

Environmental Science and Technology

Assignment - 2

Case Study

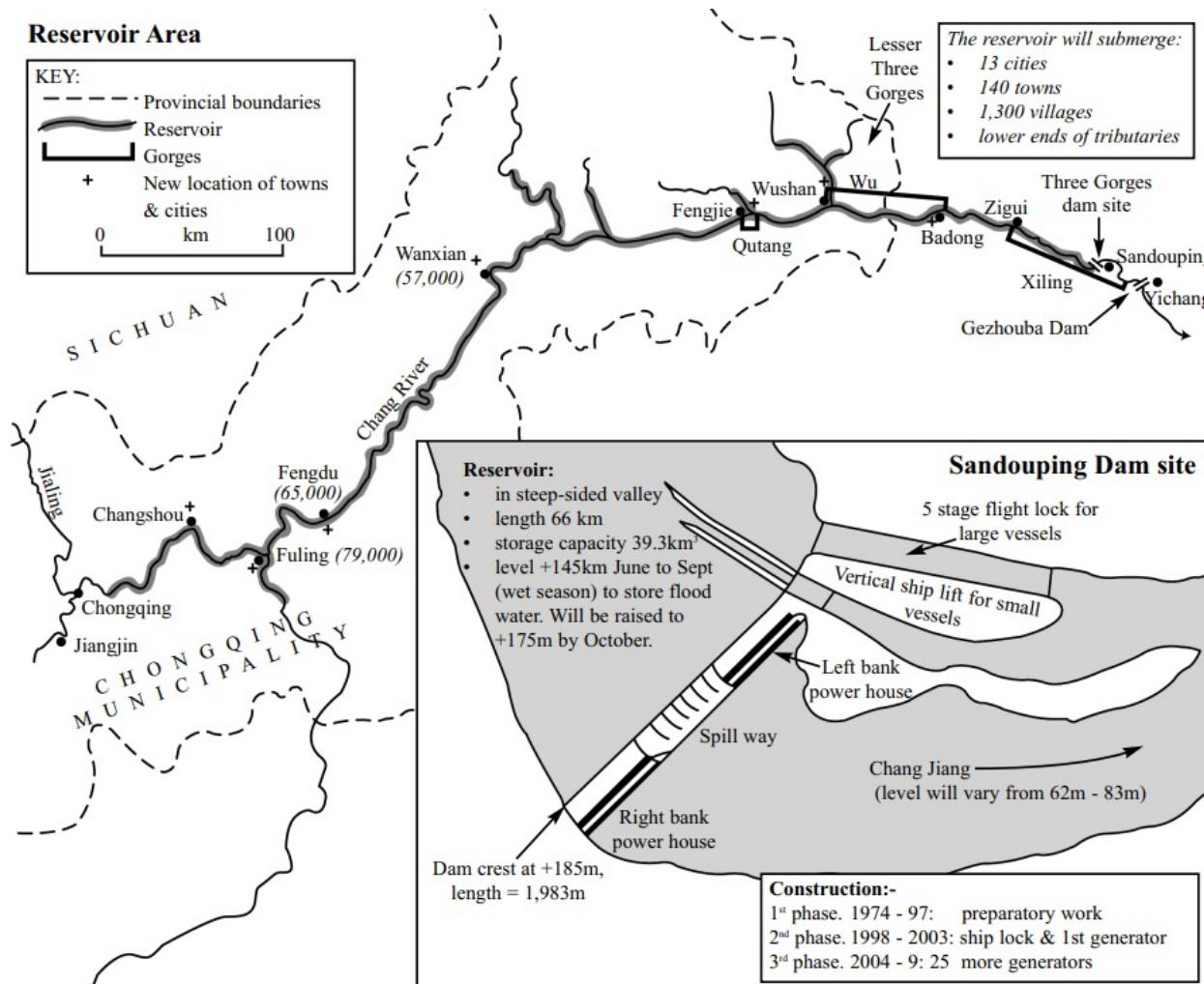
Impact of Development Activities on Environment

Three Gorges Dam



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Introduction: Exploring Three Gorges Dam



Nestled in China's Hubei province, along the banks of the **Yangtze River**, at **30°44'18" North** and **111° 16' 27" East**, the **Three Gorges Dam** is a monumental engineering marvel. Soaring to a **height of 185 meters**, it stands as the world's **largest** and most expensive dam. Its grandeur is so immense that it can even be seen from space. Its primary aims : **Flood Control , Tourism** and **Power Generation**. Project used **27.2 million cubic meters of concrete** [mainly for the dam wall] , **463,000 tonnes of steel** [Enough to build 63 Eiffel Towers] , Moved about **102.6 million cubic meters of Earth**. Concrete Dam Wall is **181 m above rock basis**. The enormous dam is situated on an **upstream section of the Yangtze** and helps prevent flooding downstream by trapping rainwater in a huge reservoir, and then controlling the release of that water through its sluice gates.

❖ Facts and Figures: The Three Gorges Dam in Numbers

- ★ The Three Gorges Dam will consist of a **610-foot high wall** running 1.3 miles from bank to bank.
- ★ The **reservoir created by the backflow** of the dam will extend **360 miles up river to Chongqing**, a distance equal to nearly **half the length of California**.
- ★ In the past **2,000 years**, the **Yangtze River** has experienced **215 catastrophic floods**.
- ★ In **1998 flooding** in the area expected to be controlled by the dam resulted in **4,000 dead, 14 million left homeless and \$24 billion in economic loss**.
- ★ When the dam is completed, **13 cities, 140 towns and over 1,300 villages** will be **submerged** by the Three Gorges Reservoir.
- ★ To make way for the Three Gorges Dam, **1.5 million people** will have to **abandon their homes**. More than **160,000 citizens have already been relocated**.
- ★ Upon the dam's completion, **1,300 known archeological sites** will be lost **forever under water**.
- ★ Over **265 billion gallons of raw sewage** are dumped into the Yangtze annually. Currently the river flushes this downstream and out into the ocean. Upon completion of the Three Gorges project, the sewage will back up in the reservoir.
- ★ Over **700 million tons of sediment** are deposited into the Yangtze annually, making it the fourth largest sediment carrier in the world. Experts believe that this sediment will build up behind the dam, with only an unproven system of sluice gates to release it.
- ★ Over **360 million people** live within the watershed of the Yangtze River. If the one in one thousand chance of a dam collapse occurred, the millions of people who live downstream would be endangered.



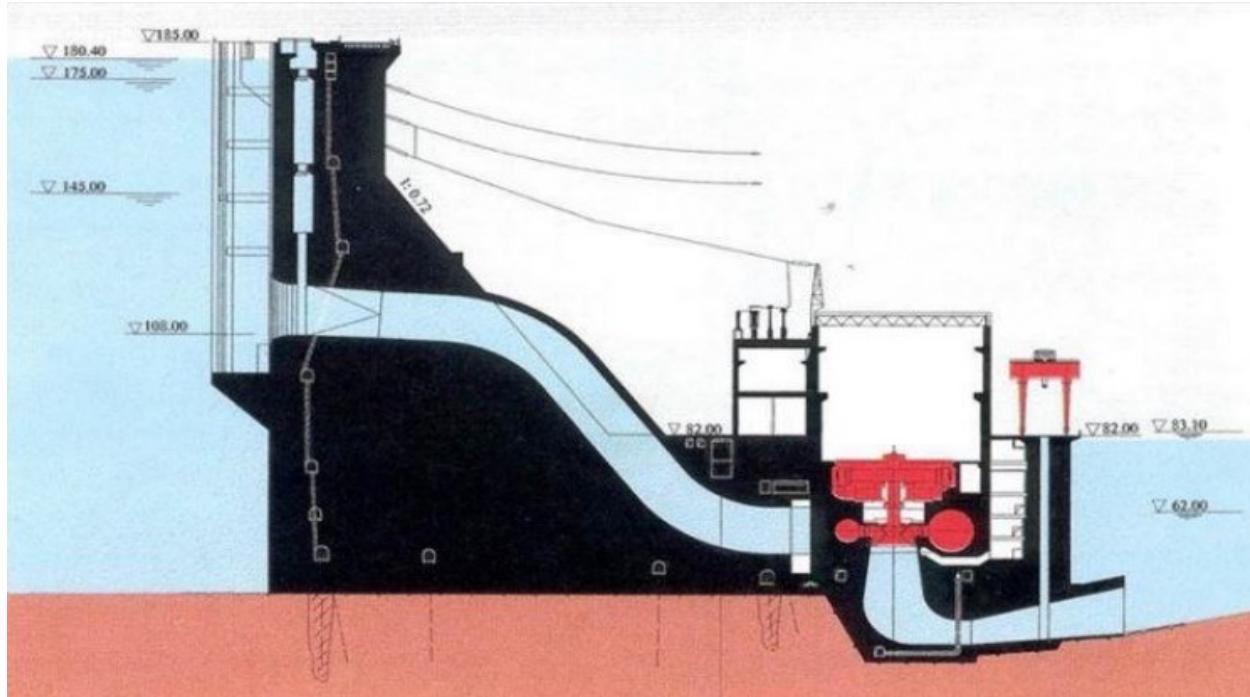
Background: From Vision to Controversy



The **idea of building a dam at the Yangtze River** was initially proposed by Dr. Sun Yat-sen in 1919. However, the project was not feasible at the time due to the lack of technology and the outbreak of the Chinese Civil War. The idea was revived in the 1950s by Chairman Mao Zedong, but was again **postponed due to technological limitations**. Deng Xiaoping proposed that China should focus on industry, agriculture, science and technology, and defense modernization, and the **Three Gorges Dam became part of the political agenda**. The project was finally approved in 1992 and construction began in 1994. The Three Gorges Dam is the **largest hydroelectric dam** in the world and was completed in 2011. Three Gorges Dam is a **concrete gravity dam** that is **2,309 meters long and 185 meters high**. It has **three main functions: flood control, electricity generation, and increased navigability** for 1000's of kilometers .The dam has been **controversial** since its inception, with critics arguing that it has **caused environmental damage and displaced millions of people**.

The **Three Gorges Dam** 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**. The **Fourteen 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. At its completion, after 2010, the project had 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 kWh of electricity** – about two-thirds of the maximum level in the completed project.

Its proponents insisted it would control disastrous flooding along the Yangtze , facilitate inland trade , and provide much-needed power for central China , but the dam was not without its detractors . Criticisms of the Three Gorges project began as soon as the plans were proposed and continued through its construction . Key problems included the Danger of dam collapse , the displacement of 1.9 million people living in more than 1,500 cities , towns & villages along the river and the destruction of magnificent scenery and countless rare architectural and archaeological sites . There were also fears - some of which were borne out - that human and industrial waste from cities would pollute the reservoir and even that the huge amount of water impounded in the reservoir could trigger earthquakes and landslides. Some Foreign Engineers argued that a number of smaller and far-cheaper and less-problematic dams on the Yangtze tributaries could generate as much power as the Three Gorges dam and control flooding equally well .



The reservoir created by the dam is approximately **660 kilometers in length** and **1.12 kilometers in width**. The total surface area of the reservoir is **1,045 square kilometers**, and it will flood a total land area of **632 square kilometers**. The reservoir contains about **39.3 cubic kilometers of water**. This water **weighs** more than **39 trillion kilograms (42 billion tons)**. Consequently, by shifting such a significant mass of water, the dam will indeed have an **impact on the Earth's rotation**. This is due to the fact that raising about 39 trillion kilograms of water 175 meters above sea level will **increase the Earth's moment of inertia** and, in turn, **slow its rotation**. According to NASA, the shift in such mass would **lengthen the day by only 0.006 microseconds**. The greater the distance of mass from the Earth's axis of rotation, the greater the moment of inertia, **resulting in a slower spin**. Consequently, this would make the Earth very slightly more spherical in the middle and **shift the pole position by 2 centimeters**.

Environmental Issues: Unveiling the Dam's Impact

❖ Erosion and Sedimentation

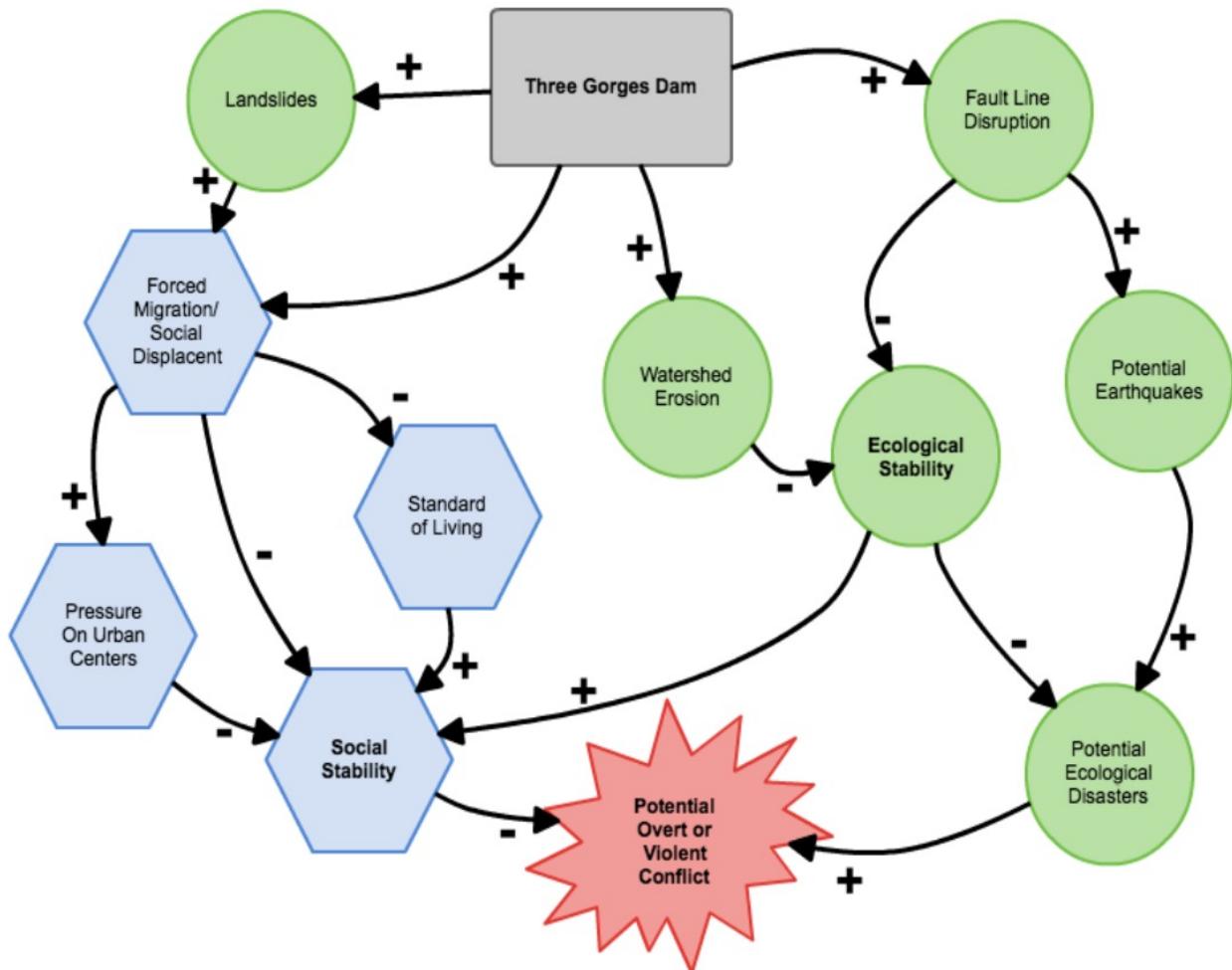
Two hazards that are uniquely identified with the dam. One is that the **sedimentation projections are not agreed upon**, and the other is that the **dam sits on a seismic fault**. At current levels, **80% of the land in the area is experiencing erosion**, depositing about 40 million tons of sediment into the Yangtze annually. **Because the flow is slower above the dam**, much of this sediment will now settle there instead of flowing downstream, and **there will be less sediment downstream**. **Soil erosion** is a major concern in its own right, apart from the effect on hydroelectric dams. **Erosion in China** annually **forces abandonment of much badly-needed cropland and reduces yields** over even wider areas. The **Yangzi basin** has been identified as the **site of particularly rapid deforestation and increase in erosion in recent years**. Of course, **increased erosion** in the catchment area would **tend to lessen the Dam's impact on downstream nutrient supply**, as sedimentation in the reservoir is partially **compensated** for by greater silt inputs. The **image** reveals the **reservoir's reach up the mountainsides**, highlighting its **impact on landslides and erosion** caused by water.

The absence of slit downstream has three effects:

- ❖ Some hydrologists expect **downstream riverbanks** to become more **vulnerable to flooding**
- ❖ **Shanghai**, more than 1,600 km away, rests on a massive sedimentary plain. The “arriving slit”—so long as it does arrive—strengthens the bed on which Shanghai is built... the **less the tonnage of arriving sediment the more vulnerable** is the biggest of Chinese cities to inundation.
- ❖ **Benthic sediment build up** causes **biological damage** and reduces **aquatic biodiversity**



❖ Landslides & Earthquakes



Erosion in the reservoir , induced by rising water , causes frequent major landslides that have led to noticeable **disturbance in the reservoir surface**, including two incidents in May 2009 when somewhere between 20,000 and 50,000 cubic meters of material plunged into the flooded Wuxia Gorge of the Wu River. **Also, in the first four months of 2010, there were 97 significant landslides.**

Earthquakes are another concern in China, a country renowned for its **advances in earthquake prediction**. At present the Three Gorges area is characterized by many small earthquakes (1-2 on the Richter scale). The weight of the water in the reservoir is expected to raise the magnitude of these to **Richter scale values of 5-6**. Earthquakes of this magnitude are within the tolerance of the dam (estimated at approximately 7-8) and are not expected to cause significant problems for other structures. **The consequences of any mistake in estimating earthquake magnitudes for Three Gorges would obviously be catastrophic**. Mark and Stuart-Alexander (1977) have reviewed methods of altering cost-benefit analyses to incorporate the risks of dam failures, although such analyses are normally limited to monetary considerations rather than loss of life.

❖ **Waste Management**



The **dam catalyzed improved upstream wastewater treatment** around Chongqing and its suburban areas. According to the Ministry of Environmental Protection, as of April 2007, more than **50 new plants could treat 1.84 million tonnes per day**, 65% of the total need. About 32 landfills were added, which could handle 7,664.5 tonnes of solid waste every day. **Over one billion tons of wastewater are released annually into the river**, which was more likely to be swept away before the reservoir was created. This has left the **water looking stagnant, polluted and murky**.

❖ **Forest Cover**



In 1997, the Three Gorges area had **10% forestation**, down from **20%** in the 1950s. Research by the United Nations Food and Agriculture Organization suggested that the **Asia-Pacific region** would, overall, **gain about 6,000 square kilometers** of forest by 2008. That is a **significant change from the 13,000 square kilometers net loss** of forest each year in the 1990s. This is largely due to China's large **reforestation effort**. This accelerated after the **1998 Yangtze River floods convinced the government** that it must **restore tree cover**, especially in the Yangtze's basin upstream of the Three Gorges Dam.

❖ Endangered Species



The **Baiji Dolphin**, often called "pandas in water," is a **rare living fossil**. It's the last of its ancient lineage, receiving **top protection** from the Chinese government. However, **fishing, river traffic, and dams have devastated their population**. With less than a Hundred remaining, **captive breeding attempts**, like those with QiQi, the lone male at the Wuhan Institute of Hydrobiology, **have tragically failed**.



Siberian cranes, the **most endangered of all crane species**, depend on Poyang Lake's seasonal flooding for food. The dam's control over the lake's water affects these cranes significantly. **With 3,000 birds in the largest flock, they migrate 3,100 miles from Siberia to the Yangtze region for winter**. The dam's ecological changes have further imperiled the already vulnerable Siberian crane population.



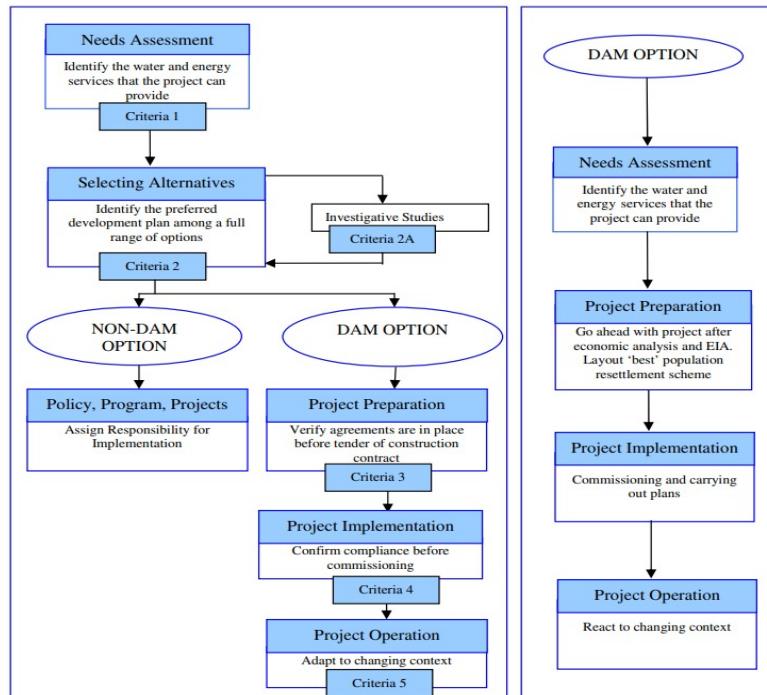
The **Finless Porpoise**, inhabiting the Yangtze River's shallow, warm waters, faces **habitat destruction**, causing **population decline**. These **small porpoises**, about 5 feet in length and **unique for lacking dorsal fins**, are legally protected in China. They are exclusively found in **Asian rivers and the western Pacific Ocean**, with some **captive breeding efforts** at the Tianzhou White-Flag Dolphin National Nature Reserve in Hubei Province, China.



The **Ancient Chinese River Sturgeon**, a species dating back 140 million years and **one of China's most endangered wildlife**, breeds at Changshu on the Yangtze River. Unfortunately, around **3,000 sturgeon are accidentally caught by fishermen each year**. The construction of the **Xinanjiang Reservoir** in the 1950s significantly **impacted their habitat by altering water temperature**, contributing to their decline. The dam worsens the Chinese river sturgeon's survival odds.

Tradeoffs and Priorities: Navigating Environmental Decisions

BENEFITS	DISADVANTAGES
<p>Socio-economic</p> <p>Flood control in middle and lower reaches is the key benefit:</p> <ul style="list-style-type: none"> * will afford protection from 1 in a 100 year flood * will save lives and livelihoods in the densely populated Jingjiang and Dongting Lake plains, the area most prone to devastating floods <p>Economic</p> <p>Flood control below Yichang losses will only be incurred in the event of a greater than 1 in 100 flood event</p> <p>Hydropower 18,200MW capacity; sale will fund project cost</p> <ul style="list-style-type: none"> • will provide about 10% of China's current needs • well placed to transmit to Beijing and to east and SE coastal provinces • will create jobs and promote economic growth in valley and other regions <p>Navigation improvements important in area where communication by land restricted:</p> <ul style="list-style-type: none"> • will enable 5,000 t vessels to reach Chongqing at all times of year, 10,000 t. vessels for 6 months It will become a major port of China • will boost growth of Pudong and valley upstream to Chongqing • other major growth points will be Wuhan-Yichang and Chongqing Water: <ul style="list-style-type: none"> • water supply for towns in the valley • will facilitate transfer of water to water short Northern Plain via Danjiangkou Reservoir to Beijing (middle route) <p>Environmental</p> <p>Reduced air pollution as hydropower replaces thermal power. At present coal fired stations produce 80% of the country's electricity.</p> <p>Reduced siltation in lakes in middle and lower reaches</p>	<p>Socio-economic</p> <p>Re-location: will involve at least 1.2m</p> <ul style="list-style-type: none"> • some settlements will be completely submerged e.g. Fengdu • some displaced people will have to be re-settled in physically different and distant regions • within the valley re-location involves movement to higher altitudes with steeper slopes, poorer soils and climate - consequently poorer quality of life. • new settlements will impact on residents of hill villages; will occupy large areas of land and loss of former land use <p>Loss of farmland:</p> <ul style="list-style-type: none"> • most fertile cropland and areas of citrus groves will be submerged • will result in urban migration for many, some of whom will lack necessary skills and mind set to cope with new jobs <p>Loss of cultural heritage:</p> <ul style="list-style-type: none"> • over 1200 sites will be drowned; only a few have been saved • removal of people from ancestral home – believe in living in same area as born <p>Loss of social tradition: belief in living in same area as born decreased tourism as Three Gorges will not be so spectacular</p> <p>Environmental</p> <p>Increased pollution from sewage and industrial effluent in reservoir area as flow will be reduced. Chongqing particularly concerned - toxic pollution from chemicals from drowned factories will also reduce water quality.</p> <p>Siltation of reservoir</p> <p>Increased scour below the dam; larger bank protection works may be needed in middle reaches.</p> <p>Landslips in reservoir area: slope stabilisation necessary in some areas of new settlement e.g. Zigui</p> <p>Earthquake threat large dams can cause earthquakes</p> <p>Ecosystems some habitats may well be affected e.g. River Dolpin</p> <p>Political</p> <p>War: dam a vulnerable target</p>



Environmental Impact Assessment: Analyzing the Effects of Three Gorges Dam

Flooding the gorges would remove a cultural landmark with great symbolic value to many Chinese. **Natural habitats** in the area to be flooded have already been heavily disturbed and are a relatively minor consideration. The dam may **negatively affect dolphins and cranes** by flooding shallow water habitats downstream of the dam; **fish migrations are already blocked** by an existing dam 40 km below the Three Gorges site. **Reservoir siltation will impede navigation** after only a few years and will eventually reduce storage volume. **Silt-free water released from the dam will erode dikes** along the middle and lower Yangzi increasing maintenance requirements. **Deprivation of nutrients to downstream agriculture and fisheries will be partly compensated** by inputs from other sources, but potential impacts need study. The same factors help reduce the potential for **coastal erosion**, but better information is needed. Officials expect that the **weight of the impoundment will provoke earthquakes of magnitudes** within the dam's limits of tolerance; high reliability is essential in assessment of seismic effects given the magnitude of the catastrophe that would result should the dam ever rupture. Filling the reservoir would **obliterate archaeological sites of interest to scholars**, a loss that could be reduced by accelerating the location and recovery of artifacts. The **public health impact of the reservoir would probably not be as severe as that experienced in many shallower reservoirs**, but the area's high human population density will make monitoring and control measures necessary. If plans are implemented to **transfer water from Three Gorges to the Yellow River basin** the dam will contribute to the many severe impacts expected from that scheme. The great expense of building Three Gorges would cost China the opportunity to implement many needed development programs, especially if cost overruns follow the example of the country's other dams.

The major justification for the Three Gorges project is reducing the risk of floods in the Yangzi plains. In addition to killing thousands of people, a major **flood might cause monetary losses exceeding the cost of dam construction**. Alternatives for reducing flood hazard include reforestation in the watershed, building smaller dams on tributaries, and reversing the flow of migrants and industries to high-risk sites. Detailed flood probability calculations and potential damage estimates under various scenarios with and without the dam constitute fundamental information that either does not exist or remains protected from scrutiny. Electricity generation from Three Gorges would be a welcome **addition to China's meager power supply**, but the **power could be produced more cheaply and quickly from smaller dams elsewhere, or could be saved through energy conservation and population control measures**. Over the period needed for dam construction, **population growth alone** would (at present rates) absorb almost the entire output of Three Gorges.

Proposed Solutions: Mitigating the Three Gorges Dam's Effects

- ❖ **Keeping upstream and downstream water in balance** : The reservoir holds water at a maximum height of 574 feet (175 meters). **If too much water is held in the dam**, then there is **flooding upstream**, but **if too much water is released**, then there is **flooding downstream**. So officials analyzed the data to determine how much water to discharge.
- ❖ **Three-month Fishing Ban:** **Each spring, a three-month fishing prohibition** is instituted **to preserve fish populations**. Nonetheless, this restriction predominantly **centers on commercial fish species** and **does not encompass** the broader ecological **equilibrium** of the Yangtze River.
- ❖ **State-Level Initiatives and Water Purification Efforts:** State-level actions to address the dam's environmental impact include **investments in water purification**. Yet, industries can still release waste into the Yangtze, casting doubt on these efforts.
- ❖ **Resettlement Initiatives:** **Gaoyang's self-resettlement scheme** faced misuse of the lump sum. Yunyang's government-led programs encountered issues like **factory bankruptcies** and **poor living conditions**. The central government later **improved resettlement by moving people to economically better regions**.
- ❖ **Smaller Dams on Tributaries:** Smaller dams on Yangtze tributaries aid the Three Gorges Dam by managing water resources, **reducing flood risk**, and **generating electricity**. They have environmental impacts, including ecosystem disruption and altered sediment flow. Balancing these factors remains a complex challenge.
- ❖ **Managing Droughts & Urban water shortages - Xylem Solution:** Jeppesen underscores the importance of **precise water level management** at the Three Gorges Dam. This strategy helps **prevent droughts**, ensuring a **stable water supply for farmers and transportation**. **Effective use of water level data** enables **efficient resource allocation**, benefiting both farmers and cities facing water shortages.
- ❖ **Managing Sediment Buildup:**



Three Gorges Dam sluice gates

Chinese experts have proposed a solution to the sediment problem. **In order to flush sediment through**, project engineers have designed a series of openings known as **sluice gates at the base of the dam**. These sluice gates have never been tested on a dam of this magnitude. Nowhere in the world is there a successful model that deals with sediment on this scale.

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