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Abstract

Approximately 78% of China's electricity demand is met by burning coal, which has taken a serious toll on the environment. Hydropower represents a sustainable alternative source, and China already derives 16% of its electricity supply from hydropower. However, evidence from other hydroelectric projects such as the Three Gorges Dam suggests that the socioeconomic consequences of such large public works projects are enormous.

A series of dams has been proposed for the middle and lower reaches of the Nu River (Upper Salween) in Yunnan Province. If completed, the 13-dam cascade would have greater power-generating potential than the Three Gorges Dam. However, the Nu is considered to be the last "virgin" river in China, and many of the proposed dams are located in an environmentally-sensitive area. Moreover, approximately 50,000 people – many of them ethnic minorities – would be forced to resettle by the resulting reservoirs (Yardley 2004). Finally, the economic status of northwestern Yunnan is quite low, suggesting that socioeconomic vulnerabilities among the displaced population would be quite acute. Although construction has officially been halted, surveying has begun on at least five of the dams, and Wang (2008) reports that the actual construction process has begun on one of these dams.

After providing a detailed account of China's electricity supply, this paper quantifies China's hydropower potential. We then describe the socioeconomic effects of population displacement from dam development using the Three Gorges Dam as a case study. Next, we provide a detailed economic profile of the Nu River area, arguing that poor farmers from disparate language groups are more likely to face extreme vulnerabilities in the resettlement process. Finally, we employ microevidence from interviews of affected households to demonstrate that the dam construction process in western Yunnan has been neither transparent nor consultative.

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I. Introduction

China's electricity demand has increased dramatically in the last decade due to rapid growth in heavy industry and in personal consumption. Approximately 78% of this demand is currently met by coal burning, which has taken a serious toll on the environment: China is already the world's largest emitter of CO_2, and the International Energy Agency predicts that the country will account for 40% of the growth of global annual CO_2 emission over the next 25 years. Hydropower represents an alternative source of electricity that produces far fewer emissions, and China already derives more of its electricity from hydropower than virtually any other country. Moreover, technological developments have made the exploitation of water resources in central and western regions economically viable. However, evidence from large dams such as the Three Gorges Dam suggests that the socioeconomic consequences of such large public works projects are enormous.

A series of dams has been proposed for the lower and middle reaches of the Nu River (Upper Salween) in western Yunnan Province. If completed, the 13-dam cascade would have greater power-generating capacity than the Three Gorges Dam and the entire Columbia River system (including the Grand Coulee, the largest dam in the US). However, the Nu is considered to be the last undammed river in China,[1] and many of the proposed dams are located in an area that has been declared a Conservation International Biodiversity Hotspot (Conservation International 2008) as well as a UNESCO World Heritage Site (UNESCO 2008). Moreover,

[1] Despite frequent use of the term "virgin" to describe the Nu River, there are already two relatively small dams on the main stem of the Upper Nu in Tibet. The first of these is near Nakchu while a second is just downstream of Biru. A third dam is also under construction upstream of Biru.

approximately 50,000 people – many of them ethnic minorities – would be forced to resettle by the resulting reservoirs (Yardley 2004). Finally, the economic status of northwestern Yunnan is quite low, suggesting that socioeconomic vulnerabilities among the displaced population would be quite acute. Although construction has officially been halted pending impact assessments, geological substrata surveying has begun on at least five of the dams, and recent news reports indicate that the actual construction process has begun on one of these.

This paper begins by describing trends in China's electricity consumption and production, including the relative appeal of hydropower. We then describe the country's current hydroelectric development and prospects for further development, providing a detailed account of the proposed Nu River dams. We then describe the socioeconomic effects of population displacement from dam development, including changes in income and production, material well-being, social capacity, health outcomes, and access to cultural sites. We use well-documented outcomes from the Three Gorges Dam as a case study to identify potential challenges associated with displacement in the Nu River area; although the two watersheds differ in many important ways, many of the challenges faced by displaced peoples are likely to be the same. Next, we provide a detailed economic profile of the Nu River area, arguing that poor farmers from disparate language groups are more likely to face extreme vulnerabilities in the resettlement process. Finally, we employ microevidence from interviews of affected households to demonstrate that the dam construction process in western Yunnan has been neither transparent nor consultative.

II. Electrical power generation in China

Growing Demand for Electricity

Since the beginning of reforms in 1978, China's GDP has grown at approximately 9.5% per year (Chow 2001; Hao 2006) Although less important in the early stages of the reform period, China's heavy industry sector has become a major contributor to growth in the last five years as a result of higher industrial output prices, preferential tax policies, and relatively cheap electricity prices. Indeed, industry accounted for 71% of energy demand in China in 2005, compared to only 25% in the United States (Steenhof 2006; Rosen and Houser 2007).

Rapid growth of personal incomes has coincided with the rapid growth of GDP, raising urban per capita incomes from 343 RMB in 1978 to 13,786 RMB in 2007 (National Bureau of Statistics 2007). In rural areas, per capita income rose from 134 RMB to 4140 RMB over the same period (National Bureau of Statistics 2007). With higher personal incomes, ordinary Chinese have found it easier to satisfy their food and shelter needs and are demanding more consumer goods such as televisions, air conditioners, refrigerators, and microwaves, all of which contribute to the increasing electricity demand in China (Smil 1998; Shen 2001; Yuan et al. 2007). The heavy subsidization of households' consumption of electricity (Rosen and Houser 2007) has also contributed to rising demand. However, the demand for electricity in China has not grown at a uniform pace across the country: coastal areas have benefited more from economic development than central and western regions (Figure 1), and the majority of the demand for electricity comes from these coastal provinces (Zhang 2004).

Sources of Electricity Generation

China has long depended primarily on coal for electricity generation; International Energy Agency (2006) and Rosen and Houser (2007) report that up to 78% of the country's electricity supply is currently derived from coal-fired plants (Figure 2). Moreover, the country's total demand for coal has increased 12% annually since 2001 (Rosen and Houser 2007), leading to double-digit annual price increases over this period (CoalPrice.cn 2007). Nevertheless, the country's relatively abundant coal reserves have struggled to satisfy this demand, and China became a net coal importer in 2007, sourcing from Indonesia, Australia, and elsewhere (Rosen and Houser 2007). Furthermore, the railway system has become clogged by increasing traffic, which makes moving the coal from sites of extraction to sites of combustion more difficult. The rail lines are also not reliable during natural disasters, as evident in the recent snow disaster in China. Such heavy reliance on coal to meet electricity demand has taken a toll on the environment: China is already the world's largest emitter of CO_2, and International Energy Agency (2006) predicts that between 2007 and 2030, China will account for 40% of the growth of global annual CO_2 emissions.

As in other countries, China has converted most oil-fired power plants to other fuels due to concerns about relative inefficiency, pollutants, and uncertainty over the supply of petroleum. Moreover, China's largest oil fields, Daqing and Shengli, produce oil that is relatively low in sulfur and high in API gravity, i.e., high-quality petroleum that is well-suited for gasoline production but that is generally considered inappropriate for electricity production given its high cost. In addition, the global price of oil has risen sharply in the last five years, making the prospect of producing electricity from oil uneconomical. As a result, less than 1% of China's electricity supply is currently derived from oil (International Energy Agency 2006).[2]

Unlike petroleum and coal, China has relatively meager proven reserves of natural gas, estimated to be between 53.3 trillion cubic feet (TCF) and 55.6 TCF as of January 2006 (Energy Information Administration 2006). China consumed 1.3 TCF of natural gas in 2004, and given an

[2] Nevertheless, China was responsible for 58% of the global growth in demand for oil in 2006 (Rosen and Houser 2007)

estimated increase of 15% per year in terms of natural gas demand, the country will likely run out of this resource before 2030. Attempts to secure supplies from neighboring Russia have been met with strong competition from Japan, and progress on the proposed Kovykta pipelines between Siberian gas fields and northeastern China has been slowed by stalled negotiations over pricing. China has recently secured rights to natural gas in the Shwe field, off the coast of Myanmar, and a pipeline to Kunming is expected to become operational by 2009. However, this pipeline will traverse difficult terrain, increasing the cost of the imported gas substantially. Moreover, the isolation of the military junta may subject the gas supply coming out of Myanmar to volatility. This is because international opposition to the current regime may bring about UN and other forms of sanctions in the future, which will add political and logistical pressure for both China and Myanmar, making a constant gas supply hard to maintain. In addition to limited resources, China's existing pipelines for transporting natural gas are fragmented and concentrated mostly in Sichuan province, far from the major source of demand on the eastern seaboard (Energy Information Administration 2006). These factors contribute to the fact that less than 0.7% of electricity in China is currently generated by natural gas (Energy Information Administration 2007).

The Chinese government has also been actively pursuing nuclear power as an alternative supply of electricity. However, concerns about the transfer of sensitive technologies and profit sharing have resulted in negotiations with foreign suppliers being quite lengthy (Leventhal 1996; Rosen and Houser 2007). Furthermore, the Chinese government is mindful that nuclear reactors are a potentially attractive target for terrorist attacks and that radioactive waste disposal incurs considerable environmental risk. For these reasons, China's expanding nuclear capability has failed to keep pace with electricity demand, and even if the ambitious plan of bringing one new nuclear power plant online each year is realized, nuclear power will only contribute between 2.5 and 4.5 percent of China's electricity by 2020 (Energy Information Administration 2006).

Given the expense and the environmental and political implications of producing electricity from fossil fuels, natural gas, and nuclear power, hydropower provides an appealing alternative supply of electricity to meet China's growing demand. Furthermore, Pacca (2007) demonstrates that greenhouse gas emissions from hydropower (measured between 35 and 380 grams of CO_2 equivalent per kilowatt hour) are considerably below those for either natural gas (454g of CO_2 eq./kWh) and coal (890g of CO_2 eq./kWh). Indeed, Balat (2007) argues that large hydroelectric power plants and nuclear power plants are the only proven alternatives to coal, oil, and natural gas from an environmental sustainability perspective.

However, while nuclear power depends critically on imported technologies, China is fast becoming a producer of leading-edge technologies for generating electricity through hydropower. For example, hydroelectric capacity in the Three Gorges Dam is being installed in three phases: the first set of 14 turbines installed on the north side of the dam include just two that were produced domestically, while eight of the 12 generators now being installed on the south side of the dam are domestic; of the remaining six underground turbines, all are likely to be domestically produced (Peng 2007). In addition, domestically-produced turbines are slated for installation in new hydropower plants along the Yangtze River and the Jinsha River (Yi 2005), suggesting that China's technological capacity in hydroelectric generation is growing rapidly. China is also a leading producer of technologies for efficient electricity transmission over long distances. In October 2007, China became the world leader in high-voltage direct current (DC) electricity transmission, with a total cable distance of 7,085 kilometers and total capacity of 18.36 million kilowatts (Jiang and Li 2007). Relative to alternating current (AC) cables, these DC cables reduce line losses over long-distance transmissions and eliminate the need for substations that periodically compensate for line losses by boosting the line voltage (Jiang and Li 2007). Moreover, they are more flexible and comparatively inexpensive to produce. These technologies make supplying China's eastern seaboard with power generated from central and western China's rivers economically feasible.

To be sure, large-scale hydropower does present certain risks and disadvantages, and many have questioned the merits of mega-dams in China and elsewhere around the world (e.g., Goldsmith and Hildyard 1986; McCully 2001; Scudder 2005). The World Commission on Dams (2003) report noted that few large dams have lived up to their promised potential in terms of power or revenue generation. Clearly, large dams with immense reservoirs present particularly serious risks in the event of failure, especially given the relatively high population density of some downstream areas, as well as the high level of tectonic activity in southwestern China.[3] And whereas hydropower is often touted as a clean, carbon-free energy sources, this position overlooks the emissions resulting from construction of the dam and related infrastructure. Moreover, World Commission on Dams (2003) and others have shown that rotting vegetation submerged when large reservoirs fill release significant quantities of methane into the atmosphere, which is some 20 times more effective as a greenhouse gas than carbon dioxide.

Another concern with all dams, and particularly those located in steep terrain with heavy deforestation and severe rains like western Yunnan, is siltation. Silt, normally suspended and transported downstream by moving water, settles out in the still waters of reservoirs. This process gradually raises the bed of the reservoir, thereby reducing water storage capacity and, consequently, the dam's ability to generate power and provide flood control. Given the

[3] That said, there have been no catastrophic failures of any of the hundreds of large dams within reach of the shocks from the massive earthquake that struck Sichuan in May 2008, and engineers have long studied the best ways to build earthquake-resistant dams.

mountainous terrain of Yunnan, steep-slope farming is the only option for farmers in many of the nearby villages, but those planted fields can easily wash into the gorge during the summer monsoons. Indeed, concerns about siltation upstream of the Three Gorges Dam has prompted the construction of dozens of smaller dams on the main stem of the Yangtze as well as many of its tributaries, each capable of trapping a portion of the sediment otherwise destined for the Three Gorges Dam. Although new gate technologies enable dams subject to siltation problems to flush sediment from the bottom of the reservoir, it is unclear at the time of writing whether or not the Nu dams will employ such technologies.

III. Hydroelectric power development in China

China has the greatest hydropower potential of any country on Earth, with an estimated total capacity of approximately 380,000 megawatts (MW) (Cheng 1999; National Bureau of Statistics 2006). In 1989, the government identified 12 large hydropower bases[4] with a total exploitable potential of 214,726 MW (China Electricity Council 2008) and announced plans to develop them concurrently. Headway in exploiting this potential has already been made, with over 20,000 large dams[5] (nearly half the world's total), up from a few dozen in 1949 (Magee 2006a). For example, the Three Gorges Dam on the Yangtze will have a total installed capacity of 18,200 MW while a series of dams slated for construction upstream on the Jinsha River will have a total capacity of 38,500 MW. For perspective, the second-largest dam in the world is the Itaipu dam on the Brazil/Paraguay border, with a total capacity of 14,000 MW. The Grand Coulee with 6,809 MW of generating capacity is the largest dam in the U.S., and the entire Columbia River

[4] We use the term "base" (*jidi*) in keeping with the Chinese usage. Although some of the "bases" identified in the nationwide hydropower survey are contiguous with "basins" (watersheds, or *liuyu*), this is not necessarily the case. For the purposes of this paper, "basin" refers to the watershed or drainage basin of a particular river.

[5] The International Commission on Large Dams (1994) defines dams exceeding 15 meters in height as "large."

basin has a total installed capacity of 24,140 MW. Hydropower development in China is thus quite advanced, providing approximately 16% of China's total electricity supply (Rosen and Houser 2007), making it the second largest source of electricity behind coal.

Figure 3 depicts the total capacity for each of the 12 large hydropower bases identified in 1989 and Table 3 shows the status of each of the high-capacity dams (which we define a having at least 1,000 MW of generating power) planned for these river systems. The Jinsha River has a potential generating capacity of 47,890 MW (Figure 3), including the Xiluodu dam and Baihetan dam, China's second and third largest at 12,600 MW and 12,000 MW, respectively (Table 1). The construction of this dam began in 2005, and eight others will follow in what will become a nine-dam cascade. The Three Gorges Dam is the most significant component in the Upper Yangtze River's 25,425 MW of hydropower, although four other high-capacity dams are slated for completion before 2020. The Dadu River Basin has the third-highest exploitable potential at 23,480 MW, including seven high-capacity dams. The Lancang River (Upper Mekong) basin has 22,590 MW of potential, including five high-capacity dams, two of which have been completed and three of which are under construction. Hydropower development on the Upper Yellow is already advanced, with three of the seven high-capacity dams completed and two others nearing completion; all told, 25 dams will be built to exploit 18,200 MW of potential. The Yalong River includes five high-capacity dams as part of 18,000 MW of exploitable potential, one of which is already operational. The 16,800 MW of exploitable potential in the Min Zhe Gan hydropower base spans Fujian, Zhejiang, and Jiangxi provinces. While one high-capacity dam will be built in Fujian, the remaining 21 dams in this system are well below 1,000 MW. The Nanpan River and Hongshui River hydropower base has a total potential capacity of 12,520 MW, including five high-capacity dams, two of which are already completed. The Northeastern watershed includes

11,316 MW of exploitable potential on five rivers, but none of the 120 planned or completed dams exceeds 1,000 MW. Finally, the Xiang system, Middle Yellow River, and Wu River have 18,505 MW of exploitable potential and six high-capacity dams either planned or completed among them.

The Nu River as 13th Hydropower Base

In addition to the 12 hydropower bases identified in 1989, the Nu River was identified for potential dam development by the Yunnan Huadian Nujiang Hydropower Development Company (hereafter, Huadian) in the 1990s, and were submitted in the "Middle and Lower Nu River Hydropower Planning Report" in June 2003 (Magee 2006b).[6] Like the Lancang, the Nu begins in the Qinghai-Tibet plateau and flows south; the Yunnan stretch of the river extends 618 kilometers and drops 1,578 meters in elevation before flowing into Myanmar.[7] The estimated theoretical hydropower potential of the river within China is 36,400 MW, of which 21,000 MW are considered to be exploitable via a cascade of 13 dams stretching from Zayu County in Tibet to Longling County near the Yunnan/Myanmar border (Figure 4).

If built, the dam at Songta will be the largest in the cascade (Table 2). Located in Zayu County of the Tibetan Autonomous Region, Songta will have a height of 307 meters and an installed capacity of 4,200 MW. The project is expected to cost 19.7 billion RMB. A field visit by one of the authors in 2005 indicated that geological substrata surveying was already underway despite the official suspension of construction. The Bingzhongluo dam is located just south of Songta in Gongshan County, Yunnan. With a height of 54.5 meters and an installed capacity of

[6] In 1989, the Nu was considered too remote to be developed for hydropower. However, development on the nearby Lancang and Jinsha Rivers subsequent to 1989 and improvements in power transmission technologies may have facilitated interest in developing the Nu River basin as well.
[7] In Myanmar and elsewhere outside of China, the Nu River is more widely known as the Salween River.

1,600 MW, Bingzhongluo will cost 5.2 billion RMB to build. Four dams are planned for Fugong County, including Maji, Lumadeng, Fugong, and Bijiang. The Maji dam will be the second-largest in the cascade at 300 meters and an installed capacity of 4,200 MW. It will cost 18.5 billion RMB, and site work was evident during field visits to the area in 2005. The 165-meter Lumadeng dam will have an installed capacity of 2,000 MW and will cost 9.1 billion RMB to build. The Fugong dam will be 60 meters tall and will have a capacity of 400 MW. The dam will cost 2.3 billion RMB to complete. The last dam in Fugong County is Bijiang, which has an installed capacity of 1,500 MW, a height of 71.4 meters, and an estimated cost of 5.9 billion RMB. Traveling down the Nu River, the first dam in Lushui County is Yabiluo. This dam will be 133 meters tall when completed and will have an installed capacity of 1,800 MW at a cost of 6 billion RMB. Site work on the Yabiluo had begun by 2005. Next in Lushui County is the Lushui dam, which will have an installed capacity of 2,400 MW and a height of 175 meters. The total estimated cost of this dam is 8.8 billion RMB. The Liuku dam is the smallest in the cascade, with an installed capacity of 180 MW, a height of 35.5 meters, with an expected cost of 0.9 billion RMB. According to Wang (2008), construction of the Liuku dam began in earnest before early 2008. The final dam in Lushui County is Shitouzhai, with a height of 59 meters, a capacity of 440 MW, and an estimated cost of 2.3 billion RMB. In Longyang District further down the Nu, the Saige dam will be 79 meters tall and will have an installed capacity of 1,000 MW. This project will cost 3.6 billion RMB, and site work was evident during field visits in 2005. The Yansangshu dam located in Longling County will have a capacity of 1,000 MW and will be 84 meters high. The cost of building this dam is estimated to be 4.4 billion RMB. The last dam in the Nu cascade is Guangpo, also in Longling County. Guangpo will be 58 meters tall, will have an installed capacity of 600 MW, and will cost 2.9 billion RMB to build. If built, all 13 dams in the cascade are expected to be completed by 2030.

Although proponents of the dams argue that hydropower would bring modernization and poverty alleviation to some of China's poorest areas, the project has come under fire over concerns about the impacts of dam development on the environment, on local cultures, and on transboundary waters. Specifically, nine of the 13 dams will be located in the Nujiang Lisu Autonomous Prefecture, which became part of the UNESCO World Heritage Site "Three Parallel Rivers of Yunnan Protected Areas" in July 2003. The area displays the geological history of the last 50 millions year through its diverse geographical features including high mountains and glaciers (UNESCO World Heritage Site List 2008). In addition, this part of Yunnan is an epicenter of biodiversity in China, and indeed the world, such that Conservation International has named it a Biodiversity Hotspot to draw attention to the region's 3,500 plant species and eight endangered animal species. Importantly, just 8% of the hotspot vegetation remains (Conservation International 2008). Even hydropower officials admit that the Nu River is one of the few remaining "undeveloped" and "virgin" rivers in China (Magee 2006a).

The Nu River region is home to 22 distinct ethnic groups, many of whom maintain their own languages, cultural traditions, and religious practices. Ethnic minorities comprise more than 92% of the overall population in Nujiang Lisu Autonomous Prefecture, nearly ten times the national average. Some of these ethnic groups are quite small, including the Derung with a total population of 7,426 in the 2000 Census, the Nu with a total population of 28,759, and the Pumi with a total population of 33,600 (National Bureau of Statistics 2000). Resettlement may be particularly hard on members of these small ethnic groups as they face resettlement into lands they have not traditionally occupied and integration into populations with different languages, customs and agricultural traditions.

Finally, dam construction would also have serious implications for downstream populations in Myanmar, many of whom depend on the river for irrigation and drinking water. Indeed, according to China's former Minister of Water Resources Wang Shucheng, construction of even one of these dams is likely to have significant implications for "downstream national interests" (Haggart 2006), referring to the proposed Nu cascade as a case of "predatory development" ("Yuan Nujiang Dianzhan Jihua" 2006)

After plans to develop the first dam at Liuku were announced by Huadian, the National Environmental Protection Bureau held a closed-door meeting with ecologists, botanists, zoologists, geologists, anthropologists, agricultural scientists, and other experts, all of whom opposed dam construction on the grounds that would threaten biodiversity and would exacerbate strained relationship between the central government and Yunnan's minority populations (Litzinger 2004). In April 2004, Premier Wen Jiabao officially suspended dam construction pending further analysis of the dam project by the scientific community (Litzinger 2004). No timeline for a final decision has yet been established, although field visits by one of the authors in 2005 indicated that geological substrata surveying was under way on five sites, and Wang (2008) reports that dam construction has begun on one of these sites.

IV. Socioeconomic vulnerabilities associated with dam development

Between 1949 and 1999, the development of some 85,000 reservoirs in China displaced 12 million people (World Commission on Dams 2000), an average of 240,000 per year. Millions more will be displaced with the completion of the Three Gorges Dam in 2009 and other large hydroelectric projects in the years that follow. Cernea (1997) reports that the social and economic effects of displacement include landlessness, joblessness, homelessness, food insecurity, community disarticulation, increased morbidity, loss of community resources, and depression among the displaced residents. In population-dense countries such as China, other important consequences of new dam construction may include the loss of cultural heritage sites.[8]

Prior to the mid-1980s, resettlement in China was conceived of as being a single event focusing on compensation. In the absence of generating buy-in from relocatees *ex-ante* mobilization and providing opportunities for economic development *ex-post*, resettlement often led to lower socioeconomic conditions (Dai 1989; Chau 1995).[9] With the encouragement of the World Bank, however, the resettlement paradigm shifted to a longer-term process coupling compensation with "mobilization" and economic development in the mid-1980s (Webber and McDonald 2004), and most commentators concur that socioeconomic vulnerabilities in the face of involuntary resettlement are greatly reduced (World Bank 1994). Nevertheless, the social and economic consequences of large dam development remain substantial,[10] and to illustrate this point explicitly, we briefly review evidence from the Three Gorges Dam.

The Three Gorges Dam

The Three Gorges Dam had been in conception for 75 years before groundbreaking in 1993.[11] When completed in 2009, the dam will be the biggest hydropower station in the world, with a total capacity of 18,200 MW (Yao 2006). Initial estimates of the population facing resettlement

[8] A further potential outcome is reduced incentives to invest in land based on expectations about land tenure, but we are not aware of any empirical demonstrations of this effect. This issue remains an important issue for further analysis.

[9] Indeed, Chen (1991) finds that people resettled from the Sanmenxia dam in 1957-1961 lived in relative poverty three decades later.

[10] To wit, some Chinese universities now offer diplomas in resettlement studies.

[11] The development of the Three Gorges Dam was first conceived by Sun Yet-sen following World War I, and serious planning began under the Nationalist government in the 1930s. The Sino-Japanese War and the Chinese Civil War halted development efforts until the 1950s, when Mao Zedong brought the Three Gorges Dam back to the national agenda. By 1958, however, the Great Famine had again disrupted the planning process, and progress on the dam did not resume until People's Political Consultative Conference took up the issue in 1985. In 1989, the China National People's Congress voted in favor of construction by the thinnest majority in the Communist Party's history.

topped 1.1 million, but these estimates have been revised upward multiple times. For example, in November 2007, it was announced that an additional 4 million people face will face resettlement to Chongqing or elsewhere by 2020 (Oster 2007).

Rural people resettled in urban communities have been provided with modern housing and improved access to education and medical services. Still, many of the vulnerabilities identified by Cernea (1997) will likely prove challenging for the large displaced population. For example, nearly 34,000 hectares of farmland have been flooded, and the government has banned clearing land or terracing on hills with slopes exceeding 25^{o} to prevent landslides around the reservoir. As a result, at least 40% of the displaced people will be resettled into urban areas (Jackson and Sleigh 2000) where they face mortgage payments (Jen 2004). Because average education in rural areas is well below that in urban areas (Brown and Park 2002), resettled people will face a distinct disadvantage in competing for employment. Moreover, the job tenure of resettled populations is often short: evidence from Yichang county shows that 60% of the first migrant workers from the dam area had been laid-off within one year (Li 2000). Meanwhile, farmers who are provided with new land to farm are likely to see reductions in income because the most fertile land in the area has been inundated. As a result, incomes of resettled peoples may fall, regardless of where they are resettled.

Food insecurity is a further concern among farmers who have been resettled. Losses of 28,000 hectares of rice fields (Jackson and Sleigh 2000) imply an annual grain shortage of 120,000 tons each year (China Yangtze Three Gorges Project Development Corporation 1994). Moreover, although many farmers have been encouraged to cultivate citrus and tea, it will likely take time for rice farmers to develop expertise in these crops (Ponseti and Pujol 2006).

Concerns about community disarticulation are especially pronounced because many rural

Chinese closely identify with a village clan (*shi*), and given that over 1,300 villages, 140 towns, and 13 cities will be inundated (Dai 1989), it has proven impossible to resettle whole communities intact (Lovell 2005). Moreover, resettlement often causes resentment in host communities because the resettled people are allocated land that once belonged to locals and because resettlement puts upward pressure on social services (Qiu, Wu, and Du 2000). In addition, displaced peoples often benefit from tax holidays and living subsidies, causing resentment among host populations (Hegelund 2006). Indeed, Li, Waley, and Rees (2001) find that one-third of people in host communities resented the resettled populations.

In terms of health outcomes, both schistosomiasis and malaria are likely to see a resurgence as the rapidly-flowing Yangtze becomes a stagnant reservoir (Zwinger 1997). Few health programs have been established to address these potential problems, and many have voiced concerns that few resources will be available to address health threats after completion of the project (Salazar 2000). Higher rates of clinical depression and suicide will likely also accompany dam construction as farmers are moved off the land (Sleigh 2006).

Finally, at least 1,282 cultural sites, including ancient cities, ancestral temples, graves, and prehistoric sites have been inundated (Ponseti and Pujol 2006). For example, the 3000-year-old hanging coffins in the Shen Na Gorge have largely been submerged, and many of the vistas made famous in Li Bai’s poetry are unlikely to ever be seen again. The cultural loss is thus considerable, if immeasurable.

V. Damming the Nu River

Poverty and vulnerability in western Yunnan

After entering northwestern Yunnan Province from the Tibetan Autonomous Prefecture, the Nu

River flows through a steep gorge that transects three counties in Nujiang Lisu Autonomous Prefecture. Slopes are precipitous and farming is extremely difficult along the river banks. Nevertheless, well over 90% of the workforce in Gongshan, Fugong, and Lushui Counties is engaged in agriculture for its livelihood (Table 3). The Grain-for-Green Campaign (*tuigeng huanlin*), an integral part of the ecological construction provision of the 10th and 11th Five Year Plans that is designed to increase afforestation, provides incentives to local leaders to plant trees and native grasses on steep slopes in order to reduce topsoil losses; the unintended consequence of this policy has been to increase pressure on farmers, many of whom farm on slopes for lack of alternatives. Dependence on agriculture is facilitated by the dearth of non-farm opportunities: in 2005, these three counties supported a total of 521 enterprises, only three of which were either state-owned or had revenues above 5 million RMB. As a result, the 2005 per-capita net income in this area ranges from just 750 RMB in Fugong County to 1,282 RMB in Lushui County. By comparison, the per-capita net income of Yunnan Province is 2,042 RMB and that for China as a whole is 6,367 RMB. Per capita GDP and per capita savings follow similar patterns, and roughly one-third of the population lived in shelters made of straw and sticks in 2004 (Duan 2004). All three counties rely heavily on government subsidies; for example, the expenditure/revenue ratio in Fugong County is 16.7. Finally, the share of ethnic minorities in each county ranges from 87% in Lushui County to 99% in Fugong County.

The Nu River then flows into Baoshan Prefecture, where the terrain flattens considerably. The share of the workforce engaged in agriculture in Longyang District is close to the figure for Yunnan Province as a whole, while nine in ten laborers in Longling County work in agriculture. Still, Longyang District and Longling County support 3,227 enterprises between them, 43 of which are either state-owned or have revenue above 5 million RMB. Per capita net income, GDP, and savings are thus considerably higher than those in the Nujiang Lisu Autonomous Prefecture, although they are still only about one-third of the national average. Residents of Baoshan Prefecture also depend on government subsidies, although the expenditure/revenue ratio is much lower than in Nujiang Lisu Autonomous Prefecture. Finally, the share of ethnic minorities in Longyang District and Longling County is well below the provincial average.

Microdata evidence from the Nu River Valley

As shown in the previous section, the areas through which the Nu River flows are poorer, more agricultural, more dependent on government subsidies, and more ethnically fragmented than many other areas affected by dam construction. By contrast, the incomes and livelihoods of people affected by the Three Gorges Dam are broadly reflective of China as a whole, and the vast majority of the displaced people are ethnically Han. Given the reductions in income and productivity, material well-being, social capacity, and health and the loss of sites of cultural significance resulting from the Three Gorges Dam, vulnerabilities may be even more acute in the Nu River area.

Unfortunately, no formal social surveys of these populations have been undertaken, so it is difficult to evaluate the likely impact of the 13 dams on the Nu River. However, a group of journalists from the Beijing-based NGO Green Home conducted a number of interviews in the Nu River region in 2006 with the purpose of better understanding the dam projects, the environmental impacts, the economic costs and benefits of dam construction, and the concerns of the local residents regarding the Nu River cascade. The transcripts of 94 of these interviews were provided for the purposes of this research; among the interviewees, 64% were male, 53% were ethnic Lisu, and 76% had six or fewer years of education (including 34% who had never attended school). Although the sample is small and the interviews were non-scientific, these interviews nevertheless provide suggestive evidence of the consultation and relocation processes.

More than three-fourths of the interviewees had heard about the possible relocation of their villages if the hydroelectric power plants were to be built (Table 4). However, only 16% had learned about the possible relocation by official government sources, and only a handful of these had been told where they would be resettled. Only one interviewee reported that the government had discussed the environmental impact assessment process with him, suggesting that local governments are not publicizing the process or consulting with affected peoples. These findings demonstrate a lack of transparency on part of the government, which may contribute to uncertainty and mistrust of the resettlement process.

Nearly nine in ten interviewees who were asked reported that their property had been measured by the government, although many of these were not told why their property was being measured. Moreover, only 9% considered the measurement methods to be fair, while many others complained that the government refused to count terraced fields or outbuildings such as sheds, barns, and toilets. These findings suggest that displaced people are unlikely to be satisfied with the compensation offered by the government should relocation occur.

The interviews also revealed considerable mistrust of the government stemming from past experience. For example, 93% of interviewees reported having had land confiscated by the government for the development of public infrastructure, but only 46% reported being offered any form of compensation. Among this latter group, only 50% believed that the compensation was fair. Such mistrust has contributed to widespread concern among the locals regarding the likely resettlement process, with 77% of interviewees reporting being concerned about their lives if they were to be resettled. Moreover, while 80% of interviewees expressed a willingness to be relocated conditional on receiving fair compensation, only 11% of the total was willing to be relocated outside of their home villages.

Overall, attitudes of interviewees toward possible dam construction were negative. Only 43% supported damming the Nu River in general while just one-third believed the dams would benefit their villages economically. Moreover, a significant share of interviewees reported that they felt pressure from the government to agree to resettlement should the dams be built.

VI. Conclusion

China's consumption of electricity is rising concurrently with its wealth, fueled not only by a growing industrial sector but also by rising consumer demand. Shanghai's real per capita GDP has already surpassed that of 1960s Japan, and incomes in Beijing, Tianjin, and other provinces and municipalities are also rising quickly. Although China enjoys both a large supply of coal and expertise in converting coal into electricity, the government has recognized the problem of CO_2 emissions associated with coal burning and has moved to identify environmentally sustainable alternatives to coal-fired power plants. Hydropower is central to this strategy, and China already derives more of its electricity from hydropower than either the US or Europe as a whole.

With a total exploitable capacity of some 380,000 MW, China is currently in the process of fulfilling a plan to develop dams in on rivers in 12 hydropower bases around the country . If fully developed, these dams would be sufficient to meet approximately 45% of China's current electricity demand, although only 11 of the 50 high-capacity dams proposed in 1989 have been completed to date. In 2003, the Nu River was publicly identified as another hydropower resource with some 21,000 MW of exploitable capacity, and moves to develop this basin were formally initiated soon thereafter. Although Premier Wen officially halted the Nu River dam project in 2004, site work on at least five dams was evident in 2005, and recent reports indicate that construction of the Liuku dam, including resettlement villages for residents displaced from around the dam site, is already underway.

Unfortunately, the environmental and ecological consequences of large dams are significant, and the history of dam development in China has demonstrated that the socioeconomic consequences of displacement may also be severe. For example, emerging evidence from the Three Gorges Dam indicates that displaced populations are vulnerable to landlessness, joblessness, homelessness, food insecurity, community disarticulation, increased morbidity, loss of community resources, and depression among displaced residents. Moreover, as recent reports of landslides around the Three Gorges reservoir show, sites in which displaced residents are resettled can be subject to their own sets of pressures and socio-natural disasters. In addition, some 1,300 places of cultural significance have been lost to the rising waters of the Yangtze.

The losses attributable to Three Gorges Dam occurred in central China's Hubei Province, where incomes, savings, education levels, farming intensity, and off-farm opportunities are broadly reflective of China as a whole. In western Yunnan Province, by contrast, the people who would be most seriously affected by dam development are less wealthy and less educated than the national average. With few off-farm activities, they are also more dependent on farming and government subsidies for their livelihoods. Political and social marginality in western Yunnan is further compounded by the fact that the vast majority of residents in Nujiang Lisu Autonomous Prefecture belong to ethnic minority groups, many of which are very small. Not surprisingly, these groups frequently lack reliable access both to information regarding alternative development models and to the decision processes through large hydraulic infrastructure projects are legitimized.

People in the Nu River area may thus be especially vulnerable to the negative consequences of dam construction, so it is especially important for the associated dam development processes to be transparent and, to the greatest extent possible, consultative. Unfortunately, evidence from interviews conducted in 2006 indicates that decisions about the Nu River dams have been neither. For example, only 16% of interviewees had been told of possible relocation by official government sources, and only one interviewee was aware that the government was responsible for undertaking an environmental impact assessment prior to dam construction. Similarly, while most of the interviewees reported having had their land measured, only 9% considered the measurement to be accurate, and fewer than one-quarter who had had land confiscated in the past considered the compensation to be fair. As such, interviewees are mistrustful of the government: few support damming the Nu River, and fewer still are willing to be relocated to another village should the dams be constructed. In addition, the Nu River flows from Yunnan into Myanmar, where tens of thousands of people – many of whom are ethnic minorities already facing repression and socioeconomic difficulties under the military regime – depend on the river to provide water and nutrients to their fields.

Equally important, the Nu River area is environmentally sensitive. For example, many of the proposed dams are located in an area that has been declared a Conservation International Biodiversity Hotspot and a UNESCO World Heritage Site. While the area is in many places far from pristine – logging, steep-slope farming, and mining have all taken their toll – it is nevertheless an important repository of biological diversity in China and the world. Indeed, according to UNESCO (2008), northwest Yunnan has the greatest biodiversity in China and is among the most biologically diverse temperate regions on Earth. Finally, although there remains disagreement over whether or not the filling of the Three Gorges reservoir was a factor in the May 2008 earthquake in Sichuan's Wenquan County, reservoir-induced seismicity has been documented in China and elsewhere (Talwani 1997), and western Yunnan has a history of seismic activity.

Energy bureaucrats and power company representatives in China are quick to associate high levels of hydropower exploitation with economic development, and it would be presumptuous to suggest that China should restrict its economic development aspirations. It is our hope, however, that effort be expended to maximize end-use energy efficiency gains, while at the same time increasing the transparency and inclusiveness of decision-making processes regarding new energy projects. In particular, with a fragile economy and a diversity of threatened cultures and species along an ecologically sensitive trans-boundary river, a careful and determined social and environmental impact assessment should be undertaken prior to construction of the Nu hydropower projects. Making the results of such an assessment publicly available would help to alleviate concerns and to identify alternatives, although we recognize that Chinese government policy prevents the sharing of certain hydrological data on trans-boundary rivers due to national security consideration. In the meantime, China has already committed to constructing 39 additional high-capacity dams in the 12 hydropower bases marked for development in 1989, many of which are likely to have moderate effects on local populations. With approximately two-thirds of the hydroelectric potential from these 12 bases still unexploited, China's immediate energy policy does not depend on the Nu River.

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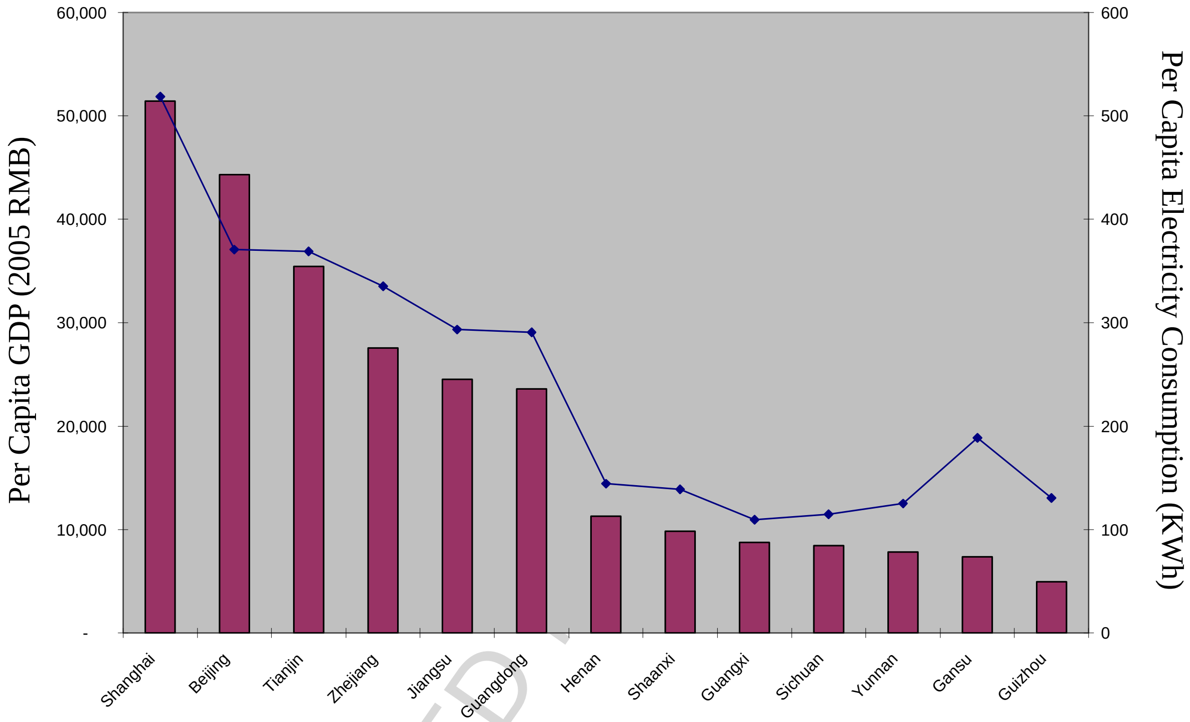
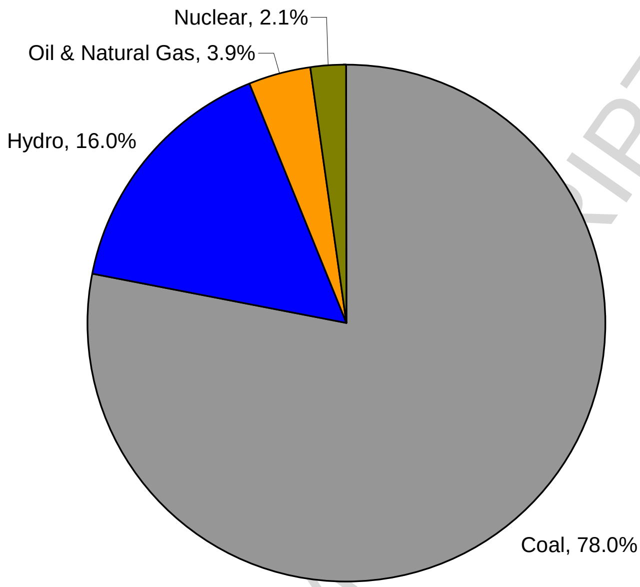
Figure 1. Per Capita GDP and Electricity Consumption by Province



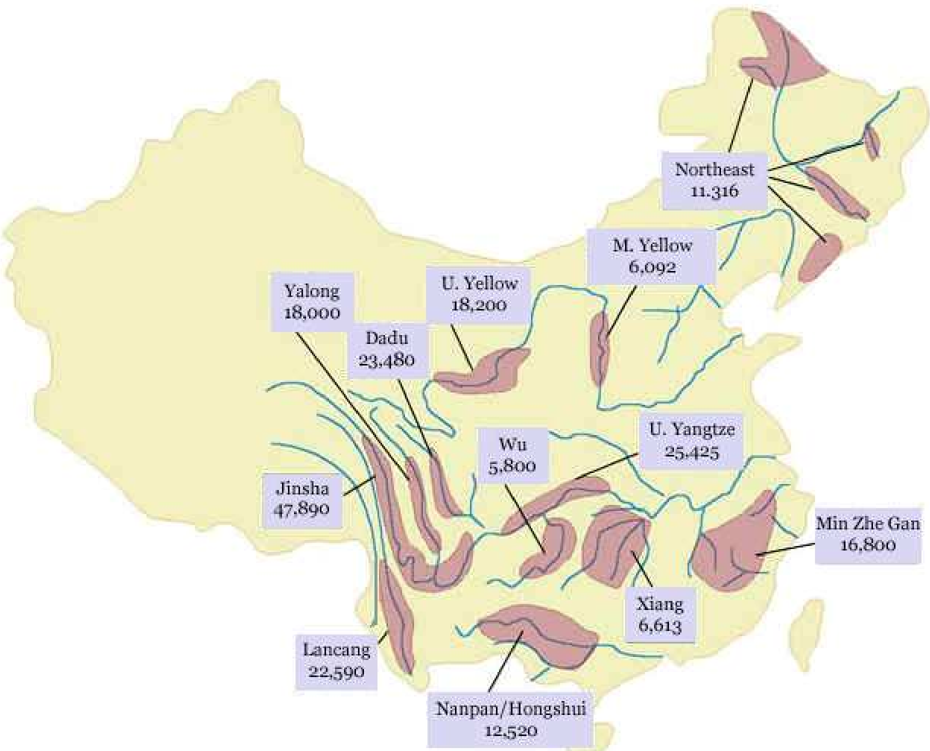
Source: National Bureau of Statistics (2007a)

Figure 2. Electricity Generation by Fuel Type



Source: Rosen and Houser (2007)

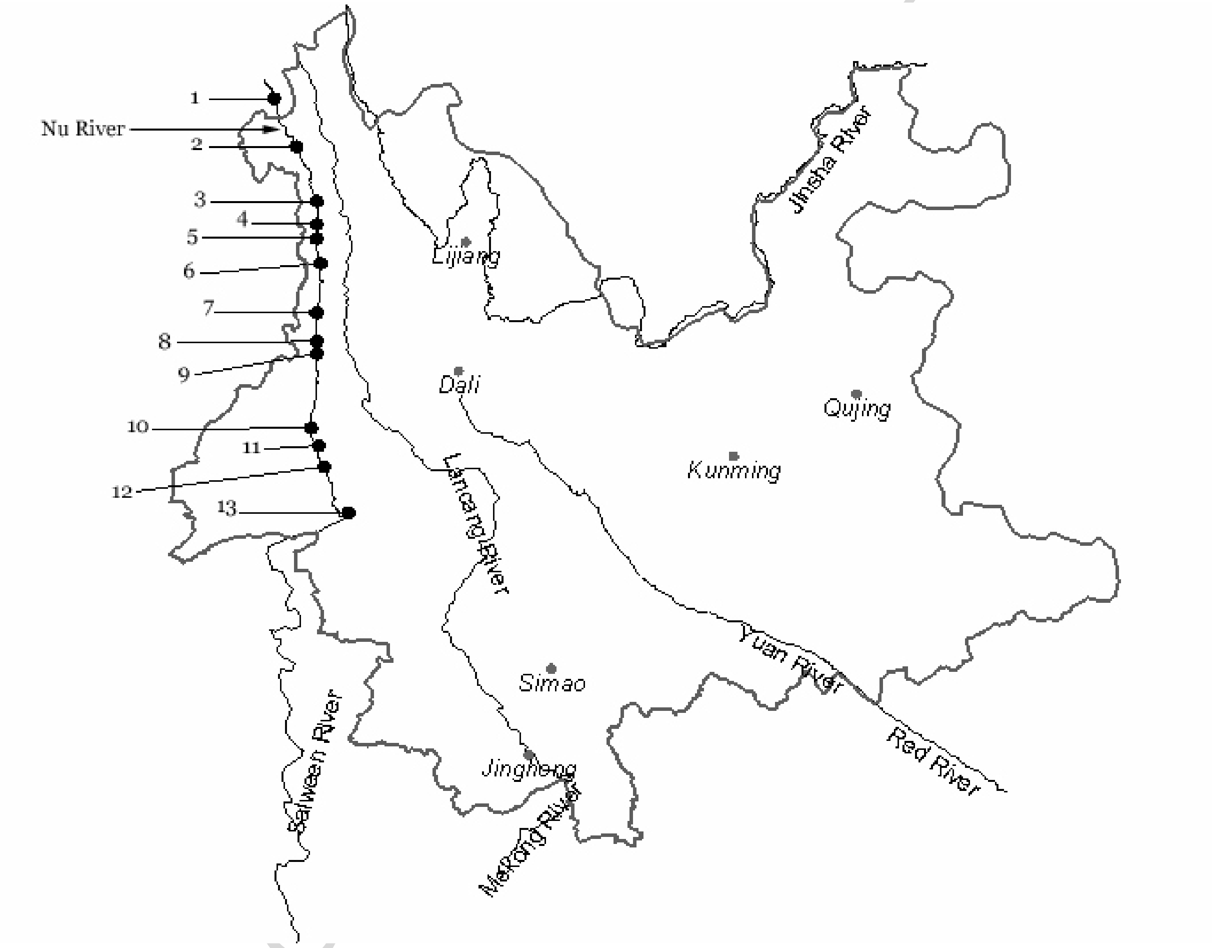
Figure 3. Twelve Hydropower Bases Identified for Development in 1989



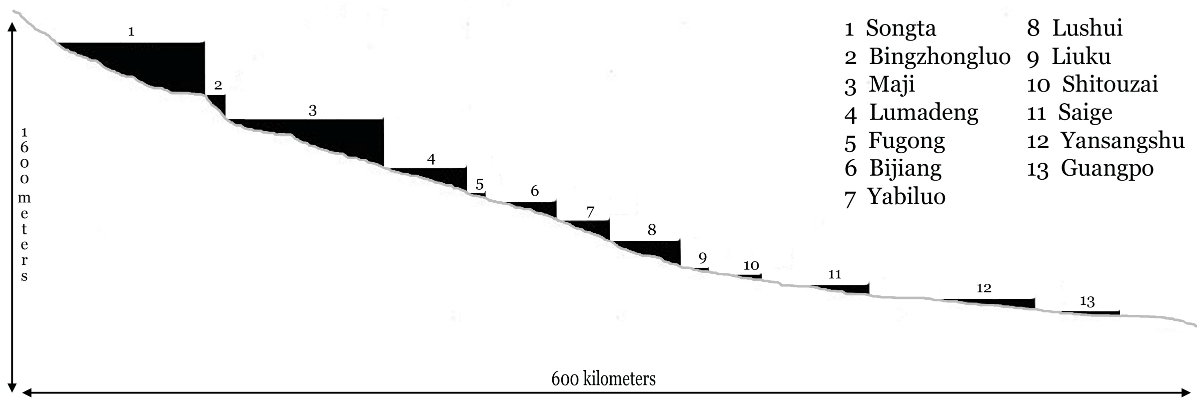
Sources: China Electricity Council (2008) and Yu (2008)
Note: Total exploitable capacity is shown for each basin.

Figure 4. Nu River Cascade

Panel A



Panel B



Source: Magee (2006b)

Table 1. Development of High-Capacity Dams in China's Twelve Hydropower Bases

Base	Dam	Capacity	Start Date	End Date
Jinsha River	Xiluodu [A, 9]	12,600 MW	2005	2015
	Baihetan [A, 10]	12,000 MW	2008 est.	2020 est.
	Wudongde [A]	7,900 MW	2006	Unknown
	Hutiaoxia [B, 11, 12]	6,000 MW	2004 est.	2015 est.
	Xiangjiaba [A, 13]	6,000 MW	2006	2015
	Hongmenkou [B]	5,000 MW	Unknown	Unknown
	Xinli [C]	2,500 MW	Unknown	Unknown
	Pichang [C]	2,500 MW	Unknown	Unknown
	Guanyinyan [C, 14]	2,500 MW	2008	2016
Upper Yangtze River	Three Gorges [B,15]	18,200 MW	1993	2009
	Zhuyangxi [D]	3,000 MW	2009	2016
	Gezhouba [B,16]	2,715 MW	1970	1988
	Shipeng [D]	2,130 MW	Unknown	2020
	Xiaonanhai [D]	1,000 MW	2007	2013
Dadu River	Pubugou [17]	3,300 MW	2004	2010
	Changheba [18]	2,600 MW	2005	2011
	Dagangshan [19]	2,400 MW	2006	2013
	Jijiahe [B]	1,800 MW	Unknown	Unknown
	Houziyan [20]	1,760 MW	2007 est.	2015 est.
	Dusong [B]	1,360 MW	Unknown	Unknown
	Yingliangbao [21]	1,300 MW	2011	2020
Lancang River	Nuozhadu [E]	5,850 MW	2005	2017
	Xiaowan [E]	4,200 MW	2002	2012
	Jinghong [E]	1,750 MW	2004	2009
	Manwan [22]	1,500 MW	1986	1995
	Dachaoshan [23]	1,350 MW	1997	2003
Upper Yellow River	Laxiwa [24]	4,200 MW	2004	2010
	Lijiaxia [25]	2,000 MW	1988	1999
	Daliushu High Dam [B]	1,740 MW	Unknown	Unknown
	Gongboxia [26]	1,500 MW	2001	2008
	Xiaoguanyin [B]	1,400 MW	Unknown	Unknown
	Longyangxia [27]	1,280 MW	1978	1992
	Liujiaxia [28]	1,225 MW	1958	1974
Yalong River	Jinping (II) [29]	4,800 MW	2007	2015
	Jinping (I) [30]	3,600 MW	2005	2014
	Ertan [B, 31]	3,300 MW	1990	2000
	Lianghekou [B]	2,000 MW	Unknown	Unknown
	Guandi [B]	1,400 MW	Unknown	Unknown
Min Zhe Gan	Shuikou [32]	1,400 MW	Unknown	Unknown
Nanpan River and Hongshui River	Longtan [33]	5,400 MW	2001	2009
	Tianshengqiao (II) [B]	1,320 MW	Unknown	Unknown
	Yantan [34]	1,210 MW	1985	1995
	Tianshengqiao (I) [35]	1,200 MW	1991	1998
	Datengxia [36]	1,200 MW	2009 est	2018 est
Northeast system	All dams < 1000 MW			
Xiang system	Wuqiangxi [37]	1,200 MW	1986	1996
Middle Yellow River	Longmen [B]	2,100 MW	Unknown	Unknown
	Qikou [B]	1,800 MW	Unknown	Unknown
	Wanjiazhai [38]	1,080 MW	1994	2000
Wu River	Goupitan [39]	3,000 MW	2003	2013
	Pengshui [40]	1,750 MW	2003	2008

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Notes:
“High-capacity” is defined as having at least 1,000 MW of generating capacity

Table 2. Size, Capacity, and Cost of Proposed Nu River Dams

Dam Name	County/District	Installed Capacity	Start Date	End Date	Dam Height	Cost, Billion RMB
Songta	Zayu County (Tibet)	4,200 MW	Site work: 2005	2020-2030 est.	307 m	19.7
Bingzhongluo	Gongshan County	1,600 MW	Unknown	2020-2030 est.	55 m	5.2
Maji	Fugong County	4,200 MW	Site work: 2005	2015-2020 est.	300 m	18.5
Lumadeng	Fugong County	2,000 MW	Unknown	2020-2030 est.	165 m	9.1
Fugong	Fugong County	400 MW	Unknown	2020-2030 est.	60 m	2.3
Bijiang	Fugong County	1,500 MW	Unknown	2015-2020 est.	71 m	5.9
Yabiluo	Lushui County	1,800 MW	Site work: 2005	2015-2020 est.	133 m	6.0
Lushui	Lushui County	2,400 MW	Unknown	2015-2020 est.	175 m	8.8
Liuku	Lushui County	180 MW	2008	2015-2020 est.	36 m	0.9
Shitouzai	Longyang District	440 MW	Unknown	2020-2030 est.	59 m	2.3
Saige	Longling County	1,000 MW	Site work: 2005	2015-2020 est.	79 m	3.6
Yansangshu	Longling County	1,000 MW	Unknown	2015-2020 est.	84 m	4.4
Guangpo	Longling County	600 MW	Unknown	2020-2030 est.	58 m	2.9

Sources: Magee (2006a, 2006b).

Table 3. Economic Description of Nu River Areas

	China	Yunnan Province	Gongshan County	Fugong County	Lushui County	Longyang District	Longling County
Per capita GDP (2005 RMB)	14,068	7,833	4,690	3,131	5,767	5,799	4,394
Per capita net income (2005 RMB)	6,367	2,042	754	750	1,282	2,121	1,750
Per capita savings (2005 RMB)	10,787	5,416	2,014	1,342	4,173	3,806	2,710
Expenditure / Revenue	107.21%	245.10%	929.84%	1673.21%	513.93%	269.64%	410.87%
Rural population	57.01%	70.50%	83.78%	91.40%	81.32%	85.86%	90.81%
Primary industry employment	44.80%	83.80%	89.10%	92.20%	92.26%	82.04%	90.31%
Minority population share	9.44%	33.87%	96.28%	98.79%	87.07%	13.50%	5.12%
Natural population growth rate	0.59%	0.80%	5.71%	1.09%	15.92%	2.69%	0.37%
Combined number of SOEs and non-state-owned enterprises			26	52	443	2,088	1,139
Combined number of SOEs and non-state-owned enterprises with revenue above 5 million RMB			0	0	3	36	7

Source: National Bureau of Statistics (2006) and Yunnan Bureau of Statistics (2006)

Table 4. Evidence from the Nu River Area

	Yes	No
I have learned about the construction of a hydro station	94%	6%
I have learned about the construction of a hydro station from government sources	17%	83%
I am in favor of damming the Nu River	43%	57%
I have learned about possible relocation or relocation of people to my village	79%	21%
If Yes, I have been informed by the government about possible relocation or relocation of people to my village	16%	84%
If Yes, I have been told by an government official as to where we will be relocated specifically	33%	67%
If Yes, The government has discussed the EIA with me	11%	89%
My property has been measured by the government	88%	12%
I think the measurement was a fair estimation of my property	22%	78%
Compensation has been discussed with me.	7%	93%
I'm willing to be relocated given proper compensation	80%	20%
I'm willing to be relocated to other parts of my village, but not outside of my village	55%	45%
I'm willing to be relocated anywhere, including other villages and counties	17%	83%
I'm worried about my life if I am relocated (or if other people moved to my village)	77%	23%
The dam will be economically beneficial for my village	33%	67%
My land has been seized by the government before for the construction of public infrastructure	93%	7%
Compensation was provided to me for previous confiscations	46%	54%
I think the compensation was fair	50%	50%
I receive subsidy from the government	64%	36%

Source: Green Home (2006)