

October 6, 2006

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RE: Three Gorges Dam

Dear Dr. Ibeh:

I am attaching the ethics paper required of me as a participant in the PSU/ONR-REU Summer 2006 Program. In this paper, I have explored the issues surrounding the world's largest dam, Three Gorges Dam, project in China. I discovered several debatable issues with the construction of the dam and have detailed these issues in this paper.

I hope that you enjoy reading this paper. I have spent significant time researching the topic to include every controversial issue from the beginning of project discussion in 1919 to the completion of the damn in 2009.

Sincerely,
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CNCMM 2006 GA
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Three Gorges Dam

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Summary

The Three Gorges Dam spans the Yangtze River at Sandouping, Yichang, Hubei province, China. Construction began in 1993. It will be the largest hydroelectric dam in the world, more than five times the size of the Hoover Dam. The reservoir began filling on June 1, 2003, and will occupy the present position of the scenic Three Gorges area, between the cities of Yichang, Hubei; and Fuling, Chongqing. Structural work was finished on May 20, 2006, nine months ahead of schedule. However, several generators still have to be installed and the dam is not expected to become fully operational until 2009. As with many dams, there is controversy over the costs and benefits of the Three Gorges Dam. Although there are economic benefits from flood control and hydroelectric power, there are also concerns about the future of over a million people who will be displaced by the rising waters, the loss of many valuable archaeological and cultural sites, as well as the effects on the environment.

Introduction

Construction timetable

1. 1993-1997: Yangtze River diverted after four years November 1997
2. 1998-2003: First batch generators will begin generate power 2003 and permanent lock for open navigation same year
3. 2004-2009: The last section of dam wall was completed in May of 2006. On June 2006, the temporary construction barriers behind the dam were demolished. As reservoirs begin to fill, floodwaters will begin to displace communities. The entire project is to be completed by 2009, when all 26 generators will be able to generate 84.7TWh of electricity annually, about one-thirtieth of the nation's electricity consumption.

Fund sources

1. The Three Gorges Dam Construction Fund
2. Revenue Gezhouba Power Plant
3. Policy loans China Development Bank
4. Loans domestic foreign commercial banks
5. Corporate bonds
6. US \$12 billion from a tax on household electricity (Bloomberg markets estimate December 2001)

History of proposal and development of project

Sun Yat-sen first proposed building a dam on the Yangtze River in 1919 for power generation purposes and the National Defense Planning Commission under the Kuomintang made the first survey of the proposed site in 1932, but the idea was shelved due to unfavorable political and economic conditions. Major floods resurrected the idea and the PRC government adopted it in 1954 for flood control. The idea was tossed around for the next couple of years by Vice Minister of Electric Power Li Rui and then

Lin Yishan, head of Yangtze Valley Planning Office. The idea in 1963 resurfaced but the project was sidetracked due to the Cultural Revolution in 1966, fearing the dam would be sabotaged by the Soviet Union. Economic reforms introduced in 1978 underlined the need for more electric power to supply a growing industrial base, so the State Council approved the construction in 1979. A feasibility study was conducted in 1982 to 1983 to appease the increasing number of critics, who complained that the project did not adequately address technical, social, or environmental issues. Further feasibility studies were then conducted from 1985 to 1988 by Canadian International Project Managers Yangtze Joint Venture, a consortium of five Canadian engineering. Leaders from Chongqing demanded the height of the dam be increased and a new feasibility study was conducted in 1986. The project received heavy criticism from environmentalist and the debated that the dam's environmental cost didn't exceed the overall benefit. In the face of much domestic and international pressure, the State Council agreed in March 1989 to suspend the construction plans for five years. After the Tiananmen Square protests in 1989, the government forbade public debate of the dam, accused foreign critics of ignorance or intent to undermine the regime, and imprisoned Dai Qing and other famous critics. In April 1992, the National People's Congress passed the project and soon after resettlement began along with physical preparations started in 1994. Corruption scandals have plagued the project. It was believed that contractors had won bids through bribery and then skimmed on equipment and materials to siphon off construction funds. The head of the Three Gorges Economic Development Corp. allegedly sold jobs in his company, took out project-related loans and disappeared with the money in May 2000. Officials from the Three Gorges Resettlement Bureau were caught embezzling funds from resettlement programs in January 2000. Much of the project's infrastructure was so shoddy that Premier Zhu Rongji ordered some of it to be demolished in 1999 after a number of high-profile accidents including a collapse of a bridge. Zhu Rongji, who had been a harsh critic of the project, announced that the officials had a "mountain of responsibility on their heads". Around the time, a significant crack had also developed in the dam. To offset construction costs, project officials had quietly changed the operating plan approved by the NPC to fill the reservoir after six years rather than 10. In response, 53 engineers and academics petitioned President Jiang Zemin twice in the first half of 2000 to delay full filling of the reservoir and relocating the local population until scientists could determine whether a higher reservoir was viable given the sedimentation problems.

Literature Review

Trice, Susan. (1997) *Dam Ethics*. Retrieved on September 27, 2006 from <http://www.langara.bc.ca/prm/1997/page8.htm>

China's Three Gorges hydroelectric project on the Yangtze River has many troubling environmental and human rights issues surrounding the dam's construction. China expects the Three Gorges Dam to flood 600 kilometers along the Yangtze River in Hubei and Sichuan Provinces. As a result, it will displace up to 1.5 million people from farms, villages, towns, and cities over the next 20 years. To oppose the building of the

Three Gorges Dam, China argues, would be to deliberately obstruct the world's largest nation from joining the developed world. Canada's involvement has been involved in the project every step of the way, for instance, in 1986, Canada's bilateral aid organization, the Canadian International Development Agency (CIDA), provided 14 million Cdn in financing for a pivotal feasibility study of the dam's design and their conclusion was that the project was both safe and economically viable. However, the study purpose was to come up with a document that would help China build the damn not to determine whether it was feasible or not, but to find a way to build it. An independent study published that there were miscalculations in all the key aspects like effects of sediment on the reservoir, terms of the impact on resettlement, endangered species, flood control, and virtually every area of the project. The primary concern is the 1.5 million people that have to resettle due to the flooding of the Yangtze River. The majority of displaced will be farmers and they will be forced to settle on the much steeper, less fertile, and erosion plagued land higher up the Yangtze's banks; and others face urbanization and unemployment. The project could have been scaled down by building a number of less disruptive, smaller dams on the river's tributaries and this would have been both faster and cheaper. China instead opted to follow a Western model by undertaking to build a massive symbol of modernization with the world's largest dam. Canada's chief interest in the project was not to help the people of China but to have access to the world's largest market and cheapest labor pools. China undoubtedly has a problem that presents a prime opportunity to Canadian dam builders. The EDC or Export Development Corporation and General Electric Canada have decided to gain monetarily from China's need of economic support. Canada is the only country that has provided export credit funding for the project. The American export credit agency, Ex-Im Bank, declined support based on its congressionally mandated Environmental Procedures and Guidelines. The World Bank also declined and so did every international development agency, including Canada's own.

Chan, Gabriel. (June 7, 2006) *The Three Gorges Dammed for Eternity*. Retrieved on September 25, 2006 from http://iwarrior.uwaterloo.ca/?module=displaystory&story_id=2369&format=html&edition...

The Three Gorges Dam will be the largest hydroelectric project in the world. The current record holder is the Syncrude Tailings in Canada (largest by volume), the Rogun Dam in Tajikistan (tallest) and the Itaipu Dam on the border of Brazil and Paraguay (largest hydroelectric plants). The Three Gorges Dam is going to surpass all of these when it is finished with 26 generators pumping out 85 billion kW-hours of electricity a year, and comes with a hefty price tag at US\$25 billion dollars. This dam wall spans over 2 kilometers across the Yangtze River. The Three Gorges Dam is a concrete gravity dam, whose 2-km wall will hold a 660-km long reservoir, submerging 632 square kilometers of land. When fully flooded, water will be 175m above sea level. Ships can travel through the dam via a two-way lock system, which became operational in 2004. Alternatively, ships can use the one-step ship elevator, which is due to open in 2009. The Dam has several negative view points like forced relocation, pollution, cultural, and environmental

losses. Many critics say the human cost has been far too high with more than a million people being moved to make way for the dam. At least 1200 towns and villages will be submerged under the rising waters of the dam's reservoir. And these people are being moved from fertile land to much crappier land. The Yangtze is slowly becoming a dead river, thanks to the pollution from all the industrial centers along its bank. And the huge reservoir threatens to become the world's biggest toilet. The reservoir would eventually cover over 1300 known archaeological sites. Some of them have been moved. Others cannot be moved due to design or size. And still others have not been discovered yet. The reservoir would also alter the legendary scenic features of the Three Gorges forever. The Three Gorges have outstanding natural beauty that would be forever lost to the dam reservoir. Many extremely endangered species, such as the Yangtze River Dolphin, the Chinese Paddlefish, and the Siberian Crane, will have their habitats carved in half or destroyed. These are just some of the dam reasons why there is so much dam controversy surrounding this dam thing. As engineers, we are supposed to foster a spirit of pride and responsibility to advance the betterment of the world while keeping strictly to our ethics and morals. So where do we draw the line?

Adams, Patricia. (Sept 1993) *Planning for Disaster: China's Three Gorges Dam*.

Retrieved on Sept 25, 2006 from

http://www.multinationalmonitor.org/hyper/issues/1993/09/mm0993_08.html

The Three Gorges Dam is located near seismic fault lines and is also located by China's most densely populated areas, and a dam burst would rank as history's worst man made disaster. Environmentalists and engineers from around the globe, and eminent scientists and economists with China, think otherwise. By forever changing the hydrology of the river for thousands of miles, they argue, the dam would destroy commercial fish stocks and deprive the complex floodplain agricultural systems of the water and silt they need, threatening the livelihoods of 75 million people who live by fishing or farming along the Yangtze's banks. Important archaeological sites, dating back to 10000 BC, would be submerged. Many species of fish and fowl would be threatened with extinction. The dam will not perform as planned. The Three Gorges would obstruct, not improve, navigation by making shipping vulnerable to an untested lock system that would prohibit the passage of every ship whenever serious technical problems arise. The promised flood control benefits are exaggerated, scientifically unsubstantiated and politically motivated. Upstream communities for hundreds of kilometers would be threatened when the fast flowing Yangtze's massive silt load is dropped in the slow moving waters of the reservoir, creating mud banks that cause floods. Downstream of the dam, millions of people with a false sense of security are expected to settle on what is considered now as floodplains of the Yangtze, putting them at risk of floods that will inevitably come. Sediment trapped behind the dam will erode banks and dykes, causing more flooding. Along the 500 kilometer coastline, lack of sediment will starve the coastline of mudflats that protect it from rising tides. Another concern in the engineering of the dam is with the spill ways that are the largest ever with an average flow of that compared to the Missouri River. The dam's engineers are confident that they can design and control even though nothing that size has ever been constructed and the

risk includes losing control of water flows, which means catastrophic destabilization of the dam structure.

On September 17, 1990, using the findings contained in its book *Damming The Three Gorges*, Probe International filed complaints against five Canadian engineering firms for their work on the Three Gorges Water Control Project Feasibility Study. The complaints were filed with the regulatory bodies which are legally responsible for regulating the profession of engineering in the provinces of British Columbia, Quebec and Ontario. Probe International accused the engineering companies of negligence, incompetence and professional misconduct, arguing that the engineers had violated their professional and ethical codes which required that they: be realistic in the preparation of all estimates, reports, statements and testimony; not distort facts in an attempt to justify decisions or avoid responsibilities; regard their duty to public safety, health and welfare as paramount; guard against conditions which are dangerous or threatening to the environment; make reasonable provision for the safeguarding of life, health or property of a person who may be affected by the work for which the practitioner is responsible. APEO explain how those "generally accepted international engineering standards" could deviate so dramatically from the standards used in Ontario, Britain and the United States, and by the U.S. Commission on Large Dams and the International Commission on Large Dams which, Probe International argued, were violated by the Canadian engineers.

Concerns with the Three Gorges Dam

Cost

Officials report that the plan is within its US\$25 billion budget and insisted early on that the project would pay for itself through electricity generation. However, the project is thought to have cost more than any other single construction project in the history of China, with unofficial estimates of US\$100 billion or more. Under the order of the biggest proponent of the dam, then Premier Li Peng, the cost was based on 1980's prices, with almost no inflation included in the estimate. Opposition to the dam and to the fraudulent numbers being used to promote it was willfully ignored in the report in order to ensure its passage. One of the main opponents of the dam, famous Chinese activist, Li Rui, repeatedly voiced his concerns about rigged numbers and estimates, but the pleas of Li and others fell on deaf ears. As a retired senior communist official and Mao Zedong's former secretary, Li Rui managed to evade governmental prosecution. Dai Qing was not so lucky.

Increasing wealth disparity

Critics see the dam as serving primarily the interests of east coast industrialists, since this group has the most need for hydro-electric power. Unfortunately, this is at the expense of millions of people displaced from prime arable land. Making matters worse, relocation compensation has been inadequate (with corrupt officials stealing from the fund), the number of people displaced has been grossly underestimated, and their new land is of poor quality. As a result, a significant portion of the displaced population has to resort to begging and garbage collecting, or even prostitution. The exact number of rural people

whose lives have been diminished or severely disrupted is uncertain because of state censorship by the Chinese government, but domestic Chinese researchers generally agree that the impact has been much more severe than Chinese state organs will admit. Domestic Chinese human-rights groups have been able to bring some members of the displaced to at least one of the international conferences held in China on dams/reservoirs to testify about their plight, to no response from the Chinese government. The suffering of those entitled even to the best available housing, land, and other benefits given the displaced, is undeniable, even by the Chinese government. Displaced peasants face hostility from people in regions in which newcomers are resettled. The locals often resent newcomers for the benefits they have received, or suspect that those benefits will be at the expense of their own meager livelihoods.

Environment

Electricity production

The amount of power generated by the dam in 2009 was originally anticipated to supply about 10% of China's electricity needs, but with China's rapidly growing economy it is only projected to produce approximately 3% at the end of 2006. In fact, the dam is predicted to produce 18.2 million kilowatt hours of electricity. According to a recent Discovery Channel special on the Three Gorges Dam, it will supply enough electricity to power a city four times larger than Los Angeles. That is a lot of energy, but, considering China's population and already immense cities, it will simply be a drop in the bucket--not considering the fact that energy demand will increase with all of the new, modern relocation cities and development from the new shipping capabilities and industry. Over 80% of the country's power is currently produced by coal. Critics point out that various levels of Chinese government's industrial developmental plans based on the increased power production have a fatal flaw: all of them lack sufficient pollution control plans. In fact, nearly all of the newly completed industrial sites in the region lack appropriate pollution treatment facilities and increased electricity output only worsen the problem.

Greenhouse gas

Although hydro-electric power is a renewable energy source, the creation of large reservoirs can generate considerable quantities of greenhouse gases, including substantial amounts of methane, due to micro-biotic activity. Compared to the greenhouse gas emissions of conventional natural gas power plants, emissions from northern reservoirs are typically about 5% of conventional power plants, while emissions from tropical reservoirs are typically 25%. Critics also argued that due to the short lifespan of the reservoir, the eventual output of the greenhouse gas will be much greater in comparison to the current level, because when the lifespan of the reservoir expires, the vegetation will need decades to recover.

Ecosystem

Huge reservoirs by their nature alter the ecosystem and threaten some habitats while helping other habitats. The Chinese River Dolphin and the Chinese Paddlefish, for example, are on the edge of extinction and will lose habitat and suffer divided populations due to the dam. Of the 3,000 to 4,000 remaining critically endangered Siberian Crane, approximately 95% currently winter in wetlands that will be destroyed by the Three Gorges Dam. While logging in the area was required for construction which adds to erosion, stopping the periodic uncontrolled river flooding will lessen erosion in the long run. The build up of silt in the reservoir will, however, reduce the amount of silt transported by the Yangtze River to the Yangtze Delta and could reduce the effectiveness of the dam for electricity generation and, perhaps more importantly, the lack of silt deposited in the river delta could result in erosion and sinking of coastal areas.

Local culture and aesthetic values

The 600 km (370 mile) long reservoir will inundate some 1,300 archeological sites and alter the legendary beauty of the Three Gorges. Cultural and historical relics are being moved to higher ground as they are discovered but the flooding of the Gorge will undoubtedly cover some undiscovered relics. Many other sites cannot be moved because of their size or design. These historical sites contain remnants of the homeland of the Ba, an ancient people who settled in the region more than 4,000 years ago. One of the traditions of the Ba was to bury the dead in coffins in caves high on the cliff, many of which will soon be submerged. This has raised some strong protests from the people. In Chinese government's own admission, the funds provided to salvage the artifacts are not enough. Chinese scholars further pointed out that the funds provided by the government is barely 10% of what needs to be (and the actual funds needed is only a rough estimate), and the so-called experts who provided funding advise to the government were only accountants, engineers and architects, instead of archaeologists, historians, and sociologists. However, the latter were willfully excluded from the advisory bodies under the order of Premier Li Peng, and some were even forced in to exile abroad, such as the famous economist Qian Jiaju, who was only able to return to China under the direct intervention of Jiang Zemin, with the condition of silencing his criticism. Another strong opponent of the project, the famous rocket scientist Qian Weichang was able to achieve better fate by avoiding been exiled, and after repeated pressure from the Chinese government, he devoted his life in the actual work of saving the artifacts. Again, such criticism was allowed in China only recently, well after the official retirement of Li Peng, but just like the criticism on the budgetary tricks, it is already too late since most artifacts are already submerged under water, making salvaging a much more difficult task.

Navigation

The installation of ship locks is intended to increase river shipping from 10 million to 50 million tonnes annually, with transportation costs cut by 30 to 37%. Shipping will become safer, since the gorges are notoriously dangerous to navigate. Each ship lock is made up of 5 stages taking around 4 hours in total to complete. Critics argue, however, that heavy siltation will clog ports such as Chongqing within a few years based on the evidence from other dam projects. The canal locks are designed to be 280 m long, 35 m

wide, and 5 m deep (918 x 114 x 16.4 ft). That is 30 m longer than those on the St Lawrence Seaway, but half as deep. The canal locks are designed to handle 10,000 ton barges. The project also includes a ship lift, a kind of elevator, which will be capable of lifting ships of up to 3,000 tons. In the original plan the ship lift would carry 10,000 ton vessels. However, since its completion, the canal lock proved to be far less capable than the Chinese government had advertised: the official record indicates that due to various factors such as the dimensions of the ships/barges/boats, the maximum capacity actually reached is only 37% of what was originally claimed. Furthermore, there were numerous congestion, with the longest one lasting more than 5 days. Critics point out that 10,000 ton barges can already reach Chongqing without the lock, and in fact, without the dam.

Flood control and drought

The reservoir's flood storage capacity is 22 cubic kilometers, or 18 million acre-feet. This capacity will lessen the frequency of big downstream floods from once every 10 years to once every 100 years. But critics believe that the Yangtze will add 530 million tonnes of silt into the reservoir on average per year and it will soon be useless in preventing floods. Additionally, the system designed to flush out the silt relies on an unproven sequence of sluice gates. Increased sedimentation resulting from the dam could increase the already high flood level at Chongqing. There is also a contradiction between the roles of the dam as flood control and hydroelectricity production. Flood control requires dam levels to be kept low, allowing for increased flow throughout flood times, whereas hydroelectricity requires higher levels to allow for continual escape of water to produce the electricity. Probe International asserts that the dam does not address the real source of flooding, which is the loss of forest cover in the Yangtze watershed and the loss of 13,000 km² of lakes (which had greatly helped to alleviate floods) due to siltation, reclamation and uncontrolled development.

Potential hazards

Concerns exist about the quality of construction materials used, highlighted by a major crack appearing in the dam in 2000, and have led some critics to fear a potential catastrophe similar to the Banqiao Dam failure of 1975. In an annual report to the United States Congress, the Department of Defense cited that in the Republic of China (ROC) on Taiwan, "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." The notion that the ROC military would seek to destroy the Dam provoked an angry response from the mainland state media. PLA General Liu Yuan was quoted in the China Youth Daily saying that the PRC would be "seriously on guard against threats from Taiwanese independence terrorists". Despite a claim by ROC Deputy Defense Minister Tsai Ming Hsian to the contrary, most analysts believe the Republic of China neither has the will nor seeks the technology to bomb the Three Gorges Dam, fearing that Beijing will respond with overwhelming force. A group of 53 Chinese engineers campaigned for the government to rethink plans for the dam. If the reservoir level is filled to 156 m, then 520,000 fewer people will have to be displaced, easing demands on the government. The original plan

for the Three Gorges Dam, approved by the National People's Congress in 1992, aimed to keep water levels behind the Three Gorges dam at 156 m for the first ten years. In 1997, dam officials changed the plans, to maximize the dam's power output. In September 2004 the *China Times* reported that heavily-armed guards had been deployed to the area to fend off a possible terrorist attack, but did not say who might want to target the dam. There are two hazards uniquely identified with the dam: sedimentation modeling is unverified and the dam sits on a seismic fault. Excessive sedimentation can block the sluice gates which can cause dam failure under some conditions. This was a contributing cause of the Banqiao Dam failure in 1975 that precipitated the failure of 61 other dams and resulted in over 200,000 deaths. Also, the weight of the dam and reservoir can theoretically cause induced seismicity, as happened with the Katse Dam in Lesotho.

Conclusion

The Three Gorges Dam is the world's largest hydroelectric dam in the world and will supply a growing national with a non coal energy source to help supply power for a growing industrial manufacturing sector of China's new culture. The Dam was overwhelming benefits and will be a staple to follow in future dam project worldwide. The dam is also a symbol of China's new future and role in the world's economy showing the size of their labor market. The dam was several contradictions that have raised up through the years on planning and construction that may have potentially hurt the dam's overall impact on the Three Gorges Valley. The dam's function is basic but on a huge scale and its flood function was the primary purpose for the project and there is much skepticism hovering around the project. The only conclusion is that only time will tell and if the dam fails then a catastrophic event will occur and if the dam doesn't then only time will tell when it will.

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