Three Gorges Dam Project, Yangtze River, China

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Introduction

The Three Gorges Dam (TGD) and associated infrastructure is the largest integrated water project built in the history of the world. It has also been one of the most controversial due to its massive environmental, economic, and social impacts. The very first volume of *The World's Water*, published more than a decade ago, reviewed the plans underway at that time to build the Three Gorges Dam, along with many of the expected benefits and costs (Gleick 1998). A decade later, the physical dam itself has largely been completed, although work is continuing on electrical generating systems and a wide range of peripheral projects. This chapter offers an update on the project and a timeline of major events. It is crucial to note that while extensive information on the project is available from authorities and government officials, reliable independent information on environmental and social costs is harder to find (Dai 1994, 1998; Heggelund 2007). This update draws on official materials, as well as information available from non-governmental and non-Chinese sources, to get a clearer snapshot of the project's complex implications.

There are growing indications that very serious problems have started to develop. In the summer of 2007, major western media began to report on growing threats from landslides, pollution, and flooding, as well as growing social and political unrest and dissatisfaction associated with relocating millions of people (Oster 2007, Yardley 2007). Even officials in China have begun to be increasingly outspoken about unresolved challenges associated with the project. Weng Lida, secretary general of the Yangtze River Forum was quoted as saying "the problems are all more serious than we expected" (Oster 2007). In September 2007, Chinese officials "admitted the Three Gorges Dam project has caused an array of ecological ills, including more frequent landslides and pollution, and if preventive measures are not taken, there could be an environmental 'catastrophe' " (Xinhua 2007c). The complex and massive effort to relocate millions of displaced and affected people has also caused a range of social, political, and economic problems.

It is impossible to try to judge whether the TGD project will have net costs or benefits. All major water projects have complicated combinations of both costs and benefits that vary over a project's lifetime and are difficult to evaluate and quantify in a consistent, comparable way. As is typical with such large water projects, the benefits are typically far easier to identify and quantify than the costs, which often only manifest themselves over many years, in complex ways. Calculating actual costs and benefits accurately may never be possible because of the difficulty of putting monetary values on many of the complex environmental, social, and cultural impacts of the project (Tan and Yao 2006). Nevertheless, enough time has gone by, and enough information is available, to begin the process of evaluating the overall implications of the project.

The Project

The Three Gorges Dam stretches more than two kilometers across one of the greatest rivers in the world, the Yangtze. The dam was built in a stretch of the Yangtze known as Three Gorges because of the canyons formed by immense limestone cliffs. These gorges—the Xiling, Wu, and Qutang—offer some of the most scenic landscape anywhere in the world and have long been a destination spot for tourists from around the world. In recent years, tourism has boomed as people have rushed to see some of the sights to be destroyed by the dam and reservoir (China View 2008). The beauty of the region has inspired Chinese poets and artists for centuries including much of the work of Li Bai (701–762 AD), considered by many Chinese to be the world's greatest poet (Fearnside 1988).

The idea of building a gigantic dam on the Yangtze River in the Three Gorges area was proposed more than 80 years ago by Sun Yat-sen. After severe flooding along the river in the 1950s, Chairman Mao Tse Tung vowed to speed up construction of a massive dam but nothing significant happened for several more decades. In 1986, the Chinese Ministry of Water Resources and Electric Power asked the Canadian government to finance a feasibility study to be conducted by a consortium of Canadian firms. The consortium, known as CIPM Yangtze Joint Venture, included three private companies (Acres International, SNC, and Lavelin International), and two state-owned utilities (Hydro-Quebec International and British Columbia Hydro International). The World Bank was asked to supervise the feasibility study to ensure that it would "form the basis for securing assistance from international financial institutions" (Adams 1997). On April 3, 1992, the National People's Congress officially approved the construction of the project. On December 14, 1994, the Chinese government formally began construction. The first electricity was produced in 2003, and the physical dam was mostly completed in 2006.

The Three Gorges Dam is nearly 200 meters high, has a volume of 40 million cubic meters, and has created a reservoir 600-kilometer long with a total storage capacity approaching 40 billion cubic meters. Maximum storage of water behind the dam is expected to occur sometime in 2008. The 14 generators in the north side of the dam have already been installed and they reached full capacity (9,800 MWe) on October 18, 2006 after the water level in the reservoir had been raised to 156 meters. Installation of seven generators in the south side of the dam was completed by the end of 2007, bringing the total power capacity to 14,800 MWe, surpassing the generating capacity of the Itaipu Dam (14,000 MWe) in Brazil (Government of China 2006). At its completion, sometime after 2010, the project is expected to have a total installed hydroelectric capacity exceeding 22,000 MWe. This power capacity is higher than originally proposed because of an expansion initiated in 2002. In 2007, the turbines generated around 62 billion kWhr of electricity – about two-thirds of the maximum level expected by the completed project. Other benefits of the project claimed by project designers include flood protection on the historically dangerous Yangtze River and improvements to river navigation for thousands of kilometers.

Major Environmental, Economic, Social, and Political Issues

Economic, environmental, social, and political concerns have been raised about the TGD project, both before the project was launched and in recent years. One of the strongest and most consistent arguments made by project proponents has been that the electricity produced by the dam would otherwise be produced by dirty Chinese coal-burning power plants, with their serious environmental impacts. One of the strongest and most consistent arguments made by project opponents has been the vast scale of the environmental and social transformations of the watershed of the Yangtze both upstream and downstream of the dam itself. These major questions are addressed here.

Economic and Financial Costs

The total cost of the Three Gorges Dam and associated projects will be enormous, but it is no longer possible to produce any definitive quantitative estimate. Even the financial costs of the infrastructure alone cannot be known because of the magnitude of the expenditures, the related development projects in the region, and expenditures made unofficially. Estimates of the construction costs made during the mid-1990s for the major parts of the project ranged from a low of $25 billion to a high of $60 billion (Dai 1994, China 1996, JPN 1996, McCully 1996, Reuters 1997). The most recent estimates have fluctuated around the upper end of these figures. The TGD is being funded by a complex mix of both internal and external sources. China has identified four internal sources of funds: the State Three Gorges Construction Funds, power revenues from existing hydropower facilities, power revenues from the Three Gorges Project itself, and loans and credits from the Chinese State Development Bank (SDB), now renamed the Chinese Development Bank (CDB).

External sources of funding have been critical for the project. International organizations have tried to maintain a list of international financiers and companies supplying equipment and services to the project through the China Three Gorges Project Development Corporation, a state-owned entity set up to finance and build the project (see, especially, Probe International 2008). Canada's Export Development Corporation, Germany's export-import bank, and other international export credit agencies provided early loan guarantees for the project totaling hundreds of millions of dollars (Financial Times 1997). Commercial banks and investment firms have offered significant financing assistance. The SDB of China signed a loan package with Germany's Kreditanstalt Fur Wiederaufbau, Dresdner Bank, and DG Bank in 1997 for the purchase of turbines and generators. Hundreds of millions of dollars in SDB bonds were underwritten at the beginning of the project by a virtual who's who of the international financial community, including Lehman Brothers, Credit Suisse First Boston, Smith Barney Inc, J.P. Morgan & Co, Morgan Stanley & Co Incorporated, and BancAmerica Securities Inc. In 1997 and 1999, SDB issued more than a billion dollars of new bonds underwritten and managed by Merrill Lynch & Co. and Chase Manhattan Bank, with contributions from Chase Securities, J.P. Morgan, Morgan Stanley Dean Witter, Credit Suisse First

Boston and Goldman Sachs. Morgan Stanley continued to participate through a joint venture with the China International Capital Corporation (CICC), which is the lead advisor on raising overseas capital. In 2004, the CDB and the Chinese Export Import Bank (CEIB) hired Goldman Sachs, UBS, HSBC, Citigroup, and others to help raise another €1.5 billion from bonds (Carrell 2004, Probe International 2008).

Far more difficult to compute than the financial costs of building infrastructure are the non-traditional costs associated with social disruption, political corruption, massive relocation, ecological losses, and unquantified geological threats associated with landslides and earthquakes.

Environmental Impacts

Much of China's electricity is produced by thermal power plants burning one of the dirtiest fossil fuels – coal. The Chinese government estimates that if the electricity generated by the Three Gorges project were produced instead with Chinese coal, 50 million more tons of coal would be burned annually, producing 100 million tons of carbon dioxide, 1.2–2 million tons of sulfur dioxide, 10,000 tons of carbon monoxide, and large quantities of particulates (China 1996, Xinhua 2007a).

Government officials also point to efforts to remove polluting enterprises from the edge of the river or reservoir, and their construction of sewage treatment facilities to improve water quality in the Three Gorges reservoir region, although they note that eutrophic conditions and algal blooms continue to occur throughout the basin (People's Daily Online 2007). In addition, while massive funding has been committed to the dam itself, much of the proposed spending on pollution control has not yet occurred. Officials estimate that about 40 billion yuan will be spent to build at least 150 sewage treatment plants and 170 urban garbage disposal centers, but many of these are not yet complete (China Daily 2007a). The city of Chongqing alone still releases nearly one billion tons of untreated wastewater into the Three Gorges reservoir every year (Hodum 2007).

Fisheries Impacts

Ecological problems have been projected to occur as a result of the construction of the dam and modification of the watershed, including impacts on the fisheries of the Yangtze River basin. This basin has 36 percent of all freshwater fish species in China, with more than 360 fish species belonging to 29 families and 131 genera (Xie 2003). Twenty-seven percent of all of China's endangered freshwater fish are in the Yangtze basin, and there are as many as 177 endemic fish species (Yue and Chen 1998).

Major changes in fish populations have been anticipated because the project is altering the dynamics of the river, the chemical and temperature composition of the water, and the character of the natural habitat and food resources available for these fish species. The dam itself blocks migration of fish and access to spawning grounds, and these impacts will be imposed on top of other significant modifications to the Yangtze that have already caused declines in fisheries. In 1981, the Chinese completed the construction of the Gezhou Dam 40 kilometers downstream from the TGD site. That was followed by rapid and sharp declines in the populations of three of China's famous ancient fish species, the Chinese sturgeon, River sturgeon, and Chinese paddlefish, each of which is now listed as endangered (Xie 2003). Of special concern is the Chinese freshwater dolphin, which may already be extinct (Hance 2008). Fisheries in the upper watershed are also at risk. A study in 2003 identified six species at high risk of complete extinction, another 14 with an uncertain future, and two dozen more that may only survive in tributaries to the Yangtze (Park et al. 2003).

Fisheries are already beginning to show the effects of altered river ecology below the dam. Data released to a Three Gorges Dam monitoring program website indicate that commercial harvests of four species of carp are well below pre-dam levels (Xie et al. 2007). Annual harvest of these commercial fish below the dam from 2003 to 2005 was 50–70% below a 2002 pre-dam baseline and even more dramatic declines are being seen on larvae and eggs below the dam (see Table WB 3.1).

Han Qiwei, a member of the Chinese Academy of Sciences, has argued, correctly, that many of the ecological problems in the Yangtze predate the building of the dam (China Daily 2007a). But many of these problems have also been worsened, not improved by the project. Despite early calls from environmentalists, limited scientific investigations were done to prepare a baseline assessment of plant and animal communities threatened or destroyed by the Three Gorges Dam project. Only in late 2007 was a formal comprehensive assessment of plant communities initiated by the Chinese Academy of Sciences (Xinhua 2007d). Prior to this, research institutes from the region had conducted small-scale investigations, but no large-scale systematic search or collection was done. A small private botanical garden set up to support rare regional plants went bankrupt in June 2007 (Xinhua 2007d). Some gene and seed banks have been set up by the Chinese Academy of Sciences to maintain genetic stocks of plants that may end up going extinct in the wild (China Daily 2007b).

River Sediment Flow

The dam is also having a significant impact on sediment loads in the Yangtze. The Yangtze River has traditionally carried a vast load of sediment from its upper reaches of the watershed to the East China Sea, supporting ecological processes in the river delta and the productivity of fisheries in the Sea. This sediment load has varied with annual climatic factors, and more significantly, with the level of deforestation, and subsequent reforestation in the upper watershed. The completion of the Three Gorges Dam, however, has led to a rapid and significant decrease in downstream sediment load. Sediment volumes have been declining from the late 1990s due to reforestation efforts and the construction of many small- and intermediate-sized dams on Yangtze River tributaries. In 2003, the closure of the Three Gorges Dam caused a further severe decrease. Sediment load at Datong, near the Yangtze's delta dropped to only 33 percent of the 1950–1986 levels (Xu et al. 2006). Among the consequences of this drop in sediment are growing coastal erosion and a change in the ecological characteristics and productivity of the East China Sea (Xu et al. 2006). Based on estimates of the historical sediment budget and erosion data from the river's delta, scientists estimate that

Table WB 3.1 Annual Commercial Harvest (x1,000 metric tons) of Four Species of Carp (Silver, Bighead, Grass, Black) and Numbers (Millions) of Drift-sampled Carp Eggs and Larvae Below the Three Gorges Dam Before (1997 and 2002) and After the River Was Impounded (2003–2005)

Year	1997	2002	2003 (Dam Closure)	2004	2005
Commercial Harvest (1000 metric tons)	NA	3360	1350	1010	1680
Eggs and Larvae (millions)	250	190	40.6	33.9	10.5

Data from Xie et al. 2007.

the delta will be increasingly eroded during the first five decades after full operation and then approach a balance during the next five decades as sediments start to move through the TGD reservoir (Yang et al. 2006).

Flood Protection

A major anticipated benefit of the project is improved flood protection on the middle and lower reaches of the Yangtze River. Historically, people living along the Yangtze River have suffered tremendous losses from flooding. In 1931, 145,000 people drowned, and over 300,000 hectares of agricultural land flooded. In 1954, 30,000 more died in Yangtze floods or the subsequent diseases (Boyle 2007). In 1998, a flood in the same area caused billions of dollars of damage. More than two thousand square kilometers of farm land was flooded, and over 1,500 people were killed (CTGPC 2002).

The Chinese government has already claimed flood benefits to the dam. According to Li Yongan, the general manager of the Yangtze Three Gorges Project Development Office, the project averted floods in late July 2007 by storing waters that would have exceeded flood levels below the dam (People's Daily Online 2007), though the overall long-term flood-control benefits provided by the Three Gorges Dam are only likely to be determined over the next several decades as a wider range of high flows are experienced.

Shipping Benefits

The Yangtze River, China's "golden waterway," plays an important role in the economy of the upper river area. In that region, river navigation is almost the only means of long-distance, cost-effective transportation of freight. For Chongqing, the major port city in Sichuan province, 90 percent of goods are transported by water, and navigation on the upper Yangtze has been difficult in the past. The Three Gorges reservoir dramatically increases the depth of water and improves navigation up to Chongqing, more than 600 kilometers upstream of the dam.

Three Gorges has been built with one of the largest systems of ship locks in the world, permitting large quantities of cargo to move into the upper reaches of the Yangtze. In 2006, 50 million tons of cargo passed through the new lock system up to Chongqing, up from 18 million tons before the dam, and the 2007 estimate exceeds 50 million tons (Peoples Daily Online 2007).

Reservoir-Induced Seismicity and Geological Instability

Large reservoirs can cause seismic events as they fill and as the pressure on local faults increases (ICE 1981). Such reservoir-induced seismicity was predicted for the Three Gorges region, which is already seismically active and indeed, there has been an increase in reported seismic activity in the region following construction of the dam and the filling of the reservoir. Official statements minimize the importance of this, saying that "no unusual phenomena which could disrupt the stability of Three Gorges Dam have occurred" – a far cry from saying that there have been no significant damages to individuals, homes, or businesses (People's Daily Online 2007).

Related to the risk of increased seismic activity is the risk of increased landslides in the regions around Three Gorges with steep slopes. Landslide activity associated with the filling of the reservoir appears to be on the rise. Very soon after the closing of the dam and the filling of the reservoir, a major landslide occurred near the town of

Qianjiangping on the Qinggan River near its confluence with the Yangtze mainstream. Early on the morning of July 13, 2003, 24 million cubic meters of rock and earth slid into the Qinggan River, completely blocking its flow, capsizing 22 boats, and destroying four factories, 300 homes, and more than 67 hectares of farmland. Official reports say that 14 people were killed and 10 more were listed as missing (Wang et al. 2004). In 2007, thirty-one people died when a landslide on a tributary to the dam in Hubei province crushed a bus (Stratton 2007).

The risk of such disruptions appears to be far more severe than anticipated and is leading to new resettlement efforts as the danger zones around the margins of the reservoir expand. In the fall of 2007, officials and experts admitted the Three Gorges Dam project had caused more frequent landslides (Xinhua 2007b,c). Tan Qiwei, vice-mayor of Chongqing, told a forum in Wuhan that the shore of the reservoir had collapsed in 91 places and a total of 36 km of shoreline had caved in. In some cases, landslides around the reservoir had produced massive waves as high as 50 meters, causing even more damage along the reservoir's edge.

Relocation and Resettlement

Every large dam built in China has led to the resettlement of local people because of the high populations and the density of towns and villages along the major rivers. Even early in the debate over Three Gorges, the Chinese Academy of Sciences (1988, 1995) acknowledged that large-scale resettlement and inundation of population centers would be among the most devastating aspects of the project.

Initial estimates of the populations to be displaced varied from around one million to almost two million. Far more than a million people have already been resettled during the project's construction – official estimates typically say "at least 1.2 million" or "1.13 million" (Yardley 2007). Other estimates range from 1.3 million to almost 2 million (Dai 1998, Chao 2001, Tan and Yao 2006). More than 100 towns are ultimately to be submerged, including the major population centers of Fuling, Wanxian, and parts of Chongqing. Chongqing is the central municipality in the Three Gorges reservoir area and recently received approval to become a centrally administered municipality – only the fourth in the country after Beijing, Shanghai, and Tianjin. Fourteen thousand hectares of agricultural land will be submerged, as will more than 100 archeological sites, some dating back over 12,000 years. The cities of Wanxian and Fuling have cultural histories extending back more than 1,000 years.

In fact, it now appears possible that as many as *six million people* in total will have to be resettled because of the dam and surrounding impacts. In late 2007, a stunning announcement vastly increased the scale and scope of the relocation effort. Vice-Mayor Tan announced that "at least 4 million people from the Three Gorges Reservoir area are to be relocated to cities in the next 10 to 15 years" (Xinhua 2007b). As part of this newly announced massive relocation, more than 4 million people currently living in northeast and southwest Chongqing are to be resettled in the outskirts of Chongqing city in new settlements. Officials dispute that these new relocations are related to the dam, arguing instead that they are part of a national experiment in economic reform. Other reasons given for the resettlement include regional overpopulation, limited opportunities for industrial development, and growing ecological and geological problems along the reservoirs edge, including massive landslides (Xinhua 2007b).

Among a growing number of scholars, there is increasing concern that people displaced due to construction projects face long-term risks of becoming poorer and are also threatened with landlessness, food insecurity, joblessness, and social marginalization (World Commission on Dams 2000, Li et al. 2001, Heggelund 2004, 2006). Certainly, the early efforts at resettlement at Three Gorges led to a worsening of conditions for many of the already relatively poor rural communities in the region. There has been some unprecedented discussion of these problems in scientific and policy journals, as well as the news media in China.

A factor that contributed to some of the early challenges with TGD resettlement was local government corruption, which led to significant resettlement funds ending up in the pockets of government officials, rather than passing to the refugees (Chao 2001, Heggelund 2006). Poor local planning also left many relocated people with bad land, homelessness, loss of jobs and social status, and other social ills. To make matters even worse, the resettled populations often receive farmland taken from the population who already live in the resettlement areas, raising tensions and conflicts between the host population and the new migrants (Qiu et al. 2000, Heggelund 2007). Recent research also suggests that women displaced by the project are more severely affected than men. They are more likely to become impoverished and less likely to find new work in the new areas (Yan et al. 2005). Forced migration is also apparently linked to worsening depression (Hwang et al. 2007).

Other Issues

The long-term implications of the TGD will only be understood fully over the coming decades. But it is likely to have some unanticipated implications, beyond the significant effects already predicted or observed. Some of these are already beginning to appear: The magnitude of the dam and reservoir are so large that it is already playing a role in military planning and in affecting local climatic conditions.

In 2004, the U.S. Pentagon released their annual report to Congress on military issues related to China. In that report, the Pentagon reported that Taiwanese leaders were considering the concept of targeting the Three Gorges Dam militarily as a deterrent against Chinese military action against Taiwan. They wrote:

> "Taipei political and military leaders have recently suggested acquiring weapon systems capable of standoff strikes against the Chinese mainland as a cost-effective means of deterrence. Taiwan's Air Force already has a latent capability for airstrikes against China. Leaders have publicly cited the need for ballistic and land-attack cruise missiles. Since Taipei cannot match Beijing's ability to field offensive systems, proponents of strikes against the mainland apparently hope that merely presenting credible threats to China's urban population or high-value targets, such as the Three Gorges Dam, will deter Chinese military coercion." (U.S. Department of Defense 2004).

This comment was taken by mainland Chinese media and political leaders as a direct threat, or as an effort to encourage Taiwan military to develop such capability, and provoked an angry response (Hogg 2004).

While the Chinese are increasingly concerned about the implications of climatic change for the water resources of China (see Chapter 5), there is now evidence that the TGD itself is affecting climate on a far larger scale than initially suggested. Early assessments raised the possibility that the massive new reservoir might affect temperatures and other climatic variables locally, on the scale of tens of kilometers. Now a study suggests that the effects are

Table WB 3.2 Chronology of Events: Three Gorges Dam Project

1919	First mention of the Three Gorges project in Sun Yat-sen's "Plan to Develop Industry."
1931	Massive flooding along the Yangtze River kills 145,000 people.
1932	Nationalist government proposes building a low dam at Three Gorges.
1935	Massive flooding kills 142,000 people.
1940s	The U.S. Bureau of Reclamation helps Chinese engineers identify a site.
1947	Nationalist government terminates all design work.
1949	Communist revolution in China.
1953	Mao Zedong proposes building a dam at Three Gorges to control flooding.
1954	Flooding along the Yangtze leave 30,000 people dead and one million people homeless.
1955	Soviet engineers play a role in project planning and design.
January 1958	Mao appoints Zhou Enlai to begin planning along Yangtze.
May 1959	Yangtze Valley Planning Office (YVPO) identifies Sandouping site for dam.
1966	All work halted by the Cultural Revolution (1965–1975).
1976	Planning recommences.
February 1984	Ministry of Water Resources and Electric Power recommends immediate commencement of construction.
Spring 1985	The National Peoples Congress delays a decision until 1987 because of economic difficulties.
1986	The Chinese Ministry of Water Resources and Electric Power asked the Canadian government to finance a feasibility study
August 1988	Canadian-World Bank "Three Gorges Water Control Project Feasibility Study" is completed and recommends construction at "an early date."
February 28, 1989	*Yangtze! Yangtze!* released.
April-June 1989	Democracy movement sweeps through China.
February 1992	Politburo Standing Committee agrees to the construction of the project.
April 3, 1992	China's National People's Congress (NPC) formally approved the "Resolution on the Construction of the Yangtze River Three Gorges Project." 177 delegates oppose the project, 644 abstain, 1,767 approve.
April 27, 1992	The Canadian government cancels development assistance for the project.
May 1992	179 members of the Democratic Youth Party reportedly detained in connection with their protests against the Three Gorges project in Kai County, Sichuan (HRW 1995).
January 1993	An armed fight involving over 300 persons occurred in the vicinity of the dam (HRW 1995).
December 14, 1993	The U.S. Bureau of Reclamation terminates agreements for technical services because of economic and environmental impacts.
Early 1994	The full resettlement program begins in earnest.

continues

TABLE WB 3.2 *continued*

Mid-1994	Excavation and preparation of the dam's foundations are underway at Sandouping, the chosen dam site.
December 14, 1994	Premier Li Peng formally declared the project under construction.
May 1996	The US Ex-Im Bank's board votes unanimously to withhold support for the project and voices serious reservations about the dam's environmental and social impacts and its economic viability.
August 1997	China awards a contract for 14 power generating units to GEC Alsthom, ABB, and an industrial consortium formed by Germany's Voith and Siemens and General Electric Canada (VGS).
September 1997	The State Development Bank of China signs a loan package with Germany's Kreditanstalt Fur Wiederaufbau, Dresdner Bank, and DG Bank that includes both export credits and a $200 million commercial loan.
November 1997	Yangtze River dammed
1998–2002	Concrete pouring on left bank
2003–2006	Concrete pouring on right bank
May/June 2003	Dam is finished and the first water is impounded. The level of water in the reservoir rises to 135 meters in June.
July 2003	The first electricity is produced.
June 2006	Dam is completed.
October 2006	North side generators reach full capacity.
2007	14 700-MW turbine generators in operation.
2008	New estimated completion date.
2009	Original estimated completion date. Reservoir estimated to be raised to 175 meters.

For a more detailed chronology of the internal political debates between 1955 and 1992, see Qing (1989, 1994).

occurring on a regional scale – a hundred kilometers (Wu et al. 2006). New research must be conducted to track and assess these kinds of unexpected consequences.

Conclusion

The Three Gorges Dam in China is rapidly approaching completion. This project, along with a vast array of peripheral projects, constitutes the largest water-supply development in the history of humanity. As with any major construction project that substantially modifies or alters a watershed, the Three Gorges Dam will have significant costs and benefits. Among the most significant benefits are the generation of electricity without greenhouse gas emissions, improvements in navigation, and potential reductions in flood risk. Among the most significant costs are massive dislocations of millions of Chinese to make way for the dam and reservoir, further ecological degradation of the Yangtze River ecosystem and fisheries, a reduction in sedimentation reaching the East China Sea, and a growing risk of new landslides and reservoir-induced seismicity. Over decades, the overall implications of the project will become more evident, but before the full benefits have begun to be delivered, the environmental, social, political, and economic costs are beginning to accumulate. Even official government spokesmen are beginning to question the substantial human and environmental costs of the project, while other officials are moving rapidly forward on new massive water infrastructure elsewhere in China, without having learned the lessons from Three Gorges. Long-term sustainable water management in China will require a better balancing of the true costs and benefits of their water choices.

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