The Three Gorges Dam Project in China: history and consequences

Marta Ponseti (ESTRATS, Gestió del Patrimoni SL) and
Jordi López-Pujol (Chinese Academy of Sciences)

Abstract/ Resum/ Resumen

After several decades of planning and deliberations, the Three Gorges Dam (*Sanxia Daba*, 三峡大坝) in the upper reaches of the Yangtze River (Central China), is near to be completed. It is expected that this mega-dam, which will harbor the largest hydropower plant in the world, will contribute to flood control in the middle and lower reaches of the Yangtze River, will solve the energetic scarcity of the region, and will improve the river navigability. Its construction, however, would also imply a series of severe negative consequences, such as the loss and fragmentation of many habitats and other effects on the wildlife, the loss of many archaeological and cultural sites, and the forced displacement of more than 1 million people.

Després de diverses dècades de planificació i deliberacions, l'embassament de les Tres Gorges (*Sanxia Daba*, 三峡大坝), al curs alt del riu Iang-Tsé (Xina Central), és a punt de completar-se. S'espera que aquesta enorme presa, que comptarà amb la central hidroelèctrica més gran del món, pugui contribuir al control de les inundacions en el curs mitjà i baix del Iang-Tsé, solventi l'escassetat energètica de la regió, i millori la navegabilitat del riu. La seva construcció, no obstant, també significarà una sèrie de greus consequències, com ara la pèrdua i la fragmentació d'hàbitats i d'altres efectes negatius sobre la biodiversitat, la desaparició de nombrosos jaciments arqueològics i d'altres indrets d'interès històric, i el desplaçament forçós de més d'un milió de persones.

Tras varias décadas de planificación y deliberaciones, el embalse de las Tres Gargantas (*Sanxia Daba*, 三峡大坝), en el curso alto del río Yangtzé (China Central), está cerca de su conclusión. De esta enorme presa, que contará con la mayor central hidroeléctrica del mundo, se espera que pueda contribuir al control de las inundaciones en el curso medio y bajo del Yangtzé, solvente la escasez energética de la región, y mejore la navegabilidad del río. Su construcción, sin embargo, también significará toda una serie de graves consecuencias, como por ejemplo la pérdida y la fragmentación de hábitats y otros efectos negativos sobre la biodiversidad, la desaparición de numerosos yacimientos arqueológicos y de otros lugares de interés histórico, y el desplazamiento forzoso de ms de un millón de personas.

Keywords / Paraules clau / Palabras clave

Three Gorges Dam, Yangtze River, China, flood control, power generation, navigation, environment, biodiversity, archaeology, resettlement.

Embassament de les Tres Gorges, riu Iang-Tsé, Xina, control d'inundacions, generació d'electricitat, navegació, medi ambient, biodiversitat, arqueologia, reassentament.

Embalse de las Tres Gargantas, río Yangtzé, China, control de inundaciones, generación de electricidad, navegación, medio ambiente, biodiversidad, arqueología, reasentamiento.

Significance of large dams

Construction of dams started as far as 3,000 years ago in the Fertile Crescent (WCD, 2000), with the primary objective of serving as water storages, but also for controlling floods, irrigating croplands, and allowing or improving navigation. With the advent of industrial revolution and the technology for generating power from water movement, humans started to construct large dams to obtain energy. The first dams to incorporate an electrical power station were built at the end of nineteenth century in Western Europe and the United States. Dam construction suffered a revolution during the second middle of the twentieth century, especially in the 1970s, and, by the year 2000, about 45,000 large[1] dams and about 800,000 small ones have been built worldwide, generating altogether about 19% of the world's electricity, and supplying water for 30-40% of the irrigated croplands (Rosenberg et al., 2000; WCD, 2000).

Until recently, large dams were considered a milestone on the development plans of nations, and they were often viewed as a symbol of modernity and economic progress (WCD, 2000; McCormack, 2001). However, the huge effects derived from their building on the environment and society, in addition to the increasing uncertainties about their economic viability, have changed this vision. As a consequence, some developed nations –such as France and the United States– have interrupted their construction and even started their demolition (WCD, 2000; McCormack, 2001). Moreover, international donors and other lending organizations such as World Bank have significantly decreased and even ceased the provision of funds for large dam construction to the developing countries, which in many cases are still reluctant to embrace the new policies of energetic sustainability (Jackson & Sleigh, 2000; McCormack, 2001).

While benefits of dam construction are significant and should be recognized, negative effects can be huge and often surpass the positive ones, especially for large dams (WCD, 2000). The list of problems associated with large dams is long, highlighting environmental and social consequences. Since the primary effect of dams is modifying river's flow, this can result in several changes on natural habitats, such as their loss, fragmentation and/or transformation (Rosenberg et al., 2000). These, together with eutrophication and water pollutants' concentration, may have a large impact on both aquatic and terrestrial biodiversity, as demonstrated in several dams located in distinct parts of the world (data compiled in Wu et al., 2004). Social consequences are mainly linked with the forced human resettlement (it is estimated that the construction of large dams have displaced 40 to 80 million people worldwide; WCD, 2000), with the associated changes in their livelihoods. The loss of cultural heritage (easily exemplified by the flooding of archaeological sites; see Brew, 1961) and the spread of some diseases (e.g. schistosomiasis; Hunter et al., 1993) are also significant social impacts derived from dam construction. Other pointed consequences are local climatic changes (Perkins, 2001), and an increased incidence of earthquakes and landslides (Chen & Talwani, 1998; Jackson & Sleigh, 2000).

The Three Gorges Dam: history of the project

Gestation of the project

China has a long history on hydraulic technology projects, which can be traced back to 598 B.C., when Qebei Dam was built in Anhui Province (Fuggle & Smith, 2000). The famous Dujiangyan Dam and its innovative irrigation system were built three centuries later, around 256 B.C., and currently is still working. The hydrologic regime of Chinese rivers, characterized by seasonal (monsoonal) floods, involved the early development of flood control systems, such as the Jingjiang levee in the Yangtze River, which was started in 345 B.C. Another ancient hydraulic work is the Grand Canal, which began to be constructed in 486 B.C. and at present is still connecting Hangzhou with Beijing. Despite this impressive background, dam construction in modern times was only discrete, and in 1949, the year of the foundation of the People's Republic, only 22 large dams with an installed hydropower of 163 MW[2] were in service (Fuggle & Smith, 2000). After the 'Liberation'[3], the development of water resources based on the

1. The International Commission on Large Dams (ICOLD) defines 'large dams' as those with a height higher than 15 m, or dams with a shorter height but a reservoir volume of more than 3 million m^3.

construction of large dams become a first-order policy for the expected[4] fast economic growth for the post-war China. As a result, more than 22,000 large dams (and more than 85,000 dams in all) have been built throughout the country until now, i.e., nearly half of the world's total (WCD, 2000).

The original idea of constructing a huge dam in the Yangtze River, however, cannot be attributed to Mao or to other Chinese leaders after 1949. As early as 1919, in his article entitled *A plan to develop industry*, Sun Yat-Sen mentioned the possibility to build a series or large dams in the Yangtze with the purposes of flood control and electricity generation (Dai, 1994). During the 1930s, under the Guomindang Party government, several studies were undertaken to check the feasibility of constructing a large dam in the upper reaches[5] of Yangtze River. In 1944, an American dam expert of the US Bureau of Reclamation, J.L. Savage, was invited to do field research in order to survey the location of the future dam and to draft a preliminary project. Two years later, the Republic of China signed a contract with the US Bureau of Reclamation, to design a large dam in the Three Gorges area (see Fig. 2), and more than 50 Chinese technicians were sent to the United States to participate in the design. However, the deep economic crisis and the upsurge of the Chinese civil war caused the abandonment of the project by the government of Chiang Kai-Shek in 1947 (Dai, 1994).

A severe series of floods in the Yangtze River in 1949 made the recently established communist government strengthen its politics towards the great hydraulic projects to control floods, planning the massive construction of large dams, dikes and sluices for the forthcoming decades. Although Mao suggested the construction of the dam in 1953, the main event which aroused the government to resurface the plans for building a large dam in the Three Gorges was the tremendous floods on the Yangtze in 1954, which caused over 30,000 deaths (Dai, 1994). One year later, planning activities began, with the collaboration of Soviet experts, and the Yangtze Valley Planning Office was established in 1956 to conduct specific design and feasibility studies for the Three Gorges Project (Barber & Ryder, 1993). Lin Yishan, the Office head, proposed to build a large dam of nearly 250 m height with the flood control as the main purpose; however, Li Rui, from the Ministry of Electric Power, advocated for a smaller dam and doubted of its unlimited flood control capacity (Dai, 1994). After two years of intense debate, and despite strong opposition enhanced by the transitory 'Hundred Flowers Movement'[6], the Three Gorges Dam construction was approved by the Central Committee of the Chinese Communist Party.

2. The first hydropower plant in China was built up in 1912 at Shilong Dam (Yunnan Province), with an installed capacity of 500 kW.
3. In China, 'Liberation' is the term used to refer to the final victory of the People's Liberation Army over the Guomindang troops in 1949.
4. 'The Great Leap Forward' was an ambitious governmental plan at the end of 1950s (1958-1960) aimed to overtake the industrial output of Great Britain in only 15 years. It mainly consisted of a series of deeply ideological campaigns aimed to transform China in a productive 'paradise', such as the campaign to construct new irrigation networks, the campaign to increase iron and steel production, and the surrealist 'Eliminate the Four Pests' campaign. This period led to a massive environmental degradation and to a huge famine that could have caused the death of up to 30 million people.
5. The Yangtze River, with a longitude of about 6,300 km –ranking first in China and third in the world– can be divided into three sections according to geographic criteria: the Upper Yangtze, from the source in Tibetan Plateau to Yichang, in Hubei Province (downstream to the Three Gorges section), spanning ca. 4,300 km; the Middle Yangtze, a section of 950 km from Yichang to Hukou, in Jiangxi Province; and the Lower Yangtze, the final 930 km section from Hukou to the East China Sea.

It seems that Mao's opinion was crucial for its endorsement. According to Lieberthal & Oksenberg (1988), Mao wished for China to have the largest hydropower project in the world, and in 1958 he had appointed Zhou Enlai[7] to take a personal implication in the dam planning. On occasion of the famous swim of 1956 in the Yangtze River in Wuhan, viewed by many as a demonstration of the triumph of humans over wild nature (exemplified the latter by the river and its destructive periodical floods; see Beattie, 2002), Mao wrote one of his most famous poems, *Swimming*, revealing not only his intentions to build the dam, but also his attitude towards the environment[8]:

> "Great plans are afoot:
> A bridge will fly to span the north and south,
> Turning a deep chasm into a thoroughfare;
> Walls of stone will stand upstream to the west
> to hold back Wuhan's clouds and rain
> till a smooth lake rises in the narrow gorges.
> The mountain goddess if she is still there
> will marvel at a world so changed."[9]

Figure 1: Mao Zedong examining the Three Gorges Project design.

In 1959, the Yangtze Valley Planning Office chose Sandouping as the best location for the dam construction. However, the 1960 calamitous famine as result of the 'Great Leap Forward' postponed the project. At the middle of the 1960s the plans for the dam construction were

6. The 'Hundred Flowers Movement' (term originated from a quotation of Mao: "Let a hundred flowers bloom: let a hundred schools of thought contend") was a short campaign, started in 1956, aimed to give the intellectuals an opportunity to discuss the country's problems and to promote culture and science. However, plenty of criticisms received –many denouncing the absolute lack of freedom and suggesting the Communist Party to leave the power– led Mao in 1957 to suspend the campaign and to start an Anti-Rightist (contra) campaign. The engineers who had opposed the Three Gorges Dam construction were labelled as 'rightists'. Huang Wan-Li, today an eminent hydro-engineer and emeritus professor at Tsinghua University, and well-known for his strong opposition to the Three Gorges Dam project in recent years due to its technical weaknesses, was sent to a labor camp in 1957 for his opposition to the construction of Sanmenxia Dam in the Yellow River (see Dai, 1994, and Shapiro, 2001).
7. Zhou Enlai (1898-1976) was the Prime Minister (from 1949 to 1976) and Foreign Minister (1949–58) of the People's Republic of China.

reactivated as a part of the 'Third Line' or 'Third Front' of industrial development in southwestern China, but the irruption of the Cultural Revolution and the aggravating tensions with the Soviet Union delayed them again (Sutton, 2004). In 1970, the building of the Gezhouba Dam (see Fig. 2), also in the upper reaches of Yangtze and very near to Sandouping –the tentative location of the Three Gorges Dam–, was approved by the Central Committee, as an 'essay' for preparing the construction of the latter. However, serious technical inconsistencies forced a re-design of the Gezhouba project in 1972. The dam was finally completed in 1989 (although it became to produce electric power in 1981), taking almost four-fold the planned time and costing also four-fold the original budget (Dai, 1994).

The market economic reforms[10] introduced by Deng Xiaoping since 1979 emphasized the necessity to produce more electric power to enable the economic growth, although a deficit in electric production was already noted from early 1970s (Jackson & Sleigh, 2000). While preliminary studies concerning the project started in 1976, the location of the Three Gorges Dam at Sandouping (see Fig. 2) was finally decided in 1979 from 15 different suggested locations. Only one year later, Deng Xiaoping visited Sandouping, making explicit his support to the project. As a consequence of the growing number of critics, both domestic and international (a group of specialists from the US Bureau of Reclamation visited the area in 1981 and found severe technical problems for a projected dam of 200 m height), a first feasibility study was conducted by the Yangtze Valley Planning Office in the period 1982-1983, recommending a 175 m high (reservoir level of 150 m) dam with its construction beginning in 1986. In 1984, the State Council approved 'tentatively' the construction of the project taking into account the results of the feasibility study, thus only pending the formal approval in the National People's Congress at its spring session in 1985 (Barber & Ryder, 1993). However, a wave of protests and criticisms by academics and experts exhorting about the catastrophic environmental consequences on one hand, and the inquiry of some governmental bodies –such as the Ministry of Communications and the Municipality of Chongqing– for a higher dam (raising the reservoir level from 150 to 180 m) on the other hand, resulted in a new feasibility study and a further delay in the project approval (Barber & Ryder, 1993). Moreover, a delegation of the Chinese People's Political Consultative Committee (CPPCC), which conducted a 38-day field trip at the beginning of 1986 to the dam site, reported many technical troubles and suggested a delay in its construction and the need of more detailed studies[11].

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8. Maoism, following the precedent Stalinism policies in the Soviet Union, view nature as an inexhaustible stock of resources for achieving economic development and modernization, and environment degradation as an inevitable consequence. Mao launched many massive campaigns following the slogan 'Humans must conquer nature', such as those for construction a myriad of irrigation projects, and the 'grain-first' campaign, which promoted the conversion of all available land into new croplands by felling forests, constructing terraces on slopes and even drying wetlands. According to Beattie (2002), the Maoist attitude against nature was still in the mind of the forthcoming communist leaders such Li Peng, Deng Xiaoping and even Jiang Zemin. However, the so-called fourth generation leaders (Hu Jintao/Wen Jiabao) have adopted the 'scientific development concept', a more comprehensive approach towards sustainable development. See Shapiro (2001) and Ho (2003) for exhaustive reporting about the environmental degradation during the Mao's era.
9. Fragment of the 1956 Mao's poem *Swimming*, quoted from *Mao Zedong's Poems*, Foreign Languages Press, Beijing 1999.
10. Deng Xiaoping launched from 1979 an ambitious program to achieve a deep structural change in the nation's policy, mainly consisting of the so-called 'Four Modernizations' (although this concept was originally coined by Zhou Enlai), i.e., agriculture, industry, military, and science and technology. This grand-scale modernization should allow China to duplicate its gross domestic product (GDP) in the 1980s to reach an adequate clothing and feed, and to duplicate again in the 1990s to build a comfortable (*xiaokang*) society.

The new feasibility study (considering a reservoir level of 175 m), initiated in 1986 and coordinated by the Ministry of Water Resources and Electric Power, involved more than 400 experts working in 14 main studies that comprised the assessment report. At the same time, another feasibility study was commissioned to a Canadian consortium[12]. Both studies, finished in 1989, gave similar conclusions, recommending the execution of the project. However, while 9 experts of the governmental feasibility study refused to sign it because of multiple problems associated with sedimentation and re-settlement issues, the responsible engineers of the Canadian study were accused of negligence by Probe International[13] and later admonished, besides to the Canadian and Chinese governments, by the Amsterdam International Water Tribunal. Moreover, a new wave of protests by environmentalists, scientists, intellectuals and also journalists opposing to the Three Gorges Dam spread over China but also worldwide in 1989, in part as a result of the publication of the book *Yangtze!*, *Yangtze!*[14] by Dai Qing. At the spring 1989 session of the National People's Congress, 272 delegates demanded to postpone the project into the next century, compelling the State Council to decide the suspension of its construction within the Eight Five-Year Plan (1990-1995). The CPPCC also denounced that the Chinese feasibility study of 1986-1989 had critical inconsistencies, and called for a complete reappraisal of the entire project (Barber & Ryder, 1993). After the incidents of June 1989 in Tiananmen Square, public debate involving the Three Gorges project was forbidden and Dai Qing and other activists were imprisoned for several months.

Li Peng[15] forced a revival of the project in summer 1990, when the State Council called for a conference on the feasibility of the project, and in August 1991 the State Council Examination Committee passed the project, awaiting for the final decision in the National People's Congress at its session of 1992. The devastating floods of 1991 in the Yangtze (about 3,000 deaths) became a crucial factor for the dam supporters to attain the approval of the project, emphasizing the urgent need of such infrastructure for preventing further floods. A comprehensive environmental impact assessment (EIA) was compiled in 1991 with the active participation of the Chinese Academy of Sciences, and approved by the National Environmental Protection Agency (NEPA). According to the China Yangtze Three Gorges Project Development Corporation[16], the dam would have both positive (in the middle and lower reaches of the river) and negative impacts (only in the reservoir area) in the environment, being the latter alleviated by taking suitable countermeasures (Wang, 2002). However, some authors completely disagree, warning that the EIA was opened to political manipulation (see Beattie, 2002). On April 1992, the Fifth Plenary Session of the Seventh National People's Congress (NPC) approved a

11. See Dai (1994) for the complete report about the Three Gorges Dam project written by the ten-members team of the Economic Construction Group of the CPPCC.
12. A consortium known as Canadian International Project Managers Yangtze Joint Venture, formed by 5 companies (three private and two state-owned) executed the feasibility study, supervised by the Canadian International Development Agency, China's Ministry of Water Resources and Electric Power, and the World Bank.
13. Probe International is a Canadian environmental organization which has campaigned against the Three Gorges Dam construction since twenty years ago.
14. *Yangtze!*, *Yangtze!*, a collection of essays, interviews and petition letters by prominent Chinese intellectuals opposed to the dam construction, was published in February 1989 but was officially banned only a short time later, in October 1989. Dai Qing published a second book about the Three Gorges Dam in 1998, *The River Dragon Has Come!*, collecting the opinion of Chinese sociologists, archaeologists and hydrologists.
15. Li Peng, a hydro-electric engineer formed in the Soviet Union, was the Prime Minister of the People's Republic of China between 1988 and 1998.
16. China Yangtze Three Gorges Project Development Corporation is a state-owned company set up in January 1993 in Yichang (Hubei Province) to manage the construction of the dam.

resolution to construct the Three Gorges Dam, with 1,767 deputies voted in favor, 177 against, and 664 abstained. Thus, the affirmative votes were only 12 over the minimum of 1,755 –two-thirds of the camera– required to approve the project, an unprecedented opposition in a body usually used by the government for rubber stamping projects (Beattie, 2002).

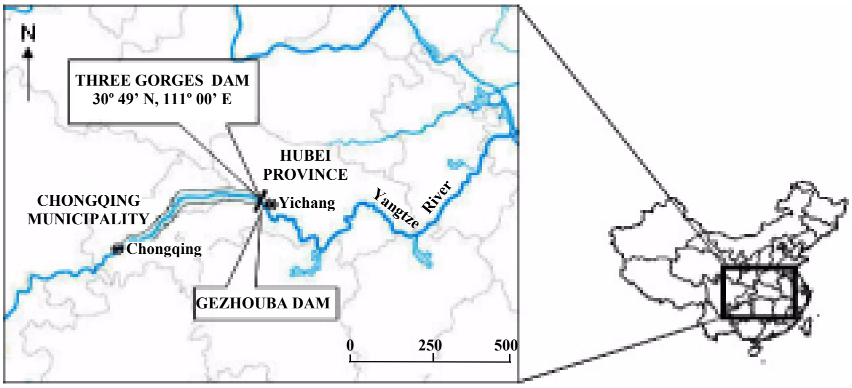

Figure 2: Location of the Three Gorges Dam.

Construction and management of the project

In June 1993, the Three Gorges Project Construction Committee[17] approved the project's preliminary design report, officially launching the preparatory stage of the project. The approved project consisted in a multipurpose dam (oriented to flood control, power generation and navigation), to be constructed over three phases starting in 1994 and finishing in 2013[18]. However, in 1997 the plans were partially modified in relation to the water filling dates, establishing 2009 as the year when the reservoir should rise 175 m, four years ahead of schedule (see Table 1), to maximize the dam's electricity output. The designed dam is a concrete gravity type dam of 185 m height (with 175 m of water normal storage level or normal pool level) and ca. 2,310 m width, with an estimated total storage capacity of 39.3 billion m^3 with 22.1 billion m^3 of flood control capacity[19]. According to the project design (Wang, 2002), the Three Gorges Dam would be able to increase significantly the flood control capacity from the present 10-year frequency flood[20] to a 100-year frequency flood. Two electric power plants will contain 26 hydro turbines (14 in the left bank power house and 12 in the right one) that, which a total generating capacity of 18,200 MW (700 MW per turbine), will provide an average annual output of 84.7 billion kW per hour, becoming the largest hydropower plant in the world[21].

17. The Three Gorges Project Construction Committee (TGPCC) was set up in 1993 to represent the State Council in project regulation and decision-making, and it is composed by three executive bodies: the administrative office, the Bureau of Resettlement and Development, and the China Yangtze Three Gorges Project Development Corporation.
18. The original plan made explicit that water level at the dam had to be maintained at 156 m for the first ten years of operation (i.e. from 2003 to 2013), in order to allow time for resettlement and for evaluating the impact of sedimentation at the tail of the reservoir. In 2000, a group of 53 engineers and academics sent two consecutive petitions to the Chinese authorities claiming to halt the water rising to 175 m in 2009 due to the serious sedimentation and relocation concerns. They advocated maintaining the water level at 156 m because this would reduce the amount of land to be inundated (with the water reaching only Tonglu Gorge), thus avoiding not only more than 500,000 people to be resettled but also the predicted siltation problems at Chongqing. A third letter was sent in 2003 (Lu, 2003).
19. The Three Gorges Dam is not, as commonly believed, the largest dam of the world, neither in height nor in reservoir capacity. According to the US Bureau of Reclamation (2004) the highest dam is Rogun Dam (335 m), in Tajikistan, while the dam with the largest reservoir capacity is Owen Falls Dam (204,8 billion m3), in Uganda.
20. A 10-year frequency flood is a flood that has 10% chance of occurring in any given year, while a 100-year flood will have the chance of 1%.

However, a further revision of the plan included the construction of a new powerhouse with six 700 MW turbines underground in the right bank, which will rise the generation capacity of the Three Gorges Dam to 22,400 MW (100 billion kWh). The dam will also improve the navigability in the section of 660 km from Yichang to Chongqing due to the increased depth of water. A double-way five-step ship-lock and a ship-lift for smaller vessels (both facilities will be the largest of the world) will allow ships to pass the dam site.

Table 1: Planned construction phases of the Three Gorges Dam.

Phase	Year	Construction stage	Water level* (m)
Preparatory Phase	1993		66
Phase I (1994-1997)	1994	Earthmoving starts; inauguration ceremony.	66
	1995	Concrete longitudinal cofferdam building starts; resettlement program is launched.	66
	1996	Xiling bridge, four-line highway from Yichang, and Yichang airport are into service; transverse cofferdams building starts.	66
	1997	Closure and diversion of the river; about 100,000 people have been resettled.	66
Phase II (1998-2003)	1998	Temporary ship-lock is put into operation	66
	1999	Excavation of the double-lane ship-lock is finished; about 230,000 people have been resettled.	66
	2000	About 295,000 people have been resettled.	66
	2001	About 325,000 people have been resettled.	66
	2002	The diversion channel is closed; left bank concrete pouring completed, about 640,000 people resettled.	66
	2003	The reservoir is filled up to 135 m pool level; first trials with the double-lane ship-lock; the four first generators are connected to the grid.	135 (139)
Phase III (2004-2009)	2004	The double-lane ship-lock is put into operation, ten turbines are already connected to the grid.	139
	2005	Left bank powerhouse completed (14 turbines in operation); about 1,000,000 people have been resettled.	139
	2006	Concrete pouring on the right bank is finished; the reservoir is filled up to 156 m; about 1,200,000 people relocated.	156
	2007	The ship-lift building starts (expected); original plan to fill the reservoir up to 156 m.	156
	2008	The reservoir will be filled up to 175 m pool level (expected); 26 turbines fully operational (expected)	175
	2009	1997 target for completion of the whole project; ship-lift will put into operation (expected).	175
	2011	The underground power plant will be connected to the grid (expected).	175
	2013	Water level should be risen to 175 m according to the original plans.	175

*Water level corresponds to the dam site, in Sandouping.

21. The second largest hydropower plant of the world in 2009 –after completion of Three Gorges Dam– will be that located in Itaipú Dam (Brazil-Paraguay), which can produce 12,600 MW (US Bureau of Reclamation, 2004).

The Three Gorges Dam will have an estimated surface area of 1,084 km^2 (632 km^2 of new flooded land), with an average width of 1.100 km (i.e. it will be more a river-channel than a lake type reservoir) and a length of about 600 km, spanning from Chongqing to Sandouping[22], near Yichang (see Fig. 2), and including the 200 km section of the Three Gorges. The total budget of the project was 90.09 million Yuan (about 8.8 million Euros[23]) based on May 1993 prices, among which 50.09 billion Yuan (4.89 billion Euros) were assigned for the construction, and 40 billion Yuan (3.91 billion Euros) for the resettlement, given that more than 1.1 million people should be displaced from their homes. The total cost after the finalization of the dam in 2009 is estimated, however, to reach 203.9 billion Yuan (19.92 billion Euros)[24] due to the inflation but also to the overrun in the costs (Wang, 2002), a very common circumstance in the construction of large dams worldwide (WCD, 2000). Nevertheless, a recent (2006) revision of the costs has reduced the budget to 180 billion Yuan (17.58 billion Euros; Anonymous, 2006). To obtain the funds for building the dam, the Chinese government initially asked to international lending organizations for funding. However, the World Bank –usually the main donor for the great development projects in low-income countries–, the Asian Development Bank, and the US Export-Import Bank, refused to finance the dam construction due to the environmental and social concerns involving the project. In 1993, as an indispensable part of the preparatory stage of the Three Gorges Dam project, fund-raising started. The Chinese State compromised to provide half of the total investment needed, mainly through domestic power sales tax, revenue from the Gezhouba Dam power plant, and even from the Three Gorges Dam itself after first turbines are operating. China Development Bank offered an additional funding of 30 billion Yuan (2.93 million Euros), and other loans came from China Construction Bank, Industrial and Commercial Bank of China, but also from foreign credit agencies[25].

The construction of the Three Gorges Dam officially started the 14th December 1994 with an opening ceremony witnessed by Li Peng, although excavations and earthmoving at the dam site had started in 1993. The construction Phase I, which essentially consisted in closing the Yangtze River main channel and opening a diversion channel, was concluded in November 1997. The four-lane highway to Sandouping (to facilitate the transport to the dame site from Yichang) and the airport of Yichang were also put into service during this initial stage. The plan to relocate more than 1 million people from the areas to be inundated was also officially launched during the Phase I –in concrete in 1995–, although a resettlement pilot project was performed between 1985 and 1993 (Wang, 2002). In 1997, at the end of Phase I, Chinese authorities reported that more than 100,000 people were satisfactorily resettled.

22. The section of the river between Chongqing and Yichang and its surrounding lands has become known as the 'Three Gorges Reservoir Region' (TGRR), comprising an area of about 58,000 km^2 and 18 counties.
23. Exchange rates at 7 July 2006. All the currency conversions along the paper are calculated according to this rate.
24. Some sources raise this figure up to 60 billion Euros (Zich, 1997).
25. According to ECA-Watch (2005), 6-8% of the total budget comes from foreign credit agencies.

Figure 3: Satellite image showing the progress of the Three Gorges Dam construction over a 6-year span. (Credit: NASA image created by Jesse Allen, Earth Observatory, using ASTER data made available by NASA/GSFC/MITI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team).

During the six years of the Phase II (1998-2003), a 1700 m-long and 185 m-high section of the dam (which included the spillway) in the left bank was completed. A cofferdam 580 m-long and 140 m-high was constructed in the right bank, which allowed the closure of the diversion channel opened in 1997, and the subsequent filling of the dam until a pool level of 135 m, in June 2003. The first turbine generator, located in the left bank power house, started to produce electricity in July 2003. The double-way five-step ship-lock was also completed during this construction stage, starting the trials in June 2003. In the same month, the resettlement of the about 550,000 people who where living under the marks of 135 m was achieved. In the Phase III, the reservoir water level should be maintained at 135 m until the building of the right bank dam, the 665 m-long and 185 m-high section remaining to complete the entire dam. However, the water level was raised four meters (to 139 m pool level) in November 2003 to improve power generation and navigation. The right bank dam was recently finished (May 2006; see Fig. 3), 10 months ahead of schedule, and the filling up to 156 m, initially scheduled for 2007, took place in October 2006, after the flood season. Although about 1,200,000 people have been moved until now, an additional contingent of more than 200,000 people should be relocated before 2009 when the reservoir will reach 175 m (Anonymous, 2006). During the first years of the Phase III, the electric production has been increased notably, with a currently output of 49.1 billion kWh from the 14 turbines of the left bank powerhouse. The first hydro turbines from the right bank power house will be put into operation in 2007, and it is expected that the 12 generators will be fully operating in 2008. The underground power house, which has been halted due to a negative environmental assessment, is expected to be put into operation at 2011. In relation to the navigation facilities at the dam, while the ship-lock was formally open in July 2004 –after one year of trial–, the ship-lift is showing a considerable delay, and its construction will not start until 2007, with a scheduled completion for 2009.

Figure 4: Images of the Three Gorges Dam construction. On the left, works on the left bank section of the dam, in September 2001 (Credit: Benjamin Lyons); on the right, works in the right bank dam, in April 2006 (Credit: Kay Young).

Benefits of the Three Gorges Dam construction

Flood control

Flood control in the middle and lower reaches of the Yangtze River is the primary but also determinant reason argued for the Chinese authorities to go ahead with the Three Gorges Dam construction (Huang, 2004). The long record of floods in the river, which have caused many human deaths but also enormous economic losses, appears as a strong argument to build the dam. Historical records indicate that 214 floods occurred in the Yangtze Valley between the beginning of the Han Dynasty (206 B.C.) and the end of the Qing Dynasty (1911 A.D.), i.e. about one per decade (Fuggle & Smith, 2000). The most disastrous flood in this period was in 1870, which killed about 240,000 people (Sutton, 2004). The worst floods in the twentieth century occurred in 1931, which caused the death of 145,000 people and inundated 34,000 km^2 of farmland, in 1935, killing 142,000 people and flooding 15,000 km^2 of cultivated land, and in 1954, which is considered as the heaviest flood of the last century. In 1954, despite the great efforts[26] to control the flood in order to protect the city of Wuhan (which fortunately was achieved), more than 30,000 deaths, about 19 million people affected, and the inundation of 32,000 km^2 of farmland could not be avoided; moreover, the Beijing-Guangzhou railway line was suspended for more than 100 days. It is estimated that the 1954 flood caused more than 10 billion Yuan (about 0.98 billion Euros) of direct losses, and uncountable indirect ones (YWRP, 1999). The last great flood in the Yangtze River occurred in 1998, which caused more than 3,000 deaths, affected about 200 million people, inundated more than 20,000 km^2 of cultivated land, and caused a total estimated loss of 25 billion Euros, without taking into consideration indirect losses (Anonymous, 2000).

The floods in the Yangtze have been a major concern for the habitants of its basin since long time ago; for example, flood-marks began to be recorded about 800 years ago (since 1153 A.D.). According to the Yangtze River Valley Water Resources Protection Bureau (YWRP, 1999), since 1153 eight huge floods showed a flood peak flow at Yichang of more than 80,000 m^3/s (which can be considered as a 40-year frequency flood), two floods reached 110,000 m^3/s (those of 1860 and 1870; 1000-year frequency flood), and in the last 110 years up to 24 floods had peak

26. The works to strengthen the Jingjiang levee and to construct several flood diversion and detention areas were completed in 1953.

discharges higher than 60,000 m^3/s (10-year frequency flood). The most prone area to suffer floods in the Yangtze Basin is the Jingjiang reach –a section of 340 km long with the Jianghan plain at the north bank and Dongting Lake plain southwards– because the water level in the river during the flood season is about 6-17 m higher than the floodplain, as a consequence of the silt deposition on the river bed for long time (Sutton, 2004). To protect the plains from major floods, a levee started to be constructed in 345 B.C. in this section of the river, and over the centuries it has been elongated (up to the current 182 km) but also raised (12 m of average, some areas up to 16 m high). With the latest improvement works undertaken in 1993, the safe capacity of the levee reached 60,000 m^3/s, i.e. it may avoid the consequences of a 10-year frequency flood. In addition to the levee, several flood diversion and detention areas have been constructed since the 1950s, which have a flood capacity of 20,000 m^3/s. Therefore, the diversion areas combined with the system of levees can provide a total flood control capacity of 80,000 m^3/s, which theoretically would protect against a 40-year flood; nevertheless, the operation of the diversion systems would imply severe damage and a myriad of losses because most of the diversion areas are densely populated (about 500,000 people) and intensively cultivated.

The threat of flooding has worsened in the last decades due to the gradual loss of natural storage systems, such as lakes (Poyang Lake but especially Dongting Lake), due to the farmland reclamation[27] –especially intense during the 1950s and 1960s– but also to the sediment deposition into the lakes from the river. The reinforcement of the Jingjiang levee in the last 50 years has involved that the silt transported by the river is directly deposited into Dongting Lake, falling its flood storage capacity from 29 to 17 billion m^3 since 1949 (Fuggle & Smith, 2000). The construction of the Three Gorges Dam is viewed by the Chinese government as the definitive solution to the severe floods, since most of the alternatives suggested by the dam opponents, such as further raising of the existent levees[28] and dykes, the dredge of waterways, the removing of polders, the restoration of lakes, and the construction of new diversion areas, are viewed as a non-viable –technically and/or economically– options. The authorities argue that raising Jingjiang levee would multiply its risk of failure, and the establishment of new diversion areas would imply enormous economic losses in case of inundation (e.g. flood of croplands, industries, buildings and other infrastructures, and evacuation of a large contingent of people).

To play its claimed role in flood control, the water level of the Three Gorges Dam will be reduced to 145 m before each flood season to provide up to 22.1 billion m^3 of flood control capacity[29], that is, the water flood peak may be reduced by 27,000-33,000 m^3/s (Huang, 2004). The flood control capacity provided by the dam, combined with that of Jingjiang levee, allow to face 100-year floods without the need of operating the diversion systems and detention basins. Even the damages caused by a 1000-year flood could be theoretically avoided if the detention basins are also used. The planned construction of more dams in the upper reaches of the Yangtze River, as well as in some tributaries, will enhance the flood regulation of the Three Gorges Dam in the future. The Chinese authorities emphasize the dam building will adequately protect not only the 15 million people living in the flood-prone areas of Jianghan and Dongting plains and their 15,000 km^2 of farmland, but also the roughly 80 million people, ca. 60,000 km^2

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27. About 12,000 km^2 of lake surface was drained for farming from the 1950s to the 1970s (Fu et al., 2003).
28. According to Sutton (2004), the average height of the Jingjiang levee should be 16 m, and with some sections up to 20 m, to prevent 1000-year floods.
29. In case of extreme flood, the water stored can be raised to 180.4 m, the maximum pool level of the dam, which would provide an effective flood control capacity of 22.1 billion m^3.

of croplands and the dense industrial network of the middle and lower basin of the Yangtze. In addition, outbreaks of infectious diseases associated with flood events such as Japanese B encephalitis, leptospirosis and schistosomiasis would be also avoided, although the contrary – their resurgence– may also occur, as reported in many dams around the world (see Hunter et al., 1993).

Figure 5: Three Gorges Dam sluice gates discharging water (Credit: Three Gorges Probe).

The flood control capacity attributed to the Three Gorges Dam, however, has been widely questioned attending to two main reasons. Firstly, there is a general agreement that whereas the Three Gorges Dam can protect from floods originated by storms in the catchment areas of upper reaches, it will not provide effective control for the floods originated by strong precipitations downstream the dam, such as those in the Yangtze middle reach tributaries (Hartmann & Becker, 2003). The Three Gorges Dam, located at the end of the upper reaches, can control only 55% of the Yangtze River watershed while the Sanmenxia Dam, also designed to control floods in the Yellow River, can control over 92% of its watershed (Dai, 1994). Therefore, it has been argued that the Three Gorges Dam would not be able to protect from floods like those of 1954 and 1998 (Dai, 1994; McCormack, 2001). Secondly, sedimentation can seriously threaten the flood control capacity of the dam because of silt accumulation within the reservoir. Sediment deposition has become a major problem in about 230 large dams in China, causing an average loss of 14% of their total storage capacity[30] and in some cases reaching more than 50% (Leopold, 1998). The Yangtze River, once a limpid waterway, has become the fourth[31] river in silt deposition in the world (the discharge load is more than 0.52 billion tons per year, averaging a sediment concentration of about 1.2 kg/m^3; Wang, 2002), due to the extensive soil erosion experienced in its basin in recent decades, caused by human activities such as deforestation and slope cultivation. According to the official estimates, during the first decades of operation a significant part (about 60-70%) of the sediments carried by the inflow water will be deposited in the reservoir (and 30-40% sluiced through the dam) until reaching a balanced state after ca. 100 years of operation, when more than 90% of the annual incoming sediment will be flushed

30. This situation is especially serious in the case of Yellow River, where the 21% of the total storage capacity of the ca. 600 large and medium-size reservoirs has been lost from 1989 due to sedimentation; see Suo (2004).
31. The Yellow River shows the heaviest silt content among all the rivers in the world, with about 35 kg/m^3 (Wang & Hu, 2004).

through the dam, and the flood control capacity of the reservoir will still remain at 86-92% (YWRP, 1999; Wang, 2002). However, many researchers disagree with these optimistic estimations, based exclusively on mathematical models and never tested in so large dams, and literature is plenty of examples of underestimation of siltation rates in dams worldwide. In China, the Sanmenxia and Gezhouba dams are clear examples of wrong estimations of reservoir sedimentation rates. The Sanmenxia Dam, in the middle reaches of the Yellow River, had to be rebuild only two years after its completion (in 1960) due to the massive siltation upstream, and Gezhouba Dam, only 40 km downstream from the Three Gorges, lost about 44% of its water storage capacity due to sedimentation only after 7 years of operation (Dai, 1994).

To achieve the goal of sediment removing in the Three Gorges Dam, the reservoir level will be lowered to 145 m (the flood control level, FCL) during the flood season (from May to September), when the water carries most of its sediment load[32]; this would allow to remove the silt through sluice gates and bottom outlets[33]. From October to April (dry season), the reservoir level will be raised again to 175 m, the normal pool level (NPL). In the case of heavy rains upstream the dam during the wet season, discharge gates will be closed to prevent floods downstream, but this will involve the build up of large amount of silt behind the dam. This contradiction between needs of flood storage and sediment removal requires a careful management of the dam, a 'know-how' really scarce from the operating dams worldwide (Leopold, 1998). The sedimentation concerns have been implicitly recognized by the Chinese authorities with the release of several projects to build dams in order to reduce the sediment inflow to the Three Gorges Dam, such as the Xiluodu and Xiangjiaba dams in the Jinsha River, the largest Yangtze tributary (Lin et al., 2004). In addition, some soil conservation measures have been implemented, such as the logging ban (decreed in 1998 after the summer floods) and the prohibition to cultivate steep slopes (> 25º) to avoid further deforestation.

The high rate of sedimentation in the dam before reaching the hypothesized equilibrium (after 100 years) will imply discharged water with lower amounts of silt, which might paradoxically cause floods downstream the dam. A fall in sediment load could strengthen the river's scouring capacity, causing serious damage to the diversion works but also to the protective levees (Leopold, 1998; Fuggle & Smith, 2000). 'Cleaner' water may also erode the riverbanks causing landslides downstream. Moreover, the construction of other dams upstream in order to reduce the sediment inflow into the Three Gorges Dam can produce these described effects in the latter. The steep and unstable soils (due to the extensive farming and clearing) in the reservoir banks are predisposing factors to landslides[34]. A collapse of the dam, as a consequence of huge floods –the flood can exceed the spillway capacity, thus overflowing and destroying the structure–, large surface waves –induced by landslides or rockslides– or an earthquake, would cause a huge flood downstream, probably causing many thousands of

32. According to the Yangtze River Valley Water Resources Protection Bureau (YWRP, 1999), 84% of the annual runoff of sediments in the Yangtze River occurs during the flood season.
33. 22 surface sluice gates and 23 bottom outlets have been constructed; however, the bottom outlets were scheduled to be sealed before the dam completion in 2009. This fact has generated strong controversy because their sealing –to assure dam safety– may involve the accumulation of high amounts of silt behind the dam, because outlets are crucial for releasing silt from the reservoir. In the case of Sanmenxia Dam, the bottom outlets were immediately closed after its building, which caused its complete siltation after only two years of operation (Lu, 2003).
34. Several landslides have occurred since the reservoir filling to 135 m in June 2003; the most serious was that of Qianjiangping, where 24 million m^3 crashed into Qinggan river, producing 20 m high waves and causing 14 deaths and numerous material losses. For more detailed information, see Fan (2006).

deaths[35]. However, the dam has been designed to cope with an extreme flood event (its safety would not be compromised even if it is overflowed; Fuggle & Smith, 2000) and earthquakes up to 7.0 on the Richter scale (Dai, 1994). The weight of the impounded water might induce low or moderate earthquakes[36], but far from affecting the dam safety and its normal operation, according to the Yangtze River Valley Water Resources Protection Bureau (YWRP, 1999).

Power generation

Power generation is officially the second purpose argued to construct the Three Gorges Dam. Although electricity supply fell short of demand from early 1970s, the economic reforms introduced from late 1970s and the subsequent skyrocket of national economy worsened this situation. In the middle 1980s, power shortages forced factories to operate at 70-80% capacity, and blackouts became very common in urban areas. The construction of thermal power plants was reactivated since the 1980s as the main solution to provide energy at short term; however, the limited coal resources of China and the high pollution associated with coal-burning power plants emphasized the need to find an alternative source of energy. The hydropower, viewed as a cleaner source of energy compared to coal, began to be regarded as a middle and long-term solution to the issue of chronic power shortages. Large plans to develop the hydroelectric resources were launched since the 1990s, aimed to increase the proportion of energy generated by hydropower stations from ca. 19% in late 1990s to 40% by 2015 (McCormack, 2001). Nevertheless, at the end of 2005, the thermal power (essentially coal burning) still represented 75.6% of the total power installed capacity and 81.5% of the overall power generation (Ni, 2006), and a recent revision has reduced the estimated proportion of energy generated by hydropower at 2020 from 40% to 26% (Hooke, 2005).

The Three Gorges Dam constitutes the backbone of the plans to develop the hydropower generation in China. As widely recognized, China possess the world's greatest potential for generating electricity from hydropower (McCormack, 2001), with a theoretical generation capacity of 448 GW, which might produce an annual power output of 2,470 billion kWh (Lu, 2004). However, the present installed hydropower capacity in China is only 117 MW (Ni, 2006), i.e. about 26% of the exploitable hydro potential. Within the scheme to develop hydropower, the western great rivers –such as Lancang (Mekong), Nu (Salween), Yarlung Zangbo (Brahmaputra), and Yangtze– play a central role due to their huge potential power production (because of the significant elevation drop of these rivers from the Tibetan Plateau). Several hydro-electric 'cascades' are projected, highlighting those in the Lancang[37] and the Yangtze River. In the Yangtze cascade, up to 23 large dams have been projected (Zhang Mingguang et al., 1999), with nearly 90,000 MW of installed capacity. The Three Gorges Dam alone will account for 25% of the electric output of this cascade; when the 32 turbines are fully operational in 2011, the installed power capacity will rise to 22,400 MW, i.e. a power output of 100 billion kWh.

35. A huge flood event in summer of 1975 caused the collapse of the Banqiao and Shimantan dams on the Huai River, in Henan Province, causing the death of about 85,000 people.
36. About 20 reservoir-induced earthquakes have occurred in China, mostly showing low intensities (less than 5.0 in the Richter scale), although the earthquake at Xinfengjiang in 1962 reached a 6.1 magnitude (Chen & Talwani, 1998).
37. The Lancang cascade is composed by 8 dams (two of them already completed) with a combined generation capacity of 16,000 MW.

The Yangtze Basin, and in general the whole central and eastern China, are poor in fossil fuels, and energy production in these areas mainly depends on coal transportation from northern China by railway. According to the Chinese authorities, the construction of the dam will guarantee the electricity supply of these areas, eliminating the shortages that restricted their economic development. It is estimated that 52% of the power originated by the dam will be served to central China (especially Chongqing Municipality), 32% to eastern China, and 16% to southern China (Anonymous, 2006). However, and taking into account the forecasts for power production and electric consumption in China[38], the Three Gorges Dam will probably provide less than 4% of the nation's electricity needs in 2011. To fulfill the energetic demands of the projected economic growth for the coming years, China should produce an additional 30 GW per year, i.e. an average annual growth of 6% (Hooke, 2005). Critics have argued that it was not worth the effort of waiting 19 years (from 1992 to 2011) for constructing so costly project just to obtain less than 4% of the China's energy needs; instead, building a series of smaller power stations on the tributaries was a much better –and quick– way to solve the power shortages (Dai, 1994; Challman, 2000a).

Chinese authorities emphasize that the construction of the Three Gorges Dam would imply a significant economic saving by avoiding the expenditures of coal transportation from northern China and the subsequent relief on the already overcrowded railway network (Sutton, 2004), in addition to the environmental advantages of hydropower respect to coal burning (emission of atmospheric pollutants such as CO_2, SO_2 and NO_x will be avoided; see section *Negative effects*, subsection *Environment and Biodiversity* for a brief discussion). Chinese government also claims that revenue from the Three Gorges Dam since the year 2003, when the first generators were put into operation, will provide enough funds for the third construction phase and even for repaying some of the bank loans. Calculated on the basis of the official tariff of 0.25 Yuan per kWh (Lu, 2004), the annual income by selling electricity after 2011 would reach 25 billion Yuan (2.44 billion Euros), amount that should contribute to the economic development of the Yangtze Basin and especially of its interior poor regions such as the Three Gorges area. Nevertheless, dam opponents affirm that the electricity generated will be too expensive to buy, and quote the case of Ertan Dam (finished in 1998), which cannot sell its power due to the lack of electricity demand (because of the closure of many state-owned industries), and to the cheaper price of the power generated by coal-fired plants in Sichuan (Ryder, 2006). Another problem that might face the Three Gorges Dam relies on the fact that sediment accumulation reduces the generating capacity of many dams, in some cases up to 80% only after a few decades of operation. Perhaps the best example is Sanmenxia Dam, where the power production has been reduced from 1,200 MW to 250 MW, i.e., it conserves only about 21% of the original power generation capacity (McCormack, 2001).

Navigation

The third main purpose of the Three Gorges Dam is improving the Yangtze River's navigation, the Chinese 'Golden Waterway'. Its navigability has made the Yangtze River to be a key artery of communication connecting east, central and west China since ancient times. The Yangtze waterway system (The Yangtze main channel, its secondary channels but also its tributaries), is formed by about 3,600 navigable rivers, stretching more than 77,000 km; of these, about 2,500 km are navigable for vessels over 1,000 tones. More than 200 ports and harbours along the main stem of the Yangtze River allow more than 200,000 tonnage of fluvial

38. While the current installed power capacity is 508GW, it is expected that it will reach 690GW in 2010 and 950GW in 2020 (Hooke, 2005).

waterborne cargo (Zhang Mingguang et al., 1999), which represents about 80% of China's total (YWRP, 1999). Until the construction of new railway lines during the 1960s and 1970s[39], the Yangtze River was the unique way to access to Sichuan. However, navigation has never been an easy matter due to the hazardousness of several sections of the river, such as the Jingjiang section, where the sandbars and the shallowness and instability of the river courses have put many risks to the shipping. But the most dangerous stretch of the river to the navigation is the 660 km section from Yichang to Chongqing, where the Yangtze runs through mountains and narrow gorges, and 139 major dangerous shoals and rapids and 46 one-way control sections (YWRP, 1999) act as 'black spots' and navigation bottlenecks. Although since the 1950s some facilities have been installed such as beacons and other navigation signals (Fig. 6), and major improvement works have been executed such as river dredging and large rocks blasting, the Yangtze can still provide neither the desired shipping capacity nor the required safety to cope with the growing demand of water trade in the region.

The filling of the Three Gorges Reservoir would imply a dramatic improvement in the navigation along the stretch of 660 km that separates Yichang from Chongqing, due to the deepening and widening of the river channel. The dangerous shoals will be inundated, the flow velocity will be significantly decreased, and the numerous one-way control sections will be removed. In addition, the minimum discharge downstream of Yichang in the dry season will be increased from 3,000 m^3/s to 5,000 m^3/s (Hartmann & Becker, 2003), improving the navigation also in the middle reaches of the Yangtze River. All this factors will drive to an expected increase of annual one-way shipping river's capacity from 10 million tons to 50 million tons, because up to 10,000 tons vessels[40] will be able to reach Chongqing from the coast for six months and 5,000 tonnage ones for the whole year, instead of the 3,000 tone-ships that previously covered the route. As a result, a decrease of 35-37% in navigation costs is expected (Wang, 2002).

Figure 6: Navigation facilities in the Yangtze River. On the left, river beacon; on the right, the Three Gorges double-way five-step ship-lock (Credits: Kay Young).

39. The Chengdu-Kunming railway, a line of more than 1,000 km framed within the 'Third Front' development campaign, and regarded as one of the most challenging engineering tasks in the world at that time, began to be constructed in 1958 and it was completed in 1970.
40. It has been some confusion about the type of vessels which can reach directly Chongqing from the coast after the reservoir filling. Some authors have stated that 10,000 tonnage 'ocean going-vessels' would do, but this is not possible because that kind of ships are too high to clear the bridges over the Yangtze at Nanjing and Wuhan.

To allow the ships to pass the dam wall at Sandouping, two major facilities were projected: a double-way five-step ship-lock and a ship-lift. Only the first one has already been constructed (put into normal operation in 2004), while the second one is still in the design stage (see Table 1). The ship-lock (Fig. 6) has 10 chambers of 280 m × 34 m × 5 m, capable to accommodate 10,000 tons ships, mainly freight ones, while the future vertical ship-lift will have a container of 120 m × 18 m × 3.5 m for up to 3,000 tonnage vessels, ideally passenger boats (Wang, 2002). The dam opponents have claimed that these infrastructures may obstruct instead of facilitate the navigation because any failure in the ship-lock or ship-lift will halt river traffic for a long time. Dai (2005) notes that an accident in the ship-lock of Gezhouba Dam, which is only one-step and one-way, can stop navigation on the Yangtze for dozens of hours and even several days, with the consequent economic losses. The chance of any failure in the Three Gorges Dam ship-lock, double-way and five-step, thus, would be much higher. Although no significant accidents have been recorded to date, vessels often have to face significant delays (almost twice as long as projected) for passing the ship-lock (Shi & Dai, 2004). According to the Chinese authorities, however, the ship-lock operation has been a complete success, because more than 190,000 vessels used the lock from its inauguration in June 2003 to the end of 2005, with a total traffic amount of 89 million tons of freight and more than 5.2 million passengers (CGOWP, 2006).

Navigation, however, could be obstructed by sedimentation processes after dam construction, such as the creation of shifting sandbars and channels (Challman, 2000a). Sediment building is expected to be increased at the tail end of the reservoir, because the slowed water flow will avoid the flushing out of gravel and pebbles (Dai, 1994; Leopold, 1998). This might make the port of Chongqing (Chaotianmen and Jiulongpo docks) unusable due to the complete siltation of the harbour and the navigation channel, only after 10 to 20 years of dam's operation (Dai, 1994). To enable the navigation of 10,000-tonnage vessels, channel dredging should be carried out every year (Lin et al., 2004). Due to the likely siltation problems, a new port at Cuntan, 40 km downstream Chongqing, is now under construction (Fan, 2006). In case of strong rains, the predicted siltation at the tail of the reservoir would significantly increase the water levels respect to those prior to the dam construction, increasing the flood risk at Chongqing[41].

A secondary benefit of the navigation improvement in the reservoir will be the boost of tourism in the region, according to the dam promoters. On the one hand, the Chinese authorities claim that the dam filling will not greatly modify the spectacular scenery of the Three Gorges, one of China's major tourist attractions, and which have inspired poets[42] and landscape painters. The Three Gorges is a section of nearly 200 km composed by three narrow passes: the Xiling Gorge (where the Three Gorges Dam is located), the Wu Gorge and the Qutang Gorge. Since the peaks along banks of the gorges range from 800 to 1,500 m, and the reservoir water rising will be only about 110 m (to 175 m)[43], the height of the gorges will be diminished only about one tenth, and the visual sense of the landscape therefore will not be significantly altered. On the other hand, the improved navigation conditions will allow not only an increase in the number of visitors to the best known tourists spots in the Yangtze River, but also the chance to visit new scenic spots upstream of some tributaries, previously inaccessible. Moreover, the "magnificent structures of the Three Gorges Dam shall certainly become a new hotspot of tourism" (Wang, 2002: 372).

41. After the Sanmenxia Dam construction, at the beginning of 1960s, massive sedimentation occurred behind the dam, menacing by floods to places as far as Xi'an city (Dai, 1994).

42. Li Bai (701-762 A.D.), the great poet of the Tang Dynasty, wrote some of his most famous poems inspired by the scenery of the Three Gorges.

43. While the water level will increase about 110 m at the dam site (Sandouping), this rise will be somewhat lesser upstream due to the river descending slope towards the sea.

Figure 7: Notebanks of the People's Republic of China with the iconography of the Three Gorges: 10 Yuan (2005), 5 Yuan (1980).

Navigation improvement is expected to act, in last instance, as a catalyst of the economic takeoff of the Yangtze Basin through trade intensification and tourism development. The Yangtze Basin supports about one third of the total population in China, and it is a region mainly devoted to agricultural and fishing production. Known as the 'land of rice and water' or 'China's breadbasket', it produces 40% of the China's total grain output, about 70% of its rice, and more than 50% of the total fishing output (Morimoto & Hope, 2003). However, industrialization has attached a notable development in recent decades, with Shanghai, Wuhan and Chongqing as the main development poles. An improved navigability, in addition to the dam's power supply, will probably boost the economy not only in Chongqing city but also in the whole region.

Water transfer

An indirect effect of the Three Gorges reservoir filling will be an increase of water availability. Due to the impounded water in the dam and to the increased minimum discharge in the middle reaches, there will be more water available for irrigation, industrial uses, and human consumption not only in the Yangtze Basin but also in the water-deficient north of China. The increased water discharge provided by the dam operation is a necessary condition for the planned South to North Water Transfer Project (Hartmann & Becker, 2003). This huge project is aimed to provide water from the Yangtze Basin, where the water resources are abundant, to the northern China plains, where about 400 million of people suffer from extreme water scarcity (MCormack, 2001).

The water lack in the north is due to a low precipitation regime (about 500-600 mm of annual average in the northeast but less then 200 mm in the northwest), much lower than in the south (more than 1000 mm on average). Moreover, the water scarcity in the north is aggravated by the inter-annual irregularity of the precipitations, and by the fact that more than 80% of the rains are absorbed by the evapotranspiration (Bravard, 2001). The increasing water consumption in recent decades has caused a severe depletion of groundwater aquifers. In Beijing, the water table has fallen about 40 m in the last 50 years, a similar trend observed for the whole North China (McCormack, 2001). The Yellow River, the main waterway of the north plains is suffering an even worst situation. As a consequence of agricultural and industrial water uptakes, the water discharge has significantly decreased (up to six times less in the estuary respect to the 1980s levels), and several sections of the river become completely dried for several weeks every year[44]. A similar trend has been observed for lakes, most of them dried in recent decades[45].

This water scarcity has led to large shortages for domestic uses but also for agricultural and industrial ones. It is estimated that up to 17% of the harvest[46] is lost every year as a consequence of water shortages, while industrial losses reach 20.3 million Euros annually, and between 400 and 600 cities in northern China face water cuts at present (McCormack, 2001; CIIC, 2006). This situation can be worst in the forthcoming years because the water consumption is expected to increase about 60% by 2010 in China (Brown, 2001). In this context, the South to North Water Transfer Project may alleviate this situation by the transfer of water surplus from the Yangtze River basin to the Yellow, Huai and Hai rivers basins. In the first phase of the project, about 40 billion m^3 should be transferred annually, which is the estimated current shortfall in northern China (in a second phase, the transferred amount of water should increase to 70 billion m^3). Three main routes have been proposed (see Zhang Mingguang et al., 1999; and Suo, 2004). The Eastern Route will depart from Jiangdu[47] (Jiangsu Province) in the lower reaches of the Yangtze River, for providing 15 billion m^3 water to the eastern part of the plains of Yellow River, Huai River and Hai River basins (i.e. mainly Shandong Province and Tianjin Municipality). The Central Route, starting from Danjiangkou Dam (Henan Province) on the Han River (a Yangtze tributary), will supply some 13 billion m^3 to the western part of the plains of Yellow River, Huai River and Hai River basins (and including Beijing and Tianjin). It is planned to divert water from the Three Gorges Dam to the Danjiangkou Dam to supply this second transfer route. The Western Route, departing from the Tongtian, Yalong and Dadu Rivers, in the upper reaches of the Yangtze (Qinghai Province), is expected to provide 10-15 million m^3 to the upper reaches of the Yellow River to solve northwestern China's water shortages. It is expected that by 2010, the first (water to Shandong) and second phases (up to Tianjin) of the Eastern Route construction and the first phase of the Central Route construction should be completed (Anonymous, 2001).

Negative effects of the Three Gorges Dam construction

Environment and Biodiversity

Among the most negative effects derived from the construction of large dams are those on the environment (Rosenberg et al., 2000). Blocking a river would involve a series of physical, chemical and geological consequences that will affect to all the three environmental matrices (air, soil, and water) which, in turn, would have severe consequences at different biodiversity levels (ecosystems, species and genomes). The Three Gorges Dam, due to its huge magnitude and the fragility of the ecosystems present in the Yangtze Basin, is expected to exert severe environmental effects (Wu et al., 2004). Even the official environmental impact assessment carried by the authorities recognizes that the dam building will have negative effects on the environment, although it also claims for positive effects downstream. According to independent sources, however, negative impacts of the dam will far overshadow the positive ones (see Lei, 1998).

On the atmosphere, dam advocates claim huge environmental benefits derived from its construction (see Wang, 2002). To achieve the same power production than the Three Gorges Dam (about 100 MW after 2011), a series of thermal plants should burn more than 60 million

44. Some sections of the Yellow River began to dry up sporadically from 1972; however, river drying became an annual phenomenon from 1985, and in the 1990s longer river sections were dried up during wider periods of time. In 1997, a record year, about 700 km completely dried during 226 days (see Liu, 1999; McCormack, 2001).
45. In Hebei Province, only 83 lakes remain from the 1,052 previously existing (Brown, 2001).
46. The North China Plain produces 27% of China's total grain output (Liu, 1999).
47. This route will use a section of the ancient Grand Canal, from Jiangdu to Xuzhou.

tons of raw coal annually. This means that the emission to the atmosphere of 120 million tons of CO_2, more than 2 million tons of SO_2, about 12,000 tons of CO, more than 400,000 tons of NO_x, and large quantities of dust, will be avoided. Therefore, it is expected that the dam will contribute to the decrease in the concentration of greenhouse[48] and other harmful gases, but also a reduction of the acid rain deposition, with beneficial effects on biodiversity and human health but also on halting the climate change. However, the statement that hydropower was an environment-friendly energy –much better than coal, oil or nuclear power– has changed in recent years due to the finding that dams may be a significant source of greenhouse gases, accounting for up to 7% of the global warming potential of greenhouse emissions (St. Louis et al., 2000). Dams can emit CO_2 and CH_4[49] due to the decay of submerged vegetation and carbon inflows from the catchment. In addition, the construction stage of the dam (e.g. fossil fuels used to produce the construction materials), and the land use change in the dam surroundings induced by displacement of people (e.g. conversion of forests into croplands and new urban areas, use of fossil-fuel-based artificial fertilizers) may also contribute to the greenhouse emissions (WCD, 2000; McCormack, 2001). Construction of large dams, besides to enhance the global climate change, might also induce more local climate changes (Wu et al., 2004). A regional warming in Japan has been hypothesized as a consequence of the decline in the river flow (Perkins, 2001), and the predicted raise of fog and humidity caused by the reservoir could aggravate the smog problem and its health consequences in Chongqing (Lei, 1998).

One of the most visible effects of the Three Gorges Dam building will consist in a large-scale habitat loss and/or fragmentation, due to the inundation of more than 600 km^2 of land. Moreover, the resettlement of over 1.2 million people would enhance this effect. The habitat loss and its fragmentation will probably involve the extinction of many plant and animal populations and even species, as occurred in other large dams elsewhere, such as Gatun Dam in Panama, Guri Dam in Venezuela, and Petit Saut Dam in French Guiana (Wu et al., 2004; and references therein). The loss of species will be aggravated because the Three Gorges Dam region is considered a 'hotspot' of biodiversity, probably because this region played a role as a refuge of life during the late Tertiary and Quaternary cold periods, and today we can found there many ancient, endemic and endangered species. Although most of the original vegetation has been replaced by secondary forests and croplands as a result of long-term human disturbance (Wu et al., 2004), the Three Gorges Reservoir Region is still home of at least 144 plant communities, corresponding to nearly 6,400 different plant species (19.3% of the total number of species found in China; López-Pujol et al., 2006). In addition, more than 3,400 insect species (8.5% of the China's total), and about 500 species (22% of the China's total) of terrestrial vertebrates can also be found (Huang, 2001).

The reservoir inundation (but also the resettlement activities) will affect at least 36 vegetation types, totalizing up to 550 plant species (YWRP, 1999). Four taxa will sustain major damage: *Adiantum reniforme* var. *sinense* (Fig. 8), *Neyraudia wushanica*, *Securinega wuxiensis*, and *Myricaria laxiflora*, since all are endemic to the Three Gorges area. Fortunately, a series of conservation measures have been planned for some of these taxa, including the translocation of populations, the establishment of species-specific reserves and the maintenance of germplasm banks (YWRP, 1999). Although one can deduce that terrestrial animals would migrate uphill and therefore they are facing a lesser threat degree, many animals have difficulties to migrate to higher places and others are highly adapted to specific habitats. Since

48. China is the world's second producer of greenhouse gases, after the United States.
49. CH_4 (methane) is considered to be about 20 times more powerful as a greenhouse gas than CO_2.

no terrestrial animal species endemic to the Three Gorges region have been reported, no species would be lost as a consequence of the dam filling. However, many animal populations will be fragmented and others lost, with the consequent interruption of intraspecific gene flow.

Construction of large dams is currently regarded as the main anthropogenic threat to freshwater environments and biodiversity (WCD, 2000; Park et al., 2003). The disruption of river's seasonal flow dynamics due to the physical blockage of the river may cause severe effects on the aquatic fauna, such as the cut off of their migratory paths, the loss of many spawning grounds and the fragmentation and decline of populations (Dudgeon, 2000; WCD, 2000). Obviously, migratory fishes are the most negatively affected aquatic animals by dam building (Fu et al., 2003). The Yangtze River harbors a large fish diversity (361 species), one of the richest rivers among the Asian ones; of these, 162 are known in the Three Gorges Reservoir river section (Park et al., 2003). Fu et al. (2003) have estimated that up to 40 fish species –including 19 endemic to the river– could be affected by the dam construction. The Three Gorges Dam will surely deepen the threat caused by the construction of Gezhouba Dam in the 1980s. This dam, located only a few kilometers downstream from the Three Gorges Dam, has caused serious declines in the populations of three endemic ancient fish species, Chinese sturgeon (*Acipenser sinensis*), Yangtze sturgeon (*A. dabryanus*), and Chinese paddlefish (*Psephurus gladius*), one of the two only paddlefishes in the world (Dudgeon, 2000; Fu et al., 2003; Wu et al., 2004). Unfortunately, no effective conservation measures were implemented to avoid the interruption of migration routes and the fragmentation of fish populations, such as the installation of fish passages. However, other measures to protect the migratory fishes have been carried out by the authorities, such as a program for the artificial reproduction of Chinese sturgeon and the prohibition of commercial fishing (YWRP, 1999). Since the hydrological alterations caused by dams are much more varied than the simple physical river blockage at the dam location, not only (migratory) fishes are vulnerable to the effects of damming. Aquatic mammals, such as the emblematic Chinese river dolphin (Fig. 8) or *baiji* (*Lipotes vexillifer*)[50] and the Yangtze finless porpoise (*Neophocaena phocaenoides asiaeorientalis*) are also seriously threatened by the hydrological alterations caused by damming the Yangtze River (not only by the Three Gorges Dam but also for the planned new dams). Due to the increased navigation in the river channel after the dam completion, physical injuries (e.g. collision with vessels) and noise disturbance are also factors which may threaten the aquatic animals (Fu et al., 2003; Wu et al., 2004).

Figure 8: Two of the 'flagship' taxa in the Yangtze Valley: on the left, the ferm *Adiantum reniforme* var. *sinense* (Credit: Mingxi Jiang); on the right, the Chinese river dolphin, *Lipotes vexillifer* (Credit: Ding Wang).

50. The Chinese River dolphin, called *baiji* in Chinese, and the only cetacean endemic to the Yangtze River, is the most endangered cetacean of the world, and probably the most endangered mammal species, with a current population of probably less than 50 individuals. Its extinction will suppose the loss of an entire family of mammals (Lipotidae) (Anonymous, 2005).

The Three Gorges Dam building will not only affect terrestrial and aquatic biodiversity and ecosystems in the reservoir area but also those located downstream. Sediment built-up within reservoirs (which involves that the water released has less silt content) would imply a series of large physical changes, including the decrease and loss of floodplains and riparian wetlands (which provide habitats for spawning and feeding for many animals), the regression of river deltas and ocean estuaries, and the elimination of beaches and backwaters (Rosenberg et al., 2000), and it would also accelerate the intrusion of salt water into the estuary region (WCD, 2000). The loss of these habitats could lead to the disappearance of the flora and fauna –often highly adapted– inhabiting them. Trapping of sediments and nutrients behind the dam will also imply a significant modification of the biochemistry properties of the downstream water, altering completely the food webs (Rosenberg et al., 2000; WCD, 2000) and having, therefore, enormous effects on the river biodiversity. It has been hypothesized that even the marine ecosystems of the adjacent shelf region can be affected (Zhang J. et al., 1999). These changes could also reduce fishery productivity, as occurred in other parts of the world (see WCD, 2000), a fact of great importance since the Yangtze River basin alone provides more than half of China's fishery output (YWRP, 1999).

The aquatic biodiversity within the reservoir, but also downstream, may be compromised by other kind of processes, such as the release of toxic substances into the river water. Because the water flow in the Three Gorges 600 km section will be slowed down due to the reservoir impoundment, the pollution could not be diluted and flushed to the sea in the same extension as occurred before damming. Moreover, the filling of the reservoir to 175 m will imply the flood of about 1,300 factories and mines, about 4,000 hospitals, around 40,000 graveyards, and about 200 garbage dumping sites (Sutton, 2004), with the subsequent migration of toxics including arsenic, sulfides, cyanides and mercury[51] from these sources to the reservoir water. Although the authorities performed a campaign to clean-up the banks of the Yangtze before suffering the first inundation in 2003 (Anonymous, 2003), some sources indicate that this was clearly insufficient, leaving many places without being decontaminated (Rennie, 2002). To avoid the reservoir becomes an enormous cesspool –it is estimated that only between 10 and 20% of the sewage released into the Yangtze River is currently treated (Ma, 2006), although other sources raise this figure to more than 60% (Fan, 2006)–, the authorities launched an ambitious plan at the beginning of the present decade aimed to build a myriad of wastewater (both domestic and industrial) treatment plants, with the final goal of treating at least 85% of sewage and garbage in the region by 2010 (Anonymous, 2003). Not only industrial and domestic pollutants may hazard the aquatic biodiversity; the massive use of fertilizers by peasants can cause the release of nitrates and phosphates into the dam, whose concentration might lead to eutrophication (an accelerated algal growth) with the subsequent oxygen depletion, producing severe effects on reservoir's fisheries and aquatic ecosystems (Zhang J. et al., 1999).

Archaeology

The Three Gorges area has a rich archaeological and cultural heritage. It has been documented an uninterrupted settlement in the area since prehistoric times. Many and different cultures have inhabited the place that will be submerged by the dam filling, such as the Daxi (ca. 5000-3200 B.C.), which was the earliest Neolithic culture in the Three Gorges area, and its successor cultures, the Chujialing (ca. 3200-2300 B.C.) and the Shijiahe (ca. 2300-1800 B.C.). The distinctive Ba culture (ca. 2000-220 B.C.) also grew up in the Three Gorges area (Childs-

51. Methylmercury, formed from inorganic mercury by the action of aquatic bacteria present in reservoirs, is bioaccumulated in the aquatic food web and may produce severe toxicity in humans.

Johnson et al., 1996). The recuperation of as much as possible information about these cultures and thus an important part of Chinese prehistory and history depends on a fast but also planned rescue. The Three Gorges Dam project will have a significant negative effect on the cultural heritage of the Yangtze Basin, because it will be virtually impossible to collect and document all the cultural and archaeological sites threatened by the reservoir before its filling. In 2000, it was estimated that the area to be inundated contained at least 1,282 cultural heritage places (Shen, 2000), but this figure may have significantly increased due the many archaeological campaigns performed in recent years. All the information not collected before the completion of the dam in 2009, will never be recovered. The dam construction will imply not only a material loss, but also an important change in the landscape. It will never be possible to recreate the setting where a battle took place or the space where cities and cultures were born. And we will never see again the scenery which served as inspiration for ancient painters and poets, such as Li Bai[42].

All the above mentioned was not taken into account by the Chinese government. In 1992, when the National People's Congress approved the construction of the Three Gorges Dam, no archaeologists were consulted. Among the panel of 412 experts involved in the dam approval, there was not any sociologist, cultural anthropologist or archaeologist (Childs-Johnson et al., 1996), being not possible for them to make any suggestion or opposition to the project. The assessment of the cultural heritage affected by the reservoir impoundment, thus, took place only after the proposal of the Three Gorges Project Dam was ratified. Even though this fact, archaeological operations were prioritized in order to officially start the dam construction, and an important salvage project was launched, including an accurate protection plan and the management of the operations by reputed Chinese cultural institutions. Before the beginning of the dam construction (at the end of 1994), some archaeological campaigns within the dam construction zone were carried out, under the direction of the State Administration of Cultural Heritage (SACH)[52], and marked the beginning of the Three Gorges Cultural Heritage Management (CHM) programs[53]. In order to co-ordinate the surveys and to test the excavations in the construction zone, the SACH established in March 1993 two working stations: the SACH Three Gorges Cultural Heritage Preservation Hubei Working Station, and the SACH Three Gorges Cultural Heritage Preservation Sichuan (later Chongqing) Working Station. Both working stations are responsible for designing annual Cultural Heritage Management plans in their territories and overseeing daily operations in the field (Shen, 2000). In March 1994, the Three Gorges Project Construction Committee (TGPCC)[17] and the State Bureau of Cultural Relics[54] designated two units to undertake the preservation of archaeological sites within and around the Three Gorges Dam area (Childs-Johnson et al., 1996). The National History Museum of Beijing was put in charge of planning and supervising the preservation programs of underground archaeology, while the China Cultural Relics Research Institute (CCRRI)[55] of

52. The SACH is the highest government department in charge of cultural heritage protection in China.
53. The Three Gorges Cultural Heritage Management (CHM) programs are managed by the Three Gorges Project Construction Committee (TGPCC) –which represents mainly engineering departments– instead of the SACH, a fact which means that this cultural heritage authority has no control of the monetary resources for archaeological tasks, thus remaining powerless to implement the CHM programs (see Shen, 2000: 57).
54. The State Bureau of Cultural Relics (SBCR) is an administrative organ under the Ministry of Culture in charge of relics and museum work in China. Some of its tasks are research and making principles, policies, regulations and plans for relics and museum development.
55. The China Cultural Relics Research Institute (CCRRI), founded in 1949, is a research institution under the State Bureau of Cultural Relics, with the task of protect and conduct research on key national relics, such as ancient buildings, grottoes, temples, unearthed relics, and museum-stored relics.

Beijing assumed the management of the aboveground sites. Both institutions, responsible of the assemblage of research teams from the different archaeological and cultural institutions involved in the salvage operations, are cooperating closely with the two SACH working stations (Shen, 2000).

The aboveground cultural sites (453 sites in total; Shen, 2000) supervised by the CCRRI include four categories: ancient buildings, stone sculptures, bridges, and cliff paths. In order to protect them, three types of preservation measures have been implemented. The first type consists in 'on-spot' protection, i.e. preserving the aboveground cultural sites at their present locations. An example of this preservation technique is that applied to the Baiheliang Stone Ridge (Fig. 9). It is a low-water calligraphy monument, an early hydrological device which dates back over 1,200 years (Sutton, 2004). Claimed by the UNESCO as the only well-preserved ancient hydrologic station (UNESCO, 2001), this 1,600 m-long flat rock girder is carved with 18 fish figures and over 30,000 characters of Chinese poems, and it give us valuable information about navigation in ancient times in this section of the Yangtze River. Now submerged due to the reservoir filling, it has been saved by constructing an underwater museum[56]. Shibaozhai (Fig. 9) will also require a special treatment from conservation specialists. Located on a mountain outcrop, it is a Buddhist temple complex of three buildings built by the Ming emperor Wan Li (1572-1619 A.D.). It includes a 12-story pagoda completed in 1819 which has a height of 56 m, the tallest wooden building in China (Childs-Johnson et al., 1996). Its preservation plan consists in the construction of a 10 m-thick concrete dike that will surround the temple and turn it into a small island after the reservoir filling in 2009 (Wang, 2003). The second type of preservation measures will consist in relocation, which implies moving the old buildings (or other kind of relics) to higher elevations or to other safe locations. The largest projected relocation is that of Zhang Fei Temple, which dates from 220-280 A.D., and which has been entirely moved 32 km away, at a cost of 70 million Yuan (6.84 million Euros) (Sutton, 2004). This memorial temple was built in honor of General Zhang Fei[57] during the Northern Song period (960-1127 A.D.), although it was restored by Emperor Tongzhi[58] in the nineteenth century (Childs-Johnson et al., 1996). The third type of preservation measure for the aboveground sites is based on data collection, which consists of a complete survey, mapping and photography of the cultural sites before being submerged. Unfortunately, this is the main protection measure being applied to most of the aboveground cultural sites.

56. The construction of the Baiheliang Underwater Museum, near Fuling city, started in 2002 and it will be completed in 2007. It will be located 40 m below the water surface in 2009, when the reservoir will reach 175 m.

57. Zhang Fei (167-221 A.D.) was a famous general who served Liu Bei, ruler of the Shu-Han State during the Three Kingdoms period. During this period (220-280 A.D.), Chinese territories were divided into three kingdoms, Wei State, Shu-Han State and Wu State.

58. Tongzhi emperor (1862-1874) was the responsible of a reforming period in which he tried to reinforce the country to avoid disasters as the recent Opium wars or the Taiping Rebellion.

Figure 9: Some of the protected cultural and archaeological sites in the Three Gorges Reservoir Region: on the left (above), Shibaozhai (Credit: Three Gorges Probe); left (below), Baiheliang Stone Ridge (Credit: Ru-Shu Wang); on the right, Baidicheng city (Credit: Yifan Jiang).

Underground archaeology, conducted by the National History Museum of Beijing, embraces underground sites to be recovered through archaeological methods. Among the more than 829 archaeological underground sites (Childs-Johnson, 2000), many are habitation settlements and historical cemetery complexes. One of the most significant places with underground relics is Baidicheng city (Fig. 9), which has been object of extensive archaeological excavations. Fortunately, not all the ancient city will be flooded. The main buildings of the complex are located at 248 m of elevation; thus, this area will become an island after the reservoir impoundment. Baidicheng, founded by Gongsun Shu[59] who at the end of West Han Dynasty (202 B.C.-9 A.D.) dominated the area, is actually a series of temple buildings, constructed during different periods. Hundreds of culture relics unearthed in Baidicheng area have a history of 6,000-7,000 years ranging from the New Stone Age to the Qing Dynasty (1644-1911 A.D.). Although many advanced techniques have been applied to the excavation of some underground relics in the Three Gorges area, and digital technology has also been used to support field work, these techniques have not been extended to all the excavations due to the lack of budget, slowing down excavation works considerably.

Sadly, the generalized lack of budget has constituted one of the main obstacles to properly carry out all the archaeological operations and rescuing activities. According to international standards, the budget for the preservation of historical relics and cultural antiquities should be 3% to 5% of the total project budget (Childs-Johnson, 2000). Taking into account these recommended percentages, the budget for relics preservation had to reach an amount of at least 1.7 billion Yuan (166 million Euros) when the Three Gorges Dam project was approved in 1992 (the initial budget for the whole project was estimated in 57 billion Yuan), and about 4 to 5

59. Gongsun Shu was a general who at the end of the West Han Dynasty was proclaimed emperor of Shu State and moved the capital from Chengdu to Yufu.

billion Yuan (391 to 488 million Euros) at the middle of 1990s, when the total budget of the project raised to 120 billion Yuan (Childs-Johnson et al., 1996). However, these suggested amounts were never allocated to the involved research institutions and agencies, and the archaeologists were forced to agree to work with an unrealistic budget, of only about 300 million Yuan (29.3 million Euros). According to Sutton (2004), the budget earmarked for the archaeological activities is in fact only about 400-500 million Yuan (39-49 million Euros), which is clearly insufficient. There would be other ways to provide the necessary funds such as calling for international support, but the Three Gorges Project Construction Committee (TGPCC) has been deeply reluctant to receive any external funding (Childs-Johnson et al., 1996). Robberies are another problem in the Three Gorges excavation area. As sites are uncovered and do not have surveillance, thieves have taken valuable artifacts in order to sell them to collectors. In recent years, artifacts of dubious origin have begun to surface on the international market; a notable example was a rare bronze spirit tree[60] from the Han Dynasty sold for 2 million Euros at New York's 1998 International Asian Art Fair (Harris, 2003).

Despite the numerous problems described above, excavation results in the Three Gorges area have brought much new information. Now we have a widest knowledge of the cultures that inhabited the Yangtze River valley, especially about the Ba[61]. There was very few information about this poorly known culture but excavations have revealed that the Ba were more widespread, influential, and older (more than 1,000 years) than previously believed (Childs-Johnson et al., 1996). But maybe one of the most important findings resulting from excavation works is that the Yangtze River valley would be a southern cradle of Chinese civilization. Traditionally, the origins of Chinese civilization were located in the Yellow River plains. Now, the results from the different archaeological campaigns carried out in the reservoir area have evidenced that the Yangtze River valley was also an early and important cultural center in addition to the northern sites (Childs-Johnson et al., 1996). However, and despite these findings, much work remains to be done. There are still a lot of sites to document and protect before the completion of the dam in 2009. Moreover, one must take into account that there is much more things to do after the fieldwork. The study of all the unearthed material will involve years of accurate work but it will give us a widest knowledge not only of the ancient Yangtze Basin cultures but also of the whole Chinese history. But all this knowledge perhaps is not comparable to all the information that will be lost forever under the Three Gorges Reservoir waters.

Resettlement

One of the most evident negative consequences of large dam construction is the huge amount of people to be resettled, which implies not only a change of residence but also a substantial modification of their livelihoods. It is estimated that 40-80 million people have been displaced as a consequence of dam building worldwide; only between 1986 and 1993, 4 million people have been resettled annually (WCD, 2000). In China, the official estimate of relocated people between 1950 and 1990 is 10.2 million people, although some sources raise considerably this figure (15 million according to Suo, 2004). For the Yangtze Basin alone, the number of relocated people would be around 10 million people (Jing, 1999).

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60. Called both *yaoqian shu* ('money tree') or *shen shu* ('spirit tree'), it is a piece made of a sculptural pottery base and a bronze tree whose branches are decorated with coin motifs and mythological images. These money trees were entombed with the deaths to ensure their wealth in the afterlife.
61. The Ba culture (2000-220 B.C.) was an ancient civilization settled from Yibin (eastern Sichuan) to Yichang (western Hubei) characterized by having coffins that resembled boats and a rich and a distinctive weaponry (Childs-Johnson et al., 1996).

Resettlement practices in China have been clearly unsuccessful until the 1980s, due to the lack of comprehensible plans for manage the relocated people. Large dam projects have been traditionally focused on the construction stage, paying only little attention to the resettlement issue. Moreover, the principal method of compensation consisted in just paying an amount of money that the house and land were worth, with no any further consideration about the new livelihoods of migrant people (Heggelund, 2003). As a consequence, about 2/3 of the officially 10 million of relocatees in China due to dam construction are currently living in a situation of extreme poverty (Challman, 2000b). However, some improvements in the resettlement policies were introduced from middle 1980s, and the so-called 'development-oriented' resettlement policy, gradually developed through the pilot relocation experiences performed in the Three Gorges area since 1985 (Wang, 2002), was endorsed in 1993 (Fuggle & Smith, 2000) to serve as the guideline of the Three Gorges Dam resettlement process. This policy is aimed to improve the livelihoods and living standards of the resettled population by means of the local economy development, the construction of new infrastructures, the improvement of sanitation and the whole health system[62], and the investment in education and training[63], instead of mere compensation (YWRP, 1999; Heggelund, 2003). In recent years, the implementation of this policy has given some examples of successful resettlements in China, such as the World Bank-funded projects of Shuikou Dam, in Fujian Province, and Ertan Dam, in Sichuan Province (Fuggle & Smith, 2000).

After the Three Gorges Dam reservoir filling in 2009, 12 major cities including 2 prefecture seats –Fuling and Wanxian (now called Wanzhou)– and 10 county seats –Badong, Changshou, Fengdu, Fengjie, Kaixian, Wushan, Yunyang, Xingshan, Zigui, and Zhongxian–, 140 towns, 326 townships and more than 1,500 villages belonging to 18 different counties[64] (see Table 2) will be partially or completely flooded. The amount of population to be displaced is a question still under dispute. In 1991, before submitting the project to the People's National Congress, the estimated population to be relocated was only 725,000, a deliberate underestimation to help the project's approval, according to the opinion of Dai (2005). After the project passed in 1992, the authorities announced that the total figure of population living in the area to be inundated was of 846,200, which, considering the natural population growth, could reach nearly 1.2 million (see Table 2) in 2009 (Heggelund, 2006). However, independent sources raise this figure to 2 million and even more (Jackson & Sleigh, 2000; Dai, 2005). In fact, a significant increase in the people to be resettled from the original plans have been evidenced in other dams constructed in China, such as Xin'anjiang (280,000 relocated from 200,000 predicted) and Sanmenxia (410,000 from the 320,000 predicted) dams (Jing, 1999). Moreover, these calculations do not include the amount of population eventually to be resettled in the Chongqing area due to the predicted raising of water produced by siltation at the tail of the reservoir (see section *Positive effects*, subsection *Navigation*), which can reach 300,000 additional people in the next 20 years (Various Authors, 2000); they also do not include many subsistence farmers living downstream of the

62. Health conditions in the Three Gorges area are quite deficient; both maternal and infant mortality are elevated, and there is a high incidence of both infectious and non-infectious diseases. For more details about the public health of the Three Gorges Reservoir Region, see Sleigh & Jackson (1998).
63. The resettlement policy contemplates two main types of training: (i) training to peasants who will continue to farm but in different lands and with different crops, and (ii) training to peasants who will change farming for a job in a factory or another occupation.
64. The administrative divisions in China are very complicated and have changed repeatedly in the last century. At present, the levels from higher to lower are the following: Province, Prefecture, County, Township, and Village. Municipalities, Autonomous Regions and Special Administrative Regions (SAR) can be roughly considered at the same level to provinces, while Districts are equivalent to Counties and Towns to Townships.

dam who should probably have to migrate after reservoir impoundment, due to the reduction of sedimentation and the subsequent floodplains regression (WCD, 2000). Even if we take the official estimation (nearly 1.2 million) for the displaced people, it represents at least 6% of the total population of the whole Three Gorges Reservoir Region[22] (about 20 million), which can give us an idea of the magnitude of the resettlement. The heaviest resettlement load corresponds to Chongqing Municipality by far, with more than 85% of the relocatees (see Table 2).

Table 2: Displaced population by the Three Gorges Dam.

County, district or other administrative unit[64]	Without population growth[a]	With population growth[b]
Baxian County	—	14,895
Changshou County	—	17,071
Fengdu County	—	77,324
Fengjie County	—	98,498
Fuling District (former Fuling County)	—	101,724
Jiangbei County	—	8,022
Kaixian County	—	164,738
Shizhu County	—	12,679
Wanzhou District (formerly Wanxian County)	—	213,594
Wulong County	—	6,703
Wushan County	—	84,306
Wuxi County	—	2,681
Yunyang County	—	128,842
Zhongxian County	—	76,724
Chongqing Municipality	719,398	1,007,801
Badong County	—	35,897
Xingshan County	—	28,397
Yichang County	—	12,144
Zigui County	—	100,708
Hubei Province	126,802	177,146
Three Gorges Reservoir Area	**846,200**	**1,184,947**

a. Source: Heggelund (2006).
b. Source: IRN (2003).

Although China has significantly improved resettlement performance in the last decade, being one of the most advanced within the developing countries framework (Heggelund, 2003), many concerns remain about the Three Gorges Dam relocation policy, mainly related to the huge amount of people to be moved and the limited environmental capacity of the reservoir area. There is a major concern about whether it will be enough farmland for the peasants to be resettled. At present, a large percentage (87.3%) of the population in the Three Gorges

Reservoir Region are peasants, who cultivate about 40% of the land in the region; however, 60% of this land is located on mountain slopes and more than 30% in slopes steeper than 25° (Heggelund, 2006). Most of the land in the reservoir region is not able to be farmed because its steeper slopes (nearly 80% of the land is mountainous; Dai, 1998) but also due to the huge erosion problem (it is estimated that erosion is affecting to 60% of the land in the reservoir region; Heggelund, 2003). Moreover, opening new farmlands in mountain slopes with gradients being more than 25° is now prohibited by law, which puts more pressure over the current available lands. Before the reservoir filling, only 1 *mu*[65] of land per capita[66] was available for farming (YWRP, 1999), a situation that will be worsened by the inundation of 25,000 ha of farmland, which accounts for nearly 3% of the total Three Gorges Reservoir Region farmland (Fuggle & Smith, 2000).

Figure 10: Images of the resettlement in the Three Gorges Reservoir Region. On the left, abandoned buildings in Fengdu city (Credit: Barry Cawston); on the right, mark announcing the level to be reached by the water in 2009 (Credit: Three Gorges Probe).

The problem arises from the fact that about 43% of all the relocatees (361,500 of the 846,200) are peasants (Heggelund, 2006), who should be compensated by providing them new land to be farmed. This implies the reclamation of high amounts of new land; however, the current lack of land in the area, and the high erosion levels, make this option clearly unsustainable. Since one of the main policies included in the 1993 Three Gorges resettlement regulations consists in moving as much people as possible in the vicinity of their former homes, mainly uphill[67] (to a higher level on the same mountainside), the reclaimed lands would be on mountainous steep slopes, with very thin soils, which have been proved to be much more unfertile and unproductive[68] than those of the river valleys and floodplains. To provide enough farmland to the displaced peasants, it is obvious that some protected land (those with slopes higher than 25°) should be reclaimed, violating the state regulations. Explicitly recognizing the unsustainability of new land reclamation, the government proposed in 1999[69] the relocation of 125,000 peasants outside the reservoir region, downstream the Yangtze River or on coastal areas (Heggelund, 2006). In addition, the project authorities also recognize that about 40% of the rural migrants will be transferred from agriculture sector to secondary and tertiary industries

65. 1 *mu* is a Chinese unit of measurement for area; 15 *mu* correspond to approximately 1 hectare.

66. The population density of the reservoir region is 296 people/km^2, significantly higher than the nation's average of 130 (Heggelund, 2006).

67. Eight of the 12 large cities, 75 of the 140 towns and 291 of the 326 townships to be inundated will be moved just to a higher altitudinal level from their former locations.

68. It is estimated that 1 *mu* of river valley farmland produces the same than 5 *mu* of farmland on the mountain slopes (Sutton, 2004).

69. This policy change was announced by the Prime Minister Zhu Rongji in a resettlement working meeting organized by the State Council in May 1999; see Heggelund (2006) for more details.

(YWRP, 1999). The new Three Gorges resettlement regulations of 2001 put more emphasis on the need of environmental sustainability in the reservoir area and the convenience of shifting from farming to other activities (Heggelund, 2006).

One of the most important issues of the 'development-oriented' resettlement policy in the Three Gorges Dam is the creation of many small- and medium-scale industries to accommodate the displaced peasants, in addition to the expansion of the already existing ones. Although about 650 factories have been or will be submerged, it is estimated that some 1,600 factories are being relocated and several hundreds created *de novo* (Li et al., 2001). To strengthen the growth of the industrial network in the reservoir area, an Economic Development Zone, similar to those existing in the coastal areas[70], has been set up (Jackson & Sleigh, 2000). However, the unemployment rates have significantly grown from late 1990s, due to the nation's economic reforms. Most of the state-owned enterprises (including the small town and village enterprises) have drastically reduced their staffs[71] to improve their efficiency, and many others have been directly closed. Many companies have old equipment and unsuitable schemes to manage in a market economy environment, while others are too pollutant and should close because they cannot cope with the environmental regulations (Li et al., 2001; Heggelund, 2006). Although the performance of private companies is better, these are not capable to expand fast enough to absorb the relocatees' contingent, both urban and rural. The employment in urban factories is especially problematic for the migrants of rural origin (peasants) because of their low educational level and lack of professional training and skills, thus being in clear disadvantage compared with the urban unemployed[72] in competing for the scarce available jobs (Jackson & Sleigh, 2000).

Other risks that the Three Gorges Dam resettlement process faces are more related to psychological and social issues. On one hand, the relocation may imply significant changes in the livelihoods of the migrant people. Even if the peasants are moved only to uplands near their former homes, they will be not familiar with the new farming environment and techniques (they are encouraged to cultivate citrus and tea, most suitable crops for the uplands than the traditional self-sufficiency farming in the river valley; Jackson & Sleigh, 2000). But the transition to be an employee in a factory is much more traumatic for peasants, because they should change a rural environment for an urban one, and the chance to find a job is unfortunately quite scarce. Moreover, the Chinese traditional attachment to the land and the importance of familiar and community ties make the relocation a really disruptive psychological experience for the migrants, due to the uprooting and disintegration of the established social network. The integration of the migrants into the host communities can also be conflictive because of the sharing of the existing land and the increasing pressure on resources and social services (Heggelund, 2006). All these reasons may explain –at least partly– why the Three Gorges Reservoir Region residents have been too reluctant to be moved away from their homes.

70. In 1979-1980, the first four special economic zones were set up in coastal areas (Shenzhen, Zhuhai, Shantou and Xiamen) as a cornerstone of the new 'open-door' policy of Deng Xiaoping. These areas benefited from low taxes and institutional special treatments, to attract foreign investment and promote trade. In 1984, new economic development zones were designated for the 14 largest coastal cities, and at late 1980s and during the 1990s the number of these areas have grown exponentially.

71. Over-staffing in state-owned enterprises in China is estimated to be between 15 and 37 million workers, i.e., between 30 and 50% of the total employees (Li et al., 2001).

72. More than 100,000 people have lost their jobs in the recent years in the reservoir region due to the closure of over 1,000 factories (Sutton, 2004).

Corruption and embezzlement are other factors that can put some threat to the success of the Three Gorges resettlement performance. The relocation process is managed by local government units, which receive resettlement funds directly from the central government and should manage them to compensate economically the migrants but also for the construction of new infrastructures. This has provided many chances of embezzlement, and, according to many sources, a widespread corruption phenomenon has rooted among the local officials (Heggelund, 2003; Sutton, 2004). As a consequence of this, many migrants have repeatedly denounced receiving less compensation than promised (IRN, 2003). Until 2000, about 100 officials were sentenced to long prison due to the embezzlement of about 470 million Yuan (45.91 million Euros) from the resettlement funds and even one –the former director of the Fengdu's District Construction Bureau, responsible of the mismanagement of 12 million Yuan (1.17 million Euros)– to death (Bezlova, 2000; Beattie, 2002). Recently (2005) another official, one of the managers of the Land Resources Bureau in Wushan County, has also been condemned to the capital punishment due to the embezzlement of 2.8 million Yuan (0.27 million Euros) of the relocation funds (Guo, 2005).

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