Chapter 2
Large Dams in China: An Overview of History, Distribution, and Case Studies

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 that 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 World Commission on Dams (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 twentieth 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 surpassed 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 Chap. 4.

The second time period, 1958–1966, featured the nationwide, large-scale construction of infrastructure, including large dams. Different levels of political

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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 the 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 nationwide. 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 1–10 million m^3 are administrated at the county level; those from 100 thousand to 1 million m^3 are administrated at the town level; and reservoirs under 100 thousand m^3 are administrated at the village level. Hydroelectric plants have different administrative systems and will not be discussed here.

2.2 The Distribution of Large Dams 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 (Fig. 2.1) (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 (Fig. 2.1), 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 chapter will provide case studies of some important dams, including the Three Gorges Dam, Xiaolangdi Key Water Control Project, and dams in Yunnan Province. More case studies are given in Chaps. 3 and 4, which focus on the environmental and social impacts of these dams, respectively.

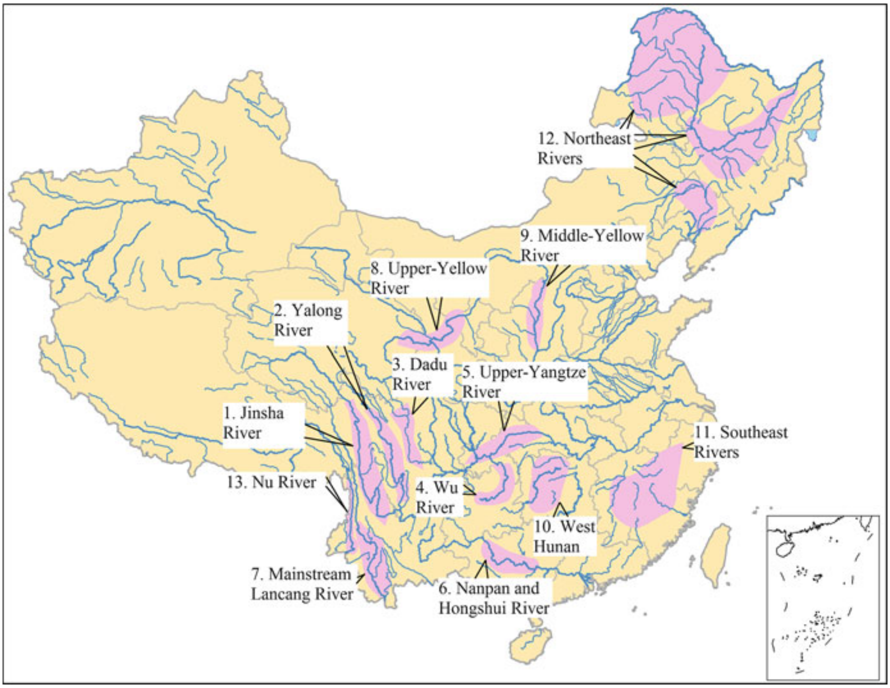

Fig. 2.1 Thirteen hydropower bases in China (Synthesized from data on China Hydropower Engineering Web (2011))

Each of these 13 hydropower bases has important characteristics that are summarized below (China Hydropower Engineering Web 2011). The numbers correspond to those provided in Fig. 2.1.

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 twentieth 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 Kong, 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 parts of this chapter and Chap. 3.
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. 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, and it is called the "last pristine major river in China." This will be discussed in the case study part of Chap. 4.

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 Lancang (Upper-Mekong) and Jinsha Rivers. The first two dams are key hydraulic projects built on the two largest rivers in China, the Yangtze and the Yellow, respectively. The other two cases are in Southwestern China, where there is the highest hydropower potential in China. The case studies in this section intend to provide a general sense of the physical, social, and environmental features of large dams in China, from the decision-making process to the various impacts of large dams. Chapters 3 and 4 will use more case studies and focus on the environmental and social impacts of large dams, respectively.

2.3.1 The Three Gorges Dam

2.3.1.1 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 the 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 United States 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 2003b).

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 Sullivan 1996; Xinhua News Agency 2003b).

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.

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, 1998–2003, involved building the dam and installing generators on the east side and completing a permanent ship lock. The third stage, 2003–2009, 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 (Stone 2008; Xinhua News Agency 2003b).

2.3.1.2 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 its power station is transported to 10 provinces, including Shanghai thousands of kilometers away (Xinhua News Agency 2003a; Jackson and Sleigh 2001; 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 exacerbated more recently 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 twentieth century, 1931, 1954, and 1998 have caused thousands of deaths and staggering 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 2003a). 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 2003a; Wu 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 upstream cities. For example, the Port of Chongqing can now accommodate large cargo ships in the 10,000-t class connecting commerce to downstream locations. This improvement in water transportation has significantly stimulated economic development in this megacity (Xinhua News Agency 2003a).

2.3.1.3 Social and Environmental Consequences

The Three Gorges Dam has caused various social and environmental impacts since its construction. It was estimated in official documents that after the completion of the relocation program in 2010, a total of 1,397,000 people had been relocated. 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 (Xinhua News Agency 2003a; Jackson and Sleigh 2000; Li et al. 2001).

After settling 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. For example, it became top news in Suqian, Anhui Province when a local woman married a relocated man because they were discriminated against and this kind of marriage was very uncommon (People's Daily Online 2010). The undetermined social costs of the almost 1.4 million relocated people make the total cost of the Three Gorges Dam difficult to estimate.

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 et al. 2008), terrestrial and aquatic biodiversity (Wu 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 mountaintops and ridges, turning them into 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

2.3.2.1 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, 1.35 billion tons of sand are 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).

The Chinese Government decided to build a large dam in the gorge areas of the Yellow River in the 1950s to resolve the sediment accumulation and flood problems. 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 at Tsinghua University and widely respected 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, it was difficult to oppose experts from the Soviet Union at that time, so the proposal was approved and Huang suffered political persecution for more than 20 years (Tianjin E-North Netnews 2003; Tan and Liu 2003).

Sanmenxia Dam was complete in 1960. Unfortunately, only 1-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 m.

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).

2.3.2.2 The Historical Missions of Xiaolangdi Dam

The 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. A new problem emerged during the 1970s when heavy water consumption in the Yellow River watershed began causing water shortages downstream during the dry seasons. 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 (Ministry of Water Resources 2009; China.org.cn 2008).

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 and Xia 2004; Ministry of Water Resources 2009).

Second, the reservoir stores water during the rainy season, and discharges it during the dry season to meet water consumption demands 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 and Xia 2004; Ministry of Water Resources 2009).

Third, learning from lessons from the Sanmenxia Dam, 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 speeds slowing the washing-out of sand along the downstream riverbed, and with collaborative efforts to restore vegetation and reduce soil erosion in upstream areas, 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 meet the electricity supply for Henan Province, where it is located (Liu and Xia 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 greatly reduced, 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, almost 278 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 Lancang River

2.3.3.1 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,

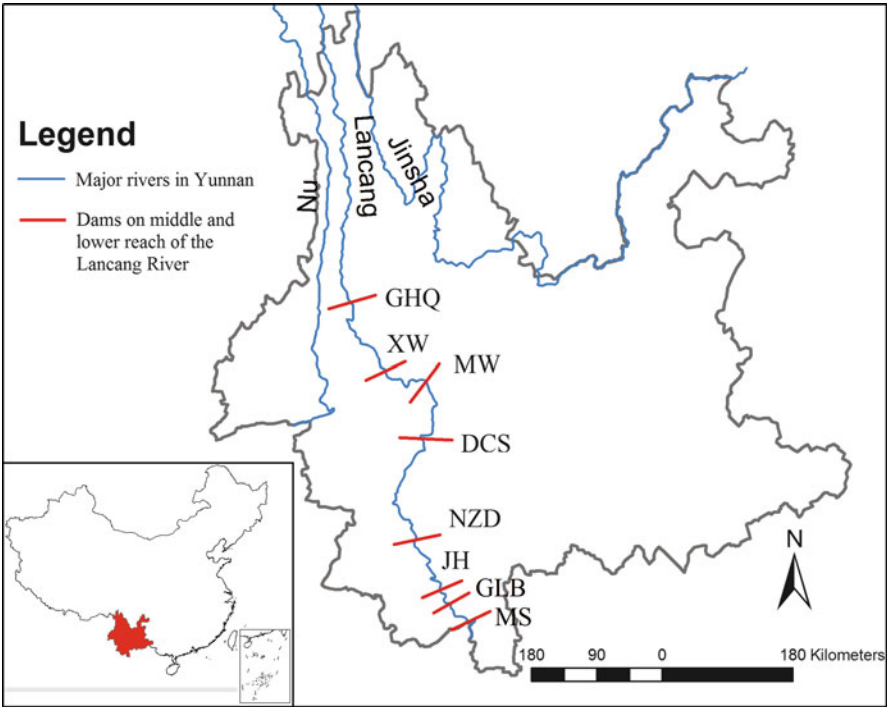

Fig. 2.2 Cascading dams on the Lancang River

Cambodia, and Vietnam before empting into South China Sea. Flowing 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 nationally renowned hydropower experts to 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 along its middle and lower reaches. From upstream to downstream, these eight dams are: Gongguoqiao (GGQ), Xiaowan (XW), Manwan (MW), Dachaoshan (DCS), Nuozhadu (NZD), Jinghong (JH), Ganlanba (GLB), and Mengsong (MS) (Fig. 2.2) (Han 2006).

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 of 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 (MW, Fig. 2.2). 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 (DCS, Fig. 2.2) 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 (XW, Fig. 2.2), is 70 km upstream of Manwan Dam (MW). It was completed in 2009, with the installed capacity of 4,200 MW. It is one of the 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 (NZD, Fig. 2.2) 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 (JH), Ganlanba (GLB), and Mengsong (MS). 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 (JH, Fig. 2.2) 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 (GGQ, GLB, MS, Fig. 2.2), 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).

2.3.3.2 Environmental and Social Consequences

Cascading dams on the Lancang will dramatically change the profile of the river, and alter its natural flow significantly (Fig. 2.3). It is also clear that Xiaowan and Nuozhadu are much larger dams than the others, and these two dams actually have

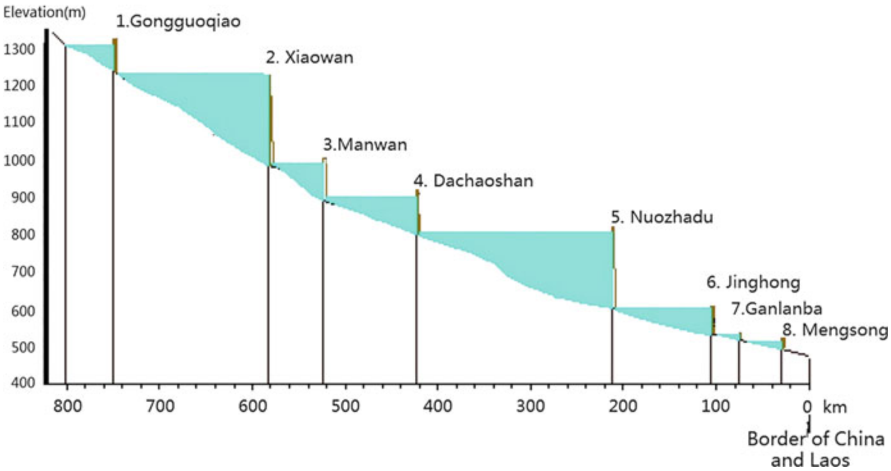

Fig. 2.3 Vertical profile of the Lancang River after dam construction (Synthesized from data on Magee 2006)

the ability to regulate the flow of the downstream dams. Such a significant change in the landscape will undoubtedly have impacts on the environment and local human communities.

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 (Dore and Yu 2004). 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 increased 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 nonmaterial 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.

2.3.4 The Jinsha River

The Jinsha River is the upper reach of 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 situations of many large dam projects on other rivers, there have been heated debates about the dams on the Jinsha River in recent years. 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 (South China Weekends 2010; Li 2009).

Opponents of the dam projects on not only the Jinsha River, but also other major rivers in Southwestern China, include some Chinese NGOs, journalists, scientists, as well as some environmental protection agencies. Their major arguments are summarized below.

1. The Southwestern Chinese Rivers are marked by high biodiversity and the “Three Parallel Rivers” are identified as part of the World Natural Heritage by UNESCO. The dam projects might cause irreversible impacts on the river gorges ecosystems and pristine scenery.
2. These rivers run 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 projects will provide golden opportunities. Those people include local government officials, managers of state-owned hydroelectricity companies, and some scientists. Their major points are summarized below.

1. 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. The dam projects could generate substantial financial returns, and, even though only a small portion would be retained locally, this would result in at least a tenfold 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 projects will have significant impacts on the river species, particularly some migratory fishes. But the environmental impact assessment showed that among many indigenous fish species, only a couple of them would likely to 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. For example, even though the installed capacity is larger than Three Gorges Dam, the dams would require the relocation of less than 10 % of the people displaced by the Three Gorges Dam project. Therefore, the social impacts of the dam project are also relatively low.

Unlike the Nu River situation discussed in Chap. 4, where environmental NGOs successfully halted the proposed dam construction, there are several dams already under construction along the Jinsha River. The fragmentation of the Jinsha River 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 (South China Weekends 2010; Li 2009).

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