

Rivers at Risk – Dams and the future of freshwater ecosystems

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Abstract

The construction of dams and the development of associated infrastructure, such as irrigation systems, have huge environmental impacts. Sixty percent of the world's largest rivers are already severely fragmented by dams, diversion and canals. This has played a major role in the rapid decline in freshwater biodiversity worldwide. This paper shows how new dam projects pose a real threat to freshwater biodiversity in a number of river basins. It presents new data on dams currently planned or under construction and discusses the implications of these schemes for key river basins. It is acknowledged that these dams will also bring economic and social benefits and the paper examines the changes needed to ensure that needs are met with minimum environmental impact. It presents examples from around the world to demonstrate alternatives to large dams, as well as successful efforts to mitigate the impacts of dams, and highlights the role of the recommendations of the World Commission on Dams.

Keywords

Alternatives to dams, River basins, World Commission on Dams

Global challenges

The world faces a huge challenge to supply the water and energy needs of a rapidly growing population, as well as reducing poverty. Currently, 2 billion people have no access to electricity, while around 1.1 billion people lack access to safe drinking water and 2.4 billion to adequate sanitation services. As the pressure to solve water and electricity needs grows, dams are being considered by many decision-makers as one of the key solutions.

Globally, there are more than 45,000 large dams operational in over 150 countries (WCD, 2000) and it is estimated that another 1500 or so are currently under construction, nearly 400 of which are over 60 m high (IJHD, 2004). There is little doubt that dams have improved agricultural output by making more land suitable for cropping through the provision of water for irrigation. They have provided flood control and hydropower for millions of people. However, dams have also caused considerable environmental damage and, together with associated activities such as irrigated agriculture, have been a major cause of the decline of freshwater biodiversity in recent decades.

Today, most dam construction has shifted from the developed to the developing world, with some countries such as China and India implementing large dam construction programmes. While water and energy needs in developing countries are real and need to be addressed, the risk to ecosystems is acute and some unique species and habitats are threatened. The environmental impacts of dams are well documented, with changes in both upstream and downstream hydrology affecting freshwater ecosystems along the river and as far as its estuaries. People are equally vulnerable; not only those who are displaced by dams, but also those who depend on these freshwater ecosystems for their livelihoods, for example through fisheries. Those most affected by dams still do not necessarily benefit directly and often remain without access to power and clean water.

Analysing dam construction: A river basin approach

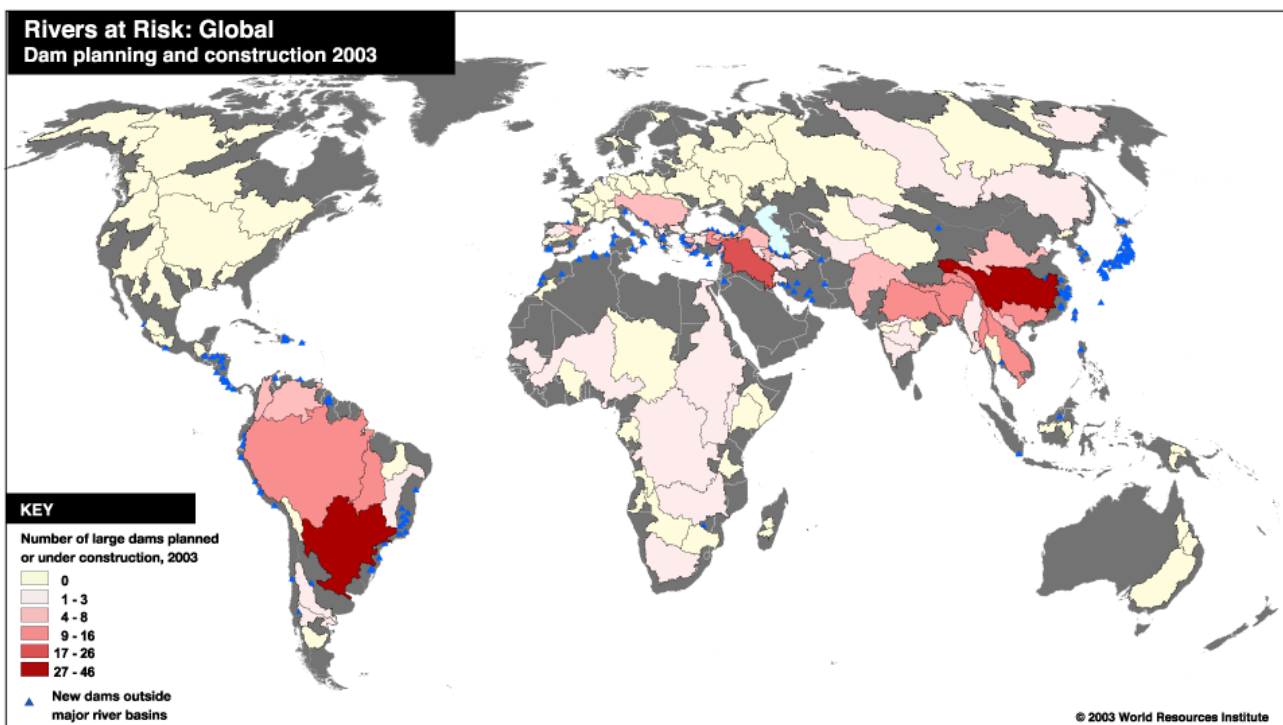
The availability of data on dam construction and planning is fragmented and the dams debate is usually fuelled by controversial dams on a project by project basis. In 2000 the World Commission on Dams (WCD) presented a large amount of data concerning dam building, but this was limited to dams already constructed or under construction at the time and analysis was presented on national and regional levels. In the same year the World Resources Institute developed an analysis of dams on a river basin scale, using the level of river fragmentation and flow regulation at the river basin level (Revenge et al., 2000). The indicator assessed 227 of the major river basins in the world and showed that 37 percent of the large rivers are strongly affected by fragmentation and altered flows, 23 percent are moderately affected, and 40 percent are unaffected.

This analysis builds on previous work and examines the present state of dam building in the world's major river basins and is unique in including both dams that are under construction as well as dams that are at various stages of the planning phase. It is based on dams under construction that are over 60m high, as well as on data on dams that are being planned that are either higher than 60m or will have an installed hydropower capacity of more than 100 MW as of 2003. The analysis includes dams of all types: hydropower, irrigation, water supply, flood prevention and multi purpose dams.

The primary data source for dams 'Under Construction' is the 2003 World Atlas & Industry Guide, published by the International Journal on Hydropower and Dams (IJHD), and in particular the table "Major dams (60 m or higher) under construction", which gives the country, name of the dam and river, the type of dam and its height and purpose. Data on planned dams is not readily available and information was obtained from several IJHD publications (journal, atlas, maps). On many dams no data is available at all and this analysis, based on 551 of the largest dams, can only provide a partial picture. Nevertheless, it serves to illustrate the threats to key river basins.

Rivers at Risk

The analysis, presented in the map below, demonstrates how vulnerable river basins are, as more and more dams get built within the same basins or even on the same river. Valuable habitats and species are at risk of disappearing from the combined effects of not only one large dam but many.



The Yangtze River Basin in China has by far the highest number of new large dams planned or under construction, 46 new dams, followed by the La Plata Basin in South America with 27, and the Tigris and Euphrates Basin in Turkey, Syria and Iraq with 26. Africa stands out for the low numbers of large dams planned or under construction, but this does not necessarily mean that there are no dams planned or under construction, as many countries do not report dam locations. However, with the investment climate in most of Africa being worse than elsewhere, it is likely that a lack of capital results in fewer dams being built.

The Yangtze Basin is a rich centre for biodiversity, both terrestrial and freshwater, with about 322 species of fish and 169 species of amphibians (WRI et al., 2003). But many species are under threat, as the Yangtze basin is densely populated and the demand for water and energy, from both within and outside of the basin, has led to intensive dam building that continues at a rapid pace. Today 46 dams over 60m high are either under construction or planned, including the Three Gorges Dam. Species at risk from further alteration of river and riparian habitats include the finless porpoise, whose population is reported to be declining rapidly, and the Yangtze River dolphin or baiji, the most threatened cetacean in the world, with only a few tens of individuals remaining. Many bird species, such as cranes, are under threat as well and the decline of fish stocks is affecting the livelihoods of people in the basin.

The La Plata River Basin is the second largest basin in South America, after the Amazon, and is home to more than 110 million people. It is shared by Brazil, Bolivia, Paraguay, Uruguay and Argentina, and has three major sub basins: the Paraná, Uruguay and Paraguay. The Paraná is already a strongly fragmented river, with many dams and hydraulic works. Fortunately, the other two major rivers in the basin, the Paraguay and Uruguay, have as yet few dams. The Paraguay is the central artery of the Pantanal, the world's largest tropical wetland ecosystem. The Pantanal wetlands are a complex system of marshlands, floodplains, lagoons and interconnected drainage lines. The flora and fauna of the area is extremely diverse and includes 80 species of mammals, 650 species of birds and 400 fish species. Six large dams are now under construction and 21 more are planned in this river basin, including the Corpus dam on the main stem of the Paraná, which will flood an area of 380 km².

The Tigris and Euphrates River Basin is shared by Turkey, Iraq, Syria, Iran and Jordan and its vulnerability lies in its water scarcity and high risk of desertification. Since the 1950s, when the riparian states entered a self proclaimed "age of dams" (UNEP, 2003), dam development has featured prominently in the economic and social development of the region and land-use changes have resulted from these major hydraulic works. Degradation of the water sources in this basin is of particular concern for the biologically rich wetlands, such as the Mesopotamian marshlands in Iraq, that host a myriad of important species. The decline in fisheries alone will have a severe impact on the livelihoods of people who depend on them. Overall the basin is already highly altered by dams and irrigation canals, and with the new dams planned upstream in Turkey, downstream water supply and hydrological regimes will be considerably altered. With a total of 26 large dams under construction or planned in this vulnerable area, there is cause for alarm and immediate action is needed to assess cumulative impacts and to mitigate the loss of species and habitats, particularly migratory birds and wetlands.

Outside the top three many other key river basins with important biodiversity values are under threat, such as the Mekong, Amazon and Ganges & Brahmaputra rivers. Table 1 summarises the main threats for the top 21 river basins.

Table 1: Rivers at Risk – Summary of threats to river basins

Basin Name	Countries within Basin	Large Dams	Types of Risk
Yangtze	China	46	Large basin under stress from population pressures. Loss of habitat threatens bird species as well as endangered Yangtze River dolphin
La Plata	Argentina, Bolivia, Brazil, Paraguay, and Uruguay	27	River basin with high biodiversity; threats to Pantanal and other internationally important wetlands
Tigris-Euphrates	Turkey, Iraq, Syria, Iran and Jordan	26	Arid basin; potential for conflicts over water withdrawal between Turkey and downstream countries
Salween	China, Myanmar, Thailand	16	Relatively pristine river with high biodiversity values; Serious concerns about human rights abuses in Myanmar
Kizilirmak	Turkey	15	Small heavily fragmented basin; Ramsar site located in Delta
Ganges	India, Nepal, China, Bangladesh	14	Endangered Ganges River dolphin; Sundarbans mangroves in delta
Tocantins	Brazil	12	Relatively developed river basin; further dam development and improved navigation will exacerbate degradation for use of farmland
Amazon	Brazil, Peru, Bolivia, Colombia, Ecuador, Venezuela, Guyana, Suriname, Paraguay and French Guyana	11	One of most important basins for biodiversity; lower dams may affect coastal areas
Mekong	Thailand, Laos, China, Cambodia, Vietnam and Myanmar	11	Basin with high biodiversity and very productive fisheries; droughts and low water levels are current threats
Brahmaputra	China, India, Bhutan, Bangladesh	11	High biodiversity in upstream areas; high population pressure in delta
Xun Jiang (Pearl River)	China, Vietnam	10	Highly developed basin; some important sites for amphibians
Danube	Germany, Austria, Slovakia, Hungary, Croatia, Serbia & Montenegro, Romania, Bulgaria, Moldova, Ukraine	8	68 Ramsar listed sites as well as UNESCO biosphere reserve in delta
Huang He (Yellow River)	China	8	River basin with severe water shortages; 4 endemic bird areas, 1 Ramsar site
Kura-Araks	Azerbaijan, Iran, Georgia, Armenia, Turkey	8	Biodiversity hotspot with 4 Ramsar sites, 1 Endemic Bird Area and 21 IBA's
Yesil-Kelkit	Turkey	8	Breeding populations of many birds in Delta
Büyük Menderes	Turkey	7	River delta protected as National Park, protected bird areas
Çoruh	Turkey	7	Fast flowing river with significant tourist industry based on rafting
Susurluk	Turkey	7	N/A
Ebro	Spain and Andorra	6	High economic importance of delta; important bird sites
Indus	Afghanistan, Pakistan, India, and China	6	Endangered Indus River Dolphin
Qezel Owzan	Iran	6	Endangered sturgeon species

Looking across the basins, in terms of freshwater biodiversity impact, it is clear that some species are highly at risk. For example, river dolphins and porpoises are among the most threatened mammals in the world, and the six basins where these species live are all included among the top 'at risk' basins. Four out of the five species of Asian freshwater cetacean are either critically endangered or endangered according to IUCN's Red List of Threatened Species (IUCN, 2003). These include the Yangtze River dolphin, the Yangtze River finless porpoise, the Indus River dolphin, and the Ganges River dolphin. The fifth species, the Irrawaddy River dolphin, is listed as data deficient, but is found mainly in the Irrawaddy and the Mekong, both of which are among the rivers at risk from dam development according to this analysis. Finally, the single South American freshwater cetacean species, the Amazon River dolphin, which is listed as vulnerable by IUCN, is found in the Orinoco and Amazon River basins, both also listed as rivers at risk in this analysis. While it is not dams alone that are bringing these species close to extinction, the altered flows and habitat degradation induced by dams are a significant threat to these species.

Other common patterns across the at risk basins, include endemic species of migratory fish, as well as important wintering and breeding sites for migratory birds, many of which are threatened with extinction. Of concern are several species of sturgeon, in Europe (Danube Basin), as well as in the Caspian (Qezel Owzan Basin and other smaller basins in Iran), and several species of endangered cranes (Siberian crane in the Yangtze basin in China) and other wetland-dependent bird species. Again, it is not dams alone that are threatening these species but the cumulative pressures from dams and other developments, as well as pollution. In the case of freshwater fish, the decline in fish population has serious socio-economic implications. In many of the basins identified in this study, freshwater fisheries have both a high commercial value and are a main food source for the poor, the importance of which is often underestimated.

The way forward

The World Commission on Dams (WCD) has provided a set of recommendations to improve decision-making, but these are still not being implemented in most countries. To avoid large-scale damage, decision-making needs to include comprehensive needs, options and impacts assessments, including cumulative assessments of planned dams by river basin. Integrated River Basin Management (IRBM) provides the tools to assess and avoid basin wide impacts and meet the needs of a range of stakeholders, yet is still far from commonly applied.

Nevertheless, there is an increasing number of best practice examples from around the globe that demonstrate that it is possible to strike a balance between water and energy needs and environmental protection. Naturally, implementation of WCD guidelines right from the planning stages of a dam is the most effective, but improvements to dam building can be done at all stages, as is demonstrated by the different approaches taken by WWF.

Reducing the need for dams

Considering the high costs of many dam projects, it is astonishing that much of the water they supply is actually wasted. Globally, nearly 70% of water withdrawals go to irrigated agriculture yet conventional irrigation systems utilised worldwide have water use efficiencies of only 38% (UN, 2003) and up to 1500 trillion litres of water are wasted annually (Clay, 2004). This unacceptable wastage of valuable water is driven by misplaced subsidies and artificially low water prices, often unconnected to the amount of water used (WWF, 2003) and needs to be addressed urgently. Technically, a more efficient use of water is not a problem. For example, drip irrigation systems for water intensive crops such as cotton can mean water savings of up to 80% compared to conventional flood irrigation systems, but these techniques are out of reach for most small farmers. Currently drip irrigation accounts for only 1% of the world's irrigated area.

In Pakistan, WWF works with farmers in impoverished areas to conserve water in cotton farming by promoting the 'bed and furrow' irrigation method. It is estimated that increasing irrigation efficiency on the Indus Plains of Pakistan by just 10% would allow 2 million more hectares of farmland to be irrigated (Hinrichsen, 1997). With an estimated water use of 10,000 m³ per hectare of field crops this could avoid the construction of two dams with the capacity of Tarbela, Pakistan's largest dam.

Comprehensive options assessment

In Poland the Nieszawa Dam was proposed to secure the stability of another dam, the Wloclawek Dam, on the Vistula River. WWF believed that no proper needs and options assessment had been carried out by the proponents of the Nieszawa Dam and that a number of options, including the decommissioning of the Wloclawek dam, had been rejected prematurely. WWF contracted a multi-disciplinary team of experts to identify all problems and threats caused by the existence of the Wloclawek Dam as well as all technically feasible options and carry out a comprehensive options

assessment. The team also assessed the relative social and environmental impacts and carried out the relevant economic analyses.

This led to the conclusion that construction of a new dam at Nieszawa can only exacerbate the adverse environmental and socio-economic problems caused by the existing dam and storage reservoir at Wloclawek and that modernisation of the Wloclawek Dam will only partly resolve the problems caused by impeded sediment transport and associated downstream erosion. The assessment concluded that the gradual decommissioning of the Wloclawek Dam and reduction in the level of the storage reservoir is the most sustainable option.

Subsequently, the Polish parliament has voted twice against allocating state funds for the construction of the Nieszawa dam. While the problems of the Wloclawek Dam have still not been solved, this option assessment has served at highlighting the various options and their costs and benefits and has opened the way for a more sustainable solution.

Mitigation: Restoring environmental flows

Even when a dam is in place it is often possible to adjust the operational regime to better meet a variety of needs. So-called 'environmental flows' provide critical contributions to river health, economic development and poverty alleviation (IUCN, 2003b). Environmental flows are not natural flows but aim to find a balance for meeting a variety of water needs, including those of ecosystems and downstream communities.

The Kafue Flats in Zambia are recognised as a major wetland resource both in ecological terms, with rare and endemic species, and in socio-economic terms as they support local industries such as floodplain agriculture, dry season cattle grazing and traditional fisheries.

The area's natural water regime was radically changed after the construction of two dams in 1969 and 1976. As a result of the construction of the two dams, the natural flood patterns in the Kafue flats were replaced by a stable river level throughout the year. The change in the water regime contributed to the decline of many species in the area. Lower fishery yields and reduced availability of grazing land as a result of the altered flooding regime have also affected communities.

To return to a more natural flow regime WWF has co-financed modelling work as well as the re-establishment of hydrological monitoring stations. New operational rules for the Itezhi-tezhi Dam were launched in May 2004 and are expected to provide major benefits for wildlife and local people.

Conclusion

Concentrated dam building activity in the river basins identified above requires further consideration. Many basins are found in countries such as China and Turkey, none of which have implemented the recommendations of the WCD. And although the water and energy needs of these countries are very real, a planned, systematic and basin-wide outlook of dam building needs to be better integrated into the decision making process. Of concern too is that as most large river systems have been dammed additional large dams are built on smaller river systems, many in coastal basins. There is a real possibility to over-capture a limited water supply, with severe implications for freshwater and coastal ecosystem health.

Dam technologies have improved over time. A large dam today can be more ecologically accommodating than past projects. Good site selection, such as avoiding building dams on the main stem of a river system, and better dam design can play significant roles in minimising impacts. Fish passes (where effective), the use of hydrological data (when available) to improve the replication of natural stream flow, and also emphasis on appropriate temperature and oxygenation of water released downstream can significantly improve the operation of large dams. Unfortunately, the lack of sound hydrological and biological data for many regions of the world can lead to unreliable

predictions and inadequate mitigation measures. Economic considerations may mean that environmental mitigation measures are not implemented, if there is no legal requirement to do so. There is an urgent need to apply an integrated river basin management approach to better balance social, economic and environmental factors. The presented case studies show examples of how the decision-making and management of dams can be improved and we call on governments and developers to make a concerted effort to learn from these and similar examples.

As the WCD report has emphasised, the debate about dams is a debate about the very meaning, purpose and pathway of development (WCD, 2000). In particular in the poorest countries, the question how those most in need will benefit should be answered at the outset. There is room for essential and well-planned dam development for water and energy supply. The opportunity society has today is to consider all options, both large-scale and small-scale, as well as demand-side and supply-side. The dams that are given the go-ahead should minimise environmental impacts and maximise social benefits, and governments should ensure a strong legal framework to facilitate this. The WCD has recommended a practical and fair path to follow; it is now the turn of governments, developers and financiers to implement and comply with the WCD recommendations and conserve freshwater habitats and species for future generations.

WWF is calling on governments and dam developers to apply the recommendations of the WCD and ensure that water and energy needs are met in a sustainable manner, without the destruction of the very ecosystems that provide the basis of a clean and stable water supply.

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