Chapter 5
Conclusions: The Future of Large Dams in China

5.1 Trends and Debates of Large Dams in China

This book included a review of large dam construction worldwide and at China's national level. While the worldwide review mostly discussed the general characteristics of dam construction, the Chinese review focused on the particular features of large dam construction in China.

The worldwide review first discussed the history, distribution, and the trends of large dams. Even though the history of dams is as long as that of human civilization, the overwhelming majority of dams were built after 1900, with the peak in construction occurring between 1970 and 1975. Five regions that have the highest dam density are East Asia, South Asia, North America, Europe, and Southern Africa. The distribution of dams is uneven between developed and developing countries: the former have already developed more than 70 % of their economically feasible dam potentials, while the latter have only developed about 30 %. Hence, most of the dams currently under construction or being planned are in developing countries, and therefore, the trend of future dam construction worldwide mainly depends on the pace of economic development in these countries.

The major purposes for dam construction include irrigation, water supply, flood control, electricity generation, and navigation. Some of the objectives are well achieved, which are the cases for most hydropower dams. But many dams intended for irrigation or water supply have fallen short in meeting their original goals. Dams for flood control could be a double-edged sword: they could regulate natural flow and reduce the magnitudes of floods, but also could cause unintended consequences, such as sedimentation of riverbeds, and making flood disasters even more pronounced. Some dams are built to raise the water level to improve navigation conditions, but this may come at considerable environmental and social costs.

General environmental impacts of large dams include inundating terrestrial ecosystems, altering natural river flow regimes, blocking routes for migratory species, increasing sedimentation, and enhancing greenhouse gas emissions. Most of the changes to natural systems are irreversible; therefore, it is necessary to conduct reasonable

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environmental impacts assessment before the construction process is approved and to identify proper mitigation measures that should be applied in the project.

There are different types of social impacts of large dams that occur at different levels, including those on agriculture, local livelihood, social inequity, and culture. Compared with environmental impacts, social impacts are harder to identify and assess, and therefore are easier to be overlooked during the decision-making process. However, a comprehensive understanding of social impacts is essential to the fair distribution of benefits and costs over all stakeholders. Therefore, incorporating a social impact assessment into the decision-making process is as important as applying an environmental impact assessment before dams are constructed.

Debates around large dams generally fall into three categories: economic feasibility, environmental sustainability, and the social equity issues. Large infrastructure projects like dams provide direct and indirect economic benefits, and have been used for a long time as an important means to stimulate economic development. But there are also externalized costs of dams, which make the benefit-cost analysis problematic. The environmental impacts of dams are difficult to deny, but the debates are in most cases on whether opponents of dams exaggerate those impacts. Social equity debates focus on one key issue: whether the groups who suffer the most from dams also benefit the most, or get fairly compensated for their losses.

In China there were very few large dams before 1950. However, during the second half of twentieth century China built about half of all the large dams constructed worldwide. Most dams built between 1950 and 1966 were aimed at irrigation and managing hazardous rivers. In contrast, most dams built after about 1980 primarily focused on generating electricity, due to the rapid increase in energy demand as China modernized. Currently, electricity generation is the single most important driver for dam construction in China. The Ministry of Water Resources identified 13 hydropower bases in different river basins in China, which cover almost all the river reaches that have technically feasible hydropower potential. The early construction projects did not account much for social impacts, but there has been a steady progression of policy and inclusion of stakeholders ever since.

The case studies in this book represented the most important or controversial dam projects in China. The Three Gorges Dam is by far the largest hydraulic project in the world, and it was finally build after a 70-year-long debate. With multiple functions to control floods, improve navigation, and generate electricity, it has also caused substantial environmental and social impacts in the reservoir-affected area. The Xiaolangdi Key Water Control Project is the most critical facility on the Yellow River to manage flow and mitigate sedimentation. Since the Yellow River is a seriously degraded river system, Xiaolangdi Dam is generally successful in harnessing this unpredictable river. The cascading dams on three rivers in Southwest China, the Nu, Lancang, and Jinsha were discussed last. Dams on these rivers are all intended for electricity generation, and use the same model of cascading development, which means planning a series of dams on one river and using the profits from earlier complete dams to finance the building of the rest. This cascading model could be an economically efficient means for developing entire river systems, but the social and environmental impacts are also extended to entire watersheds.

5.2 Understanding the Environmental Impacts on Biological Diversity and Ecological Integrity

Environmental impacts are among the most significant concerns of large dam construction. This book reviewed the environmental impacts of large dams from the perspective of biological diversity and ecological integrity. In Chap. 3, we showed generally the environmental impacts of large dams in major river basins throughout China. After the general review of the environmental impacts, we also introduced frameworks for assessing these impacts at watershed and ecosystem scales based on the case studies in the Upper-Mekong river basin.

Inundation of the reservoir area is the most obvious direct impact a dam will have on the environment. Most large dams are located in valleys, which often have relatively high biodiversity. Thus, dam construction inundates critical habitats for many plant and aquatic species. Reservoir inundation could also cause a change in land use patterns. After impoundment, local people may be forced to move up the hillsides and clear new farmland where forests may have been before the construction of the dam. This change in land use also might aggravate soil erosion, further threatening biodiversity. In Chap. 3, we developed the vegetation impact index (VII) and the ecological risk grades to quantify the impacts of the large dams on plant diversity.

Many aquatic species in rivers have specific migratory patterns during their life cycles. During different life stages, such as spawning, juveniles, and sexual maturation, many species shift to different reaches of a river. Dams can block migratory paths, and reduce the populations of many species, possibly driving some species to extinction. Some large dams have established fish bypasses (ladders) as a means for mitigating the negative effects on migratory species, but the percentage of large dams with such structures is very low, and ladders only aid the movement of certain species. Also, these structures sometimes do not work effectively, since the migration of different species requires various navigational cues, such as strong currents.

Dam construction is considered one of the most significant alternations to natural hydrologic systems. The evolution of a river ecosystem is a process of adapting to the flow regime over several thousands of years. However, dam construction causes rapid changes in natural flow regimes in several aspects. The flow regime changes, that in associated with water quality alternation, will significantly impact the integrity of river ecosystems. In Chap. 3, we structured the fish index of biological integrity (F-IBI) and the planktonic index of biological integrity (P-IBI) to quantify the impacts of large dam on the ecological integrity of river ecosystem.

Another alteration of dam projects to the natural system is sedimentation, which is not only a technical problem for the dam itself, but also has noticeable environmental consequences. For many large dams, serious sedimentation shortens the service life and long-term sustainability of the facility. Dams capturing sediment moving downstream can also cause the erosion of downstream channels and tributary headcutting. Estuaries and deltas need sediments from upstream to offset the erosion by waves and tides. Dam construction not only captures the sediment, but also reduces the amount of water flowing downstream because of evaporation and water consumption by agriculture and/or industry. Therefore, seawater might encroach and erode estuary areas.

Hydropower has been considered a clean energy source with lower greenhouse gas emission rates than electricity generated by fossil fuels. However, studies show that decomposing organic matter in reservoirs emits a large amount of greenhouse gases. This problem is more severe in shallow reservoirs in tropical regions. However, since natural lakes and wetlands also emit greenhouse gases, whether the contribution of reservoirs to global climate change is significant remains controversial.

5.3 Understanding the Social Impacts and Compensation Policy

Large dam projects will not only dramatically change the physical conditions of the rivers, but also will have significant impacts on local communities. In Chap. 4 we identified three classes of wealth for the affected people, namely material wealth, embodied wealth, and relational wealth, and comprehensively compared the loss and compensation in each dimension of wealth. Case studies showed that the division of three dimensions of wealth can help researchers and policy makers better understand the multilevel social impacts on relocated people. Dam construction has direct impacts on material wealth, primarily by submerging houses and farmlands. Material wealth is easy to understand, and therefore its loss is most often equitably compensated, or even overcompensated. But embodied wealth and relational wealth are generally affected in indirect manners, and thus they are more difficult to recognize by policy makers. Hence, most unfair compensation practices arise from ignoring either embodied wealth or relational wealth. However, the impact is not always negative, as some dam projects bring concurrent opportunities for villagers to enhance these two types of wealth, such as by providing more job opportunities or improved infrastructures.

Recommendations for more reasonable compensation policies were also identified based on the analysis of the three dimensions of wealth. In Chap. 4 we showed that it is critical to systematically assess the three dimensions of wealth loss caused by dam construction, and that in order to improve the accuracy of the assessment, a transparent decision-making process is necessary. Then, to achieve the goal of fair compensation, the government needs to compare which dimensions of wealth loss are covered and fairly compensated by the policy and compare them with the actual wealth loss in each dimension as perceived by villagers. The ideal compensation policy should compensate fairly in all three dimensions. The compensation policy should also take social inequity effects into consideration and make sure to avoid uneven impacts on different individuals or communities that would widen the inequity gap between them.

5.4 New Decision-Making Schemes in Large Dam Projects

Large dam construction is not merely an engineering problem, but is rather at the center of resource exploitation, environmental protection, and social development. The complexity of this problem demands that resolving it will require interdisciplinary knowledge and collaboration. Figure 5.1 illustrates the interactions among the three components of large dam construction. Owing to the inter-relationships between these components, failing to address any one of them likely will result in the eventual failure of the project. While it is critical to coordinate the demands arising from all three components, it is also important that experts in different fields study each component in detail. The following suggestions are provided for improving the understanding of each component.

Economic feasibility is at the center of resource exploitation. When planning to build a dam, resource potential, technological capacity, finance, and market are all among the factors that need to be evaluated. Beside these considerations, it will be helpful to research the financial and physical performances of dams, such as the possibilities for overrunning estimated budgets and/or failing to meet planned objectives. The World Commission on Dams' (2000) report did interesting statistical analyses of the physical and financial performances of dams around the world. However, it might be more persuasive to make thorough inquiries into the reasons behind the high or low performances of dams with different purposes, such as why most of irrigation dams fail to meet their original goals, while most hydropower dams not only recover their costs, but also surpass their original objectives. Another possible research topic involving economic feasibility would be to compare the profit rate of large dams with other alternatives. For example, comparing hydropower plants with solar or wind power plants, or comparing the economic effects of irrigation dams with new, innovative water saving technologies. Such comparisons will help developing economies decide if they should build large dams or pursue other options.

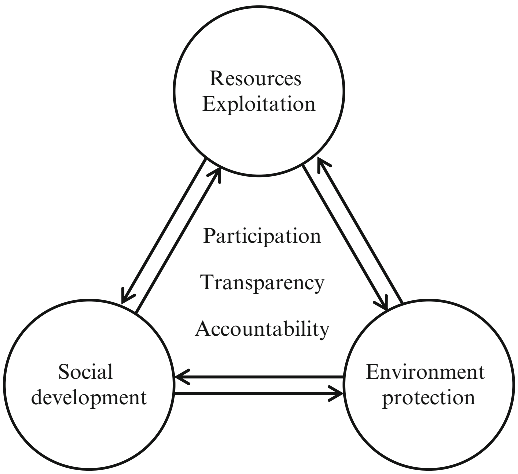

Fig. 5.1 Economic feasibility, environmental sustainability, and social equity

Environmental sustainability is another goal that large dam projects should strive to achieve. Much research has focused on the environmental impacts of large dams, including studies on immediate changes in terrestrial and aquatic ecosystems, geological features, and water quality following the construction of large dams. Future research on environmental sustainability problems should also focus on long-term impacts, such as greenhouse gas emission rates, regional climate changes, and relationships between reservoir size and the frequency of earthquakes. Since a substantial percentage of freshwater on the planet is held in large dam reservoirs, these long-term impacts to the global environmental sustainability should not be neglected.

Social equity was not emphasized in dam projects until the recent decade. Even though large dams have been used as an important means for social development, the distribution of benefits and costs are not equitable in most cases. The following suggestions are potential directions that future research on the perspective of social equity should advance. First, this book proposed a framework for better understanding the social impacts of large dams, where wealth was divided into three categories. Future researchers may work on designing a more scientific and reasonable division of wealth. For example, the definition and examples of embodied and relational wealth need to be further specified. Second, a global decision-making framework is necessary to fully understand the social impacts, and the World Commission on Dams has made great contributions in building such a framework. However, large dam problems vary significantly between different regions, therefore geographic and socioeconomic differences should be taken into consideration and necessary adjustments should be made to the framework to better fit specific situations. At last, certain universal standards need to be developed to ensure basic social equity during and after the dam building process, in order to make sure that all the stakeholders are fully informed, the decision-making process are participatory, and the policy designs are transparent.

The future of large dams in China is shaped, and being shaped, by the different interests held by different stakeholders, and the complex relationships between economic, social, and environmental systems. The solution to the large dam dilemma should not be a simple judgment of building dams or not. It should be a mechanism that ensures that different factors in human and nature systems are considered, and interests of different groups are respected and protected. Participation by all key stakeholders, transparency in the decision-making process, and accountability in the implementation of new projects comprise the cornerstone for this mechanism, which assures that the decision-making process is scientific-based, efficient, and fair. In sum, this reasonable decision-making mechanism, rather than a moral or economic judgment, is the answer to the large dam dilemma.

Reference

WCD (2000) Dams and development: a new framework for decision-making. World Commission on Dams