Ten years of the Three Gorges Dam: a call for policy overhaul

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Abstract
The Three Gorges Dam (TGD), the world’s largest source of ‘clean’ hydroelectric power (Shen and Xie 2004), has entered its tenth year after the first turbine went into operation in June 2003. The dam, with a generating capacity 20 times that of the United States’ Hoover Dam, has been hailed as a crucial part of a solution to China’s energy crisis. Despite great benefits, however, major concerns have been voiced over the disastrous environmental and social consequences of this massive engineering project (Stone 2011). In this paper, we review the benefits and impacts learned from the controversial megadam over the past decade and discuss perspective quests on policy overhaul for future environmental protection.

1. Great benefits
An important function of the dam is to protect 15 million people and 1.5 million acres of farmland from flood disasters (Stone 2008), which have threatened communities along the Yangtze River for centuries. In late July 2012, water flow into the dam area reached 71 200 m$^3$s$^{-1}$, a higher flow rate than during the devastating Yangtze River floods of 1954 and 1998. The dam reduced the flow by almost half and protected both banks of the Jingjiang River, the section of the Yangtze River between Yichang and the Dongting Lake, from devastating flood damage.

In the last ten years, the cumulative power generation of the dam has surpassed 629 billion kWh, equivalent to a reduction of nearly 600 million tons of carbon dioxide. At 0.25 RMB (US$0.039 68) per kWh, hydropower generation alone has created 157 billion RMB or US$25 billion in revenue. Despite the impact of flooding biomass and the resulting generation of methane, which is a potentially large source of greenhouse gases (St Louis et al 2000, Barros et al 2011) that was not addressed in the official reports, compared with fossil fuels it still is a more efficient means of power generation.

Located at the outlet of the upper Yangtze River, the TGD has substantially improved waterway navigability conditions from Yichang to Chongqing. The TGD increased the Yangtze River’s barge capacity six fold, and from 2003 to 2012, a total of 500 million tons of goods passed through the ship locks (MEP 1997–2012). The Yangtze has continued to be the world’s busiest cargo-bearing river, with 1.5 billion tons of throughput in 2010, three times that of the Mississippi and five times that of the Rhine.

2. Undesirable environmental impacts
Perhaps the most immediate consequence of the reservoir was an increase in geological risks within the Three Gorges Dam area (figure 1). This results primarily from erosion caused by the drastic fluctuations in reservoir water levels,
which, when at their peak, create a body of water almost as long as Britain. More than 500 earthquakes of $M \geq 2.0$ and several thousand smaller events have occurred in the vicinity of the reservoir head region since 2003. Furthermore, the earthquakes and water-level fluctuations in the reservoir have increasingly destabilized surrounding slopes, leading to 430 landslides and nearly 2900 smaller related incidents (MEP 1997–2012). In addition, stagnant water in the tributaries has elevated pollution levels—an existing concern for populations along the Yangtze River. The dam has blocked approximately ten million tons of plastic bags, bottles, animal corpses, trees, and other detritus that would have otherwise flowed out to sea. Since 2004, algal blooms caused mainly by dinoflagellates have occurred each February in 22 Yangtze tributaries including the Xiangxi, Pengxi, and Daning rivers (Fu et al. 2010) (figure 1).

The riparian ecosystem has also been significantly disrupted by the TGD (Wu et al. 2003). The destruction of spawning grounds and the obstruction of migration routes have resulted in sharp declines in number of different fish species and freshwater cetaceans. The latest investigation in 2012 shows that the population of finless porpoises in the Yangtze River basin has declined to approximately 1000, making them even rarer than giant pandas in the wild (Qiu 2012). WWF and the Ministry of Agriculture (MOE) reported the presence of only 17 species of fish during their scientific investigation on the Jinsha River, a dramatic decline from more than 140 species found decades ago (WWF and MOA 2013). The TGD also increased the downstream snail’s habitat and the consequent risk of human schistosomiasis infection (figure 1). In endemic areas near lakes and wetlands, prevalence hovers near approximately 5% (Stone 2011), compared to only 1% before the construction of TGD.

The reservoir has slowed the water flow, resulting in a total of 1263 million tons (Mt) of trapped sediment (CWRC 2001–2011) and eventually causing an estimated 565 Mt of downstream river bank collapses and channel incisions. Water impoundment has resulted in lower water levels in the downstream channel and less water storage in the adjoining riparian lakes (e.g., Dongting and Poyang lakes), which contributed to extreme drought conditions in 2011 when precipitation was low (Yang and Lu 2013). Additionally, the delta front has shifted from sediment accumulation during the 1960s to an erosion rate of approximately $100 \times 10^6$ m$^3$ yr$^{-1}$ in recent years (Yang et al. 2011), exacerbating saltwater intrusion in the Yangtze estuary (figure 1).

3. Weak policy enforcement

It is commendable that China has gradually acknowledged the undesirable consequences (Qiu 2011) and passed a new plan to rein in the potential harms (the State Council of China, 2011). However, authorities have been blamed on the weak enforcement of relevant regulations. For example, environmental authorities have invested significant funds to battle algal blooms and treat sewage, yet they have undone much of this investment by simultaneously permitting hundreds of factories to release pollutants into the Yangtze River. The amount of sewage in the Three Gorges Reservoir Area (TGRA) soared fivefold from 100 million tons in 2001 to 500 million tons in 2009 (MEP 1997–2012). Also, a three-month fishing ban has been imposed in the Yangtze River each spring since 2003 to ensure the recovery of endangered fish resources and the ecosystem. However, the policy is limited in improving the basin’s overall biodiversity because it focuses primarily on the restoration of commercial species. Natural reserves have also been established, but most reserves are too small to ensure species survival and sustain ecosystem function. Another resultant signal of environmental impacts is the increased reproduction of oncomelania snails downstream (McManus et al. 2010).
Figure 1. Undesirable consequences of the Three Gorges Dam: (1) geological risks; (2) algal blooms and water pollution; (3) loss of biodiversity; (4) increase in water-borne diseases; (5) severe drought; (6) delta erosion and saltwater intrusion.

Although health authorities are improving sanitation and implementing other measures to reduce infection rates, villagers who have relocated to downstream schistosome-endemic areas from non-endemic areas have less resistance and are more likely to develop severe illness as a result (Gray et al. 2012).

The dam also reflects the power of bureaucratic expertise over the rights and views of resettled peasants, 1.3 million of whom were relocated to make way for the TGD beginning in 1993. Few residents were consulted about the eviction plans or appropriate entitlements. And, eviction continues today. According to Chongqing’s development plan for 2007–2020, more than four million people in Chongqing municipality will be encouraged to resettle on the city’s outskirts. If the earlier displacement of 1.3 million people cost a reported RMB 80–90 billion (Bates 2002), the anticipated financial expense to relocate four million additional people will be around RMB 200–300 billion (Stone 2008), more than doubling the official cost of the project.

4. Policy recommendations

Although the aforementioned remedy (the State Council of China, 2011) in environmental protection and biodiversity conservation is laudable, the management policy of the TGD also needs an urgent overhaul to enforce relevant regulations. We therefore call for a policy overhaul for future environmental protection and biodiversity conservation.

First, a comprehensive, independent agency such as the Changjiang (Yangtze) Water Resources Commission (CWRC), a department of the Ministry of Water Resources, should be assigned to provide management in flood control, power generation, navigation, and environmental protection across the Yangtze River basin. At present, the institutional structure of the dam is a multilevel and territorially hierarchal model, with the State Council at the highest level: the State Council oversees the TGD. Under the State Council there are at least 19 additional bureaus involved in the management of the TGD, although the dam is chiefly in the charge of the China Three Gorges Corporation (CTCG). Because the bureaus are ranked similarly, they are unable to compel one another to pursue certain policies. For example, the Ministry of Environmental Protection plan to manage new riparian areas formed by fluctuating water levels was disrupted by a development program introduced by the MOE that resulted in conflicting
resource use. The fragmented management structure has caused unsustainable water regulation, worsening biodiversity loss, and inefficient flood protection and drought relief measures. Therefore, updating the CWRC directly under the State Council as a single, independent agency controlling the TGD and implementing all laws and regulations throughout the Yangtze River basin is necessary to coordinate all relevant bureaus and to reduce bureaucratic conflicts that might arise.

Second, the independent agency should place equal emphasis on power generation, flood control, and environmental protection. Although environmental protection has become a key element of dam operation since 2003, short-term economic gain through the dam’s power generation remains a high priority. Because environmental protection and water-level control for flood and drought management are often perceived to conflict with advancing economic gain, current government officials reluctantly give emphasis to these issues. For instance, when the Ministry of Water Resources demanded the release of water to relieve the severe drought in the middle and lower reaches in May 2011, the CTCG initially tried to impound more water for power generation (Lu et al. 2011). The widespread ideology of ‘power generation first, environmental protection later’ is an important cause of weak implementation of relevant laws and regulations.

Third, environmental performance should become a major criterion for evaluating government officials at the regional and local levels. Although more than 100 environmental laws and regulations are implemented in the TGRA, these laws and regulations are often ignored by local government leaders who tend to regard high economic growth as their main barometer of success and the basis for their promotion. Because environmental protection agencies lack the power to override local leaders, many environmental regulations are not enforced. For example, under the ‘Three Gorges Dam Post-Construction Plan’, the prefecture-level city of Yichang, where the TGD is located, announced the first batch of projects in February 2012 and only one of these 33 projects was relevant to environmental protection. If local governments do not value environmental performance equally to economic performance, laws and regulations will have minimal impact at the local level.

Existing laws and regulations in place to manage the TGD can also be strengthened through public participation, particularly to ensure implementation. This will likely remain a slow process in China, where the management structure has historically been top-down. For example, during the TGD’s early planning stages, authorities selected resettlement sites without consideration of available livelihood opportunities. However, the public plays a crucial role in ecological protection: 90% of stranded Chinese sturgeons were found by local fishermen. Timely communication of information on or delivery of the stranded sturgeons facilitated their protection.

In conclusion, to be successful in environmental protection and biodiversity conservation in the TGRA, the management policy of the TGD needs urgent overhaul to enforce relevant regulations at national, regional and local levels. Although this policy overhaul applies specifically to the TGRA, given the booming Chinese dam-building business at a rate unmatched in human history—about 100 dams in various stages of construction or planning on the Yangtze and its tributaries such as the Yalong, Dadu, and Min rivers, it is a fair specimen of operative efforts between the governmental agencies at different levels to protect environment and conserve biodiversity and meet the needs of a rapidly growing economy. The policy overhaul is a great challenge to authorities, but the potential benefits to save various endangered species, improve the environment, and encourage economic development are compelling.
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