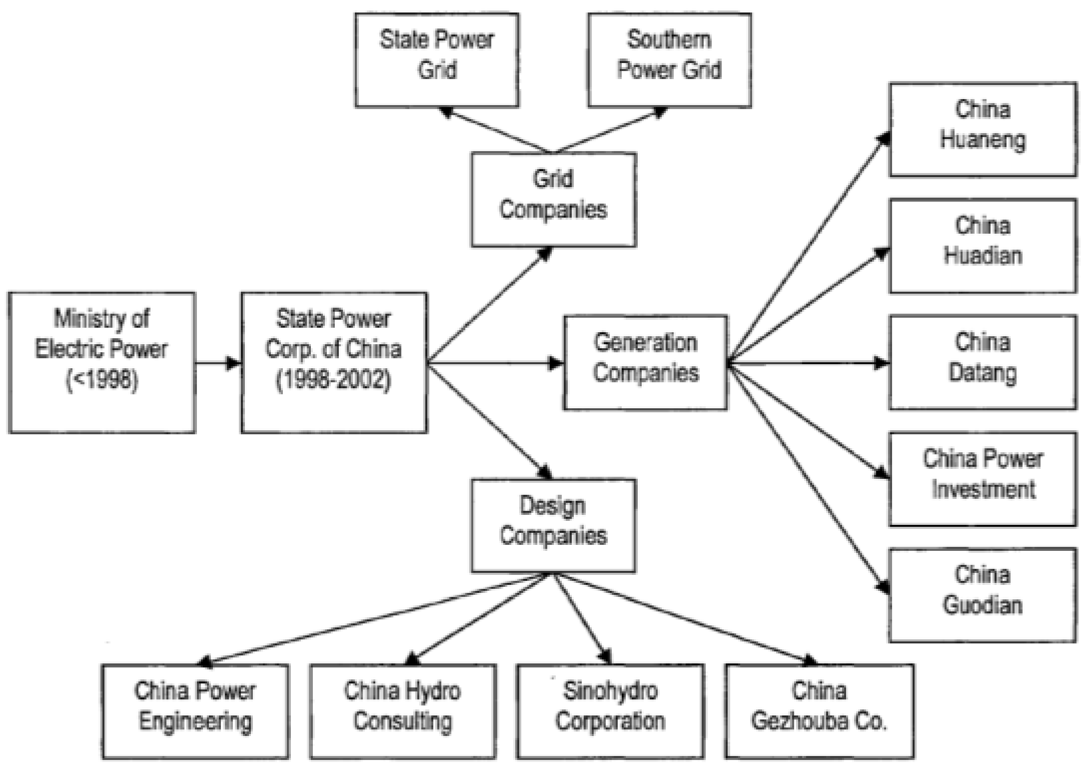

Figure A- 1 From Ministry to stock corporations

The third contribution of Magee's dissertation research was to help understand the central-local and interprovincial relationships in China. After studying various research projects related to central-local models in China, Magee provided a summary for these models. In a vertical control model proposed by Tsui and Wang (2004), the Central Government still had the power to control the cadre management system, issue unfunded mandates, and legislate expenditures. In Whiting's (2001) institutional model, the local cadres were actually motivated by career advancement when making policies, and it was critical to understand the changes in property rights and extraction regimes for the central-local analysis. Oi's (1992; 1999) local state corporatism model was considered influential by Magee. In this model, local officials had the ability to allocate and utilize resources, and their high motivation for economic growth and social stability made them act as managers in a vertically integrated system. Finally, in Mertha's (2005) soft centralization model, the recentralization of some offices in China's reform stopped at the provincial level and empowered the provinces to make decisions about resources development policies. After introducing these models, Magee also discussed literature on China's uneven development across regions, caused by "an uneven geographic distribution of resources, an emphasis on industrialization and national defense, decentralization and policy changes, and political and social unrest". Finally, resources exploitation decisions were made according geography/area studies, scale politics, and political ecology specific to China.

The fourth contribution arising from Magee's dissertation research was an analysis of the energy development patterns that looked at geographic politics and national wide regional development strategies. He created an analysis framework called the "powershed" to understand the factors that determined the patterns and strategies of energy development. Magee used a powershed analysis to break through the limits of a political-ecological scale analysis, and explained the dynamics that the water resources and hydropower projects developed in Yunnan Province to support economic growth in Guangdong Province and other industrial urban areas. The uneven development of different regions in China was the root cause of the distribution of risks and profits and determined a pattern where a "Western Regions Development Strategy" provided energy and resources to eastern urban areas. It was also important that Magee pointed out that it should be the process that decides the scale, instead of the other way around.

Magee's final contribution was to emphasize the importance of academic and non-governmental organizations (NGOs) in the decision-making process about dam construction in Yunnan and the whole of China. First, he discussed the role of quasi-NGOs in China, or NGOs with "Chinese characteristics." Such organizations were not totally independent from the government, but they generally assumed positive roles in addressing certain immediate concerns, such as pollution, environment protection, and cultural preservation. Magee used the term "Civil Society Organizations" to refer to them. Three cases of these organizations were discussed in his dissertation, which were Green Watershed, Yunnan EcoNetwork, and Green Earth Volunteers. Some of these organizations' actions began to influence national-level decisions, such as the halting of dam construction on the Nu River by the Premier of China in 2004. Magee also discussed the use of scholars in the dam construction decision-making process, particularly the role of The Asian International Rivers Center. This institute and its Director, HE Daming, have published widely on issues related to hydrologic projects and have become world renowned for research on the Lancang River.

(5) *Yunnan Hydropower Expansion: Update on China's Energy Industry Reforms & the Nu, Lancang & Jinsha Hydropower Dams* is a working paper written by John Dore and YU Xiaogang in 2004. Even though it is not published in a peer-reviewed journal, the abundant information and profound analysis on the relationship between China's institutional reform and hydropower exploitation, and decision-making dynamics still makes it a very important work for the study of China's hydropower and large dams.

According to this paper, Yunnan has been identified as an important hydropower base and there are plans to intensively exploit the province's three major river systems, namely the Jinsha (Upper-Yangtze), Nu (Upper-Salween), and Lancang (Upper-Mekong). Hydropower development in Yunnan is also part of a national plan, termed the "Western Region Development Strategy", which focuses on exploiting the resources and energies in western China to support the economic growth in eastern China.

Several key factors that drive hydropower development in Yunnan were identified in the paper. First, hydropower development in Yunnan must be viewed in the context of globalization, which brings advanced technology to rural areas, as well as affects decision-making processes by removing business restraints, and encouraging trade and exports. Second, China's energy demand is expected to increase dramatically over the next 30 years, and domestic and foreign investors are expected to fund large dam projects due to the prediction that the energy sector of China will significant increase. Third, the shift in the Chinese economy from central planning to a free market along with energy industry reforms is stimulating competition among various corporations. Hence, several large industrial entrepreneurs, such as Huaneng, Huadian, Guodian, and Datang, have been intensively competing in energy development in Southwest China.

Additional useful information this paper provides is an update on the status of hydropower projects on the three major rivers in Yunnan. The construction of the Nu River hydropower plants has been under fierce controversy national wide. Thirteen dams were proposed for the Nu River, which caused extensive concern about the irreversible changes they would trigger on the ecosystems and local communities. Dam construction proponents, mainly energy companies, vigorously promoted the proposal, while the State Environment Protection Administration raised doubts about ecosystem alterations, biodiversity losses, and geological instability. Civil society also has been actively involved, with 62 well-known artists, journalists, and environmentalists signing a petition to protect the Nu River. The future of the Nu River remained unknown by the time the paper was written.

On the Lancang River, there were eight dams proposed and three of them have already been constructed. This paper provided brief introductions to these three dams, namely Manwan, Xiaowan, and Dachaoshan, and also discussed issues related to trans-boundary water resources use, since the Lancang is an international river. The Jinsha River is the name of the Upper Yangtze, and it is upstream to the Three Gorges Dam. There were no serious plans to build dams on the upper Jinsha, but eight dams were proposed for the middle region, and four more for the lower Jinsha. The fact that three different companies with different ownership types will construct these dams might make flow management more complex.

Lastly, the paper provides recommendations on different scales. The first order included recommendations that China needs to revisit its energy policy, and overhaul energy development governance processes to include option formulation, debate, evaluation, negotiation, and monitoring. The second order recommendations were specifically for the governance of Yunnan Hydropower, suggesting comprehensive social, economic, and environmental assessments before the construction of any new dam. The approval and impact assessment processes are two key areas requiring strengthening.

(5) Professor HE Daming and his Asian International Rivers Centre at Yunnan University have also made tremendous contributions to better understanding large dam issues in Yunnan Province. Beginning in the 1980s, Professor HE has extensively researched the ecological, environmental, and social impacts of Yunnan’s dams. As an important consultant for the government in hydropower projects and international river issues, his research also has influenced the decision-making process related to the dam-building process. For example, according to his findings and suggestions, the heights of several dams in Yunnan were reduced by dozens of meters compared to their original designs. He has also suggested a social impact analysis framework for assessing of social impacts of dam project construction.

APPENDIX 2: QUESTIONNAIRES IN FIELD STUDY

Questionnaire for Local Farmers

No: ________________

Date: ______________ Time: _________ Recorded by: _________.

_________City (County) ________Town_____Village__________.

Part I: Household basic information

1. Family members:

Number of: Males: ______ Females: ________.

2. Family age structure:

0~20:____; 21~50:_____; 51~70:_____, >70:_____.

3. Education level of family members:

Didn't attend high school: ________High school:________.

College:__________ Graduate school: ________.

4. Work information

Farmers: Other jobs:

5. House location:

House and cropland location relative to the dam and reservoir:

Part II: Agriculture information

6. How many hectares of farmland did you own before the construction of the dam? How many hectares do you own now?

7. Did the reservoir submerge some of your farmland? If so, how many hectares were submerged? Where is your land? Uphill? Or somewhere else?

8. What kind of crops did you grow before the construction of the dam? What kind of crops do you grow now? If they are different, what are the reasons for this change?

9. Do you now grow crops on steeper land than before? Can you describe the changes if any?

10. Is the soil fertility poorer or richer than before? Can you describe the changes if any? Choose one answer below that is closest to the reality.

a. Much worse b. a little worse c. Stays the same d. a little better e. much better

11. Is the farmland temperature cooler or warmer than before? Can you describe the changes if any?

12. Is the irrigation of the farmland easier or more difficult than before? Can you describe the changes if any?

Part III: Incomes from agricultural production

13. What was the yield per hectare before the construction of the dam? What is the yield per hectare now?

14. How much money per hectare annually did you invest before the construction of the dam? How much money per hectare do you invest now? Material costs

15. How much was your income *per hectare* before the construction of the dam? How much is your income *per hectare* annually now?

16. Were there any changes in the amount of fertilizer and pesticide use after the construction of the dam? If so, can you describe the change?

17. Were there any changes in the amount of time you invest in farmland after the construction of the dam? If so, can you describe the change?

18. Did some of your family members quit growing crops and find another job? If so, what were the reasons for this change? What other job did she/he find?

19. Did you ever receive any kind of compensation for your submerged farmland? If so, how much was it per hectare? Was the compensation paid in a lump sum, or it lasted for several years?

20. What's your expectation of the compensation? How much per hectare do you think is reasonable?

Questionnaire for Relocated People

No: ______________

Date: ________________ Time: ___________ Recorded by: __________.

City(County) _________Town______Village____________.

Part I: Household basic information

1. Family members:

Number of: Males: ________ Females: _________.

Ethnicity and religion: _____________

2. Family age structure:

0~20:______21~50:__________ 51~70:______ >70:__________.

3. Education level of family members:

Didn't attend high school: _________High school:_________.

College:___________ Graduate school: _________.

4. Work information

Farmers: Other jobs:

5. House location:

Previous Location and current location:

____.

Part II: Change in Housing

6. What kind of house did you live previously? What kind of house do you live now? Do you like your new house better or not? Why? Can you describe the environment of the house?

7. How many square meters was your previous house? How many square meters is your house now?

8. Is it easier or harder to access to clean water compared to your previous house? Can you describe the change in water supply?

9. Is the transportation now more or less convenient than before? Can you describe the change in transportation?

10. Can you describe the change in energy supply after you moved to this new place?

Part III: Change in standard of living

11. What was your previous job before the dam construction? What is your job now? If you are not a farmer, do you think it's easier or harder to find a job now than before?

12. How much was the approximate annual income of your family before the dam construction?

A. <10,000RMB B. 10,000~20,000 C. 20,000~50,000

D. 50,000~100,000 E. >100,000 F. More Accurate number: ________.

13. How much was the approximate annual income of your family before the dam construction?

A. <10,000RMB B. 10,000~20,000 C. 20,000~50,000

D. 50,000~100,000 E. >100,000 F. More Accurate number: ________.

14. Is it easier or harder to access to healthcare compared to your previous house? Can you describe the change in healthcare?

15. Is it easier or harder to send children to school? Is the quality of education better or worse? Can you describe the change in education?

16. Did you ever receive any kind of compensation for your migration? If so, how much was it? Was the compensation paid in a lump sum, or it lasted for several years?

17. What’s your expectation of the compensation? How much and in what form do you think is reasonable?

Part IV: Change in culture and social activities

Questions 18 and 19 are for minorities only.

18. What language did your family speak previously? What language do you speak now? If you changed your language, can you explain the reasons for it?

19. What festivals did you celebrate in your former community? Do you still celebrate these festivals now? Is there any change in the manners that you celebrate them?

20. Do you think the relationship between members in community is closer or not compared to that in your former community? Can you describe this change?

22. Are you still living with your ethnic groups before? Did the relocation make it easier or harder to communicate with relatives and friends?

23. Do you think the crime rate in your community is higher or lower compared to your former community? Can you describe this change?